

Ergonomics Research Techniques

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Week – 04

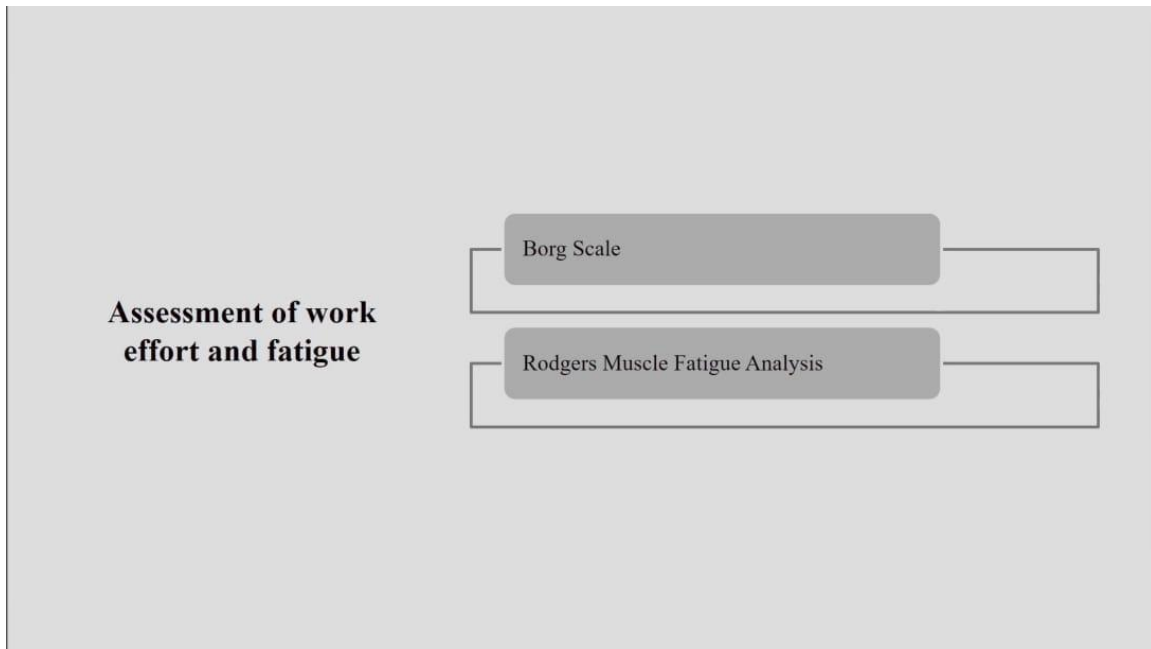
Lecture - 15

Lec 15: Borg scale & Rodgers muscle fatigue analysis

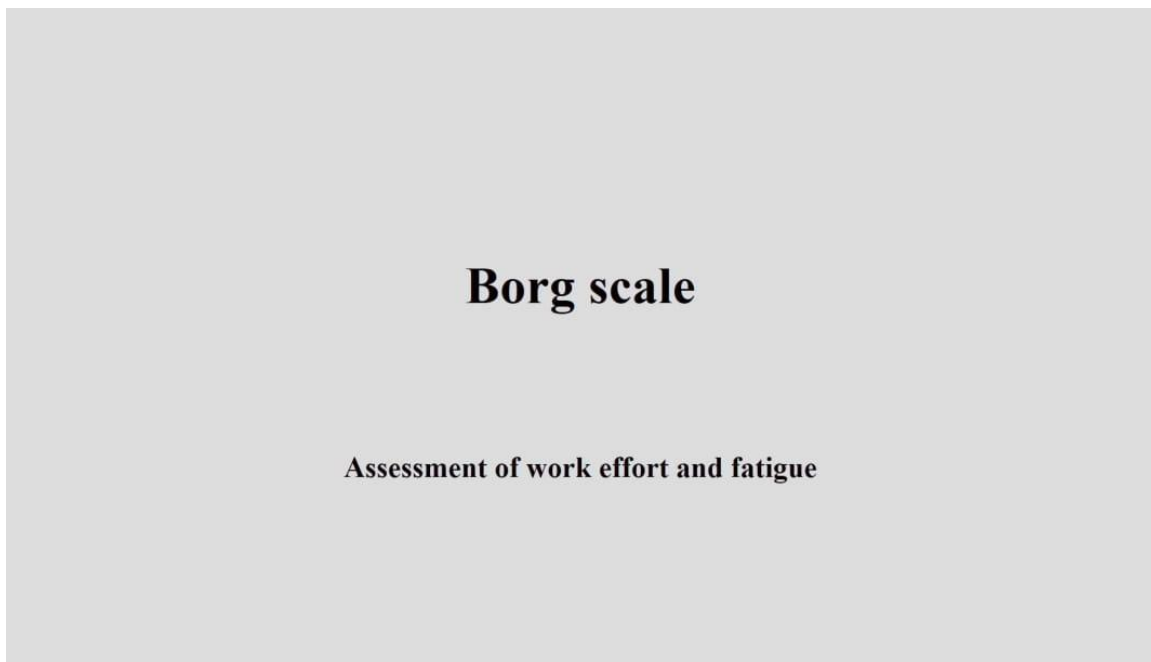
Physical methods

Assessment of work effort and fatigue

Welcome back. Today we will be talking about assessment of work effort and fatigue under the physical methods. So, we already started learning about different method like techniques related to physical methods. So, today we will take up the work effort and the fatigue. Few only we will be learning there are many more. However, due to course time we will be taking two major tools which are normally being used by the ergonomics researchers.



So, first, let us understand what are those. First, we will be learning about Borg scale, it is a subjective method. We have two types of Borg scale we will be learning both and the muscle fatigue analysis or muscle fatigue assessment. So MFA which is also again a kind of new combination of subjective and objective rating and it gives you an understanding or kind of indexing which says that is this work is suitable for so many hours or not. So, these types of when we are doing some kind of physical activity, how our muscles are getting fatigue, so that we will be talking about in MFA. So, these two tools we will be learning specifically for today's session.



So let us start with the Borg scale. Everybody understand who is Borg? So Professor Borg who is really a very prominent research like prominent scientific person, science person who developed lot of things in the field of ergonomics and occupational health and his contribution towards assessing the subjective fatigue or subjective exertion is very very important to understand and learn. And this is so simple tool that any person can use that to understand or assess the preliminary exertion level by a worker of a worker. So, let us start with that.

Introduction

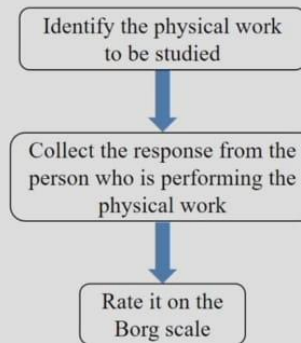
- Perceived exertion and difficulty level measurement were introduced for understanding the physical work and its costs.
- The way a person experiences the work will depend on his/her adaptability, performance and satisfaction.
- The subjective experience measurement methods use verbal expressions defining the scale points for rating.

So, perceived exertion in the Borg's scale or Borg's fatigue assessment scale in that we actually what we do we try to understand what is perceived level of exertion by the person who is actually operating or actually working in that particular situation. So, perceived exertion and difficulty level measurement were introduced for understanding the physical work and its cost. So, the way a person experiences the work will depend on his or her adaptability, performance, and satisfaction. So, here two very important concept were being introduced.

First is if it is all about the person's perception, the person who is actually working the operator, their perception. So, if on a similar level of job two person can adapt or two person can take different time to adapt that particular situation. So, the level of fatigue or level of exertion will be different from one person to another person. So, person's capacity or person's capability to adapt the situation, person's performance on that particular situation and how satisfied they are in that particular situation all these are being considered in this particular scale. And based on these different level the perception or perceived exertion also will change, level of perceived exertion also will change.

The subjective experience measurement method and is used for verbal expression defining the scale points for the rating. So, that way we actually use Borg's scale. We have two different Borg's scale that we are going to describe in the next slides.

Procedure



So, what is the particular procedure that we are going to follow? First, we are going to identify the physical work that to be you know studied. So, we need to understand what kind of physical work we are going to study by this particular scale.

So, we need to identify that particular work, then collect the responses from the person who is performing the physical work and we need to rate that into the Borg scale.

Borg RPE scale

- Borg RPE (Rating of Perceived exertion) scale was developed by Gunnar Borg (1998).
- Tool for measuring an individual's effort and exertion, breathlessness and fatigue during physical work.
- Used to monitor and guide exercise intensity.
- The scale 6 to 20 is related to the high correlation between the scale and heart rate.

$$\text{Heart rate} = 10 \times \text{Scale value}$$

So, first, we will be discussing the Borg's RPE scale. RPE means rate of perceived exertion. So, how much the person the worker is perceiving about that particular exertion. It was developed in 1998 you can understand it is not very very old tool it is only few decades old tool.

So, this particular scale was very much connected with any kind of activity where you are doing some kind of physical exertion. Borg's RPE scale is always connected with some activity where somebody is doing some physical activity. So, where you are using cardiac muscle like cardiac capacity to work on. So, you are doing lot of muscular activity. So, this tool for measuring an individual's effort and exertion breathlessness and fatigue during any physical work.

This is very important RPE scale that rate of perceived exertion scale developed by Borg is only applicable where we are involved in a particular physical type of work. So, used to monitor and guide the exercise intensity initially it was for the when somebody is exercising we use this particular scale to understand what is the kind of intensity level the person is working so that we can control the exercise module. This particular scale starts at 6 ends at 20. Now it has very nice connection with our heart rate approximate heart rate. So, what it says heart rate is equal to 10 into this scale value.

Suppose you are at the level of 6 that means your heart rate supposed to be near around 60. So, what what we do? We say that suppose somebody said my rate of perceived exertion is 7. So, we can predict that it is somewhere near around 70. It is not that exact 70. Here we have to be very clear that it is not that heart rate is exactly 70.

It can vary from somewhere around 65 to 75. Because next point of this particular scale is 80 where may 8 where we can say that heart rate is 80. Again this can vary from 75 to 85. It is approximation. It says that it is possible that heart rate is near to that region because from 6 to 7 it is a 10-bit gap 7 to 80 it is 10 bit gap.

So, the heart rate can be there can be somewhere in this particular region. So, it has very much direct connection with your heart with the worker's heart rate. So, physical activity. So, those activities are causing increase increment in your heart rate due to work can be rated or the exertion level can be rated using this particular scale. And researchers can easily identify what is the possible level of or perceived level of exertion by that particular person in actual. So that is box RPE scale.

Borg RPE scale

Score	Level of exertion
6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Now, this looks like this like the whole scale you know looks like this. So, it has major three division. So, you can see that this blue color is like you know kind of light exertion level. So, 110 till 100 like this is 11.

So, till 110 kind of heartbeat if you are having. So, you are doing some kind of light physical work. It is all about physical activity. Whereas, this particular section talks about maybe heart rate starting from 120 to 160 and this is very very heavy.

So, 170 to 200. Now, why 60 and why 200? Now, here this particular scale was developed for the young adult. So, it is expected the people who are around the age of 20, 25 that particular range they are they were the major number of participants in this particular study and the scale is developed based on that. So, we know what is the theoretically possible maximum heart rate. So, it is 220 minus your age. So, it is expected who is like the person of 20 years of age can achieve a heart rate of maximum possibly of 200 bits per minute as per this scale.

Now, this is completely theoretical. It is theoretical explanation. However, in practical pushing someone to you know till this 200 bits per minute is absolutely depending on the total experimental setup and what is the kind of experimental objectives and this scale is like we take observation from the participant. We try to understand what is the kind of perceived exertion level for them. So, if someone is saying that my level of perceived exertion is 20, it does not mean it is always 200 bits per minute.

It says it is maximum possible that they are actually trying. So, they are at the very very high level of their exertion level. It may be 80 bits per minute or maybe 190 bits per minute. It is actually it is at the maximum possible level for that particular person for that particular

person. So, the scale looks like although it is very much connected to the heart rate like bits per minute, but at the higher values these are theoretically correct, but in practical we may not see 200 bits per minute to achieve such level.

That is quite difficult or I would rather say it is dangerous to someone to push up to that level for a particular person. So, we really need to see actual reserve heart rate when the person is working or exercise in different other method and then only we can push someone to the maximum exertion in theoretically. Now, these particular scale that is rate of perceived exertion was very much connected to the physical activity. So, somebody if they are doing the manual activity, so they are as so it is a linear progression. If you are doing more work your heart rate is increasing more.

So, level 1, 1 pattern of heart rate maybe 670 bits per minute. So, you are increasing the level of exertion it is going towards next level of heart rate maybe 70 or 80 something like that. So, it is a linear progression. So, when somebody is working physically, so manual activity is there. However, if you look at the Industrial Revolution we see that when somebody due to different changes due to automation in the industry most of the work in different industry becomes sedentary in nature.

So, in that case, the person actually is not physically doing lot of activity they are sitting in a particular place, sitting in a sedentary position, and doing lot of activity. That does not mean that they are not getting exerted. Of course, due to work, they are that their exertion level is increasing. However, that is not very much connected to the heart rate. If somebody is working for 4 hours sitting in a table chair position you know in a sedentary posture, sedentary work is being done by that particular by that particular person.

It is not that heart rate will increase. However, there will be some kind of exertion. In on the other side if the same number of hours like 2 hours if somebody is doing some kind of physical activity like you know load lifting, load shifting, pulling, pushing definitely heart rate will increase and that can be reflected in the box RPE scale. But for the first case, it is not really possible to get the reflection of exertion level in the RPE scale because there is not such increment in the heart rate because the RPE scale mostly associated with the physical exercise. Whereas, in the sedentary activity there is less physical exercise, there is actually no physical exercise. They are doing the job in a sedentary condition.

CR-10 scale

- CR-10 (category ratio) scale was developed by Borg (1994).
- It incorporates the best properties of a category-rating (C) scale for absolute levels of intensity and a ratio (R) scale for good metric properties.
- It is a general intensity scale with special anchors to measure exertion and pain.

To understand the exertion level of such cases there is a new development by the same person Gunnar Borg that is CR 10 scale category ratio scale. So, what exactly it says? It says that it incorporates the best properties of category rating. It talks about the category rating scale for absolute level of intensity and a ratio scale for good metric properties. It is a general intensity scale with special anchors to measure the exertion and the pain.

Now, how it looks like? It looks like it starts. So, RPE scale is linear scale you know 6, 7, 8, 9 linearly it is increasing. If the exertion level is increasing the level of the rating also increasing in a linear level linearly.

CR-10 scale

Score	Level of exertion	
0	Nothing at all	
0.3		
0.5	Extremely weak	Just noticeable
0.7		
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	Maximal
11		
*	Absolute maximum	Highest possible

Whereas, if you look at this particular scale CR 10 scale it starts with 0, then increment is up to 0.3. Whereas, in the next level when there is an another increment it is only 0.2, here also it is 0.2. Then again 0.3, then 0.5, 0.5, 0.5, 0.5, then 1, 1, 1, 1 increment. So, this scale is not really a linear scale. However, we can understand the level of exertion for a person who is doing the job in sedentary condition. So, it has some these type of numbering these values along with that we have verbal expression. So, if it is 0 we we try to connect it as the no exertion level at all.

There is no exception. So, the person is relaxed. Whereas, after 11 we do not have any numbering it is some marks star marks it says absolute maximum. So, it absolutely depend on the person. So, for a person for a for two different person this is this may be the level of exertion may be different because it is perceived by that particular person. So, like that, we have some verbal expression over here as well. So, this is CR 10 scale category ratio scale.

Advantages

RPE scale

- Easy to use and the instructions are simple.
- Linear relations are obtained for work with high aerobic demands.

CR-10 scale

- It has the advantage of determining absolute S-R (stimulus-response) functions.
- Can be used for most kinds of experiences.

Now, we as I am telling for each and every tool that there are some advantages and there are some disadvantages for these particular two scales also has some advantages. So, first, let us understand about the RPE scale. It is easy to use and instruction are very very simple. It is linear relations are obtained from work with the high aerobic demand. As I said it is very much connected with the heart rate and which is linear in nature.

CR 10 scale has an advantage of determining absolute stimulus-response function and can be used for most kind of experiences. RPE scale only possible to use where you have physical activity whereas, CR 10 scale can be used for any kind of activity. Although it they have some kind of disadvantages. So, RPE scale responses do not reflect to growth

function absolutely as I mentioned earlier, and can be used only for perceived exertion and related symptoms. In case of CR 10 scale, it is more complicated and in its construction than the perceived exertion other perceived exertion stool and more time is required for the explanation, instruction, and training.

It takes lot of time because when we are talking about a particular scale. So, when it is dumping 0, then 0.3, then 0.5 then there are always a question why. So, we need lot of explanation, lot of understanding and training to explain all these the characteristics of this particular scale.

Disadvantages

RPE scale

- Responses do not reflect true growth function.
- Can be used only for perceived exertion and related symptoms.

CR-10 scale

- More complicated in its construction than PE scale.
- More time is required for the explanation, instruction and training.

So, these that kind of disadvantages is it has. So, these are the two scale which are always being used, mostly being used not always, mostly being used for understanding the perceived exertion box RPE scale and box CR 10 scale ok.

Approximate training and application times

Borg RPE

- Few minutes of instruction is sufficient for the subjects to understand the scale and know how to rate overall perceived exertion or specific strain.

CR-10 scale

- Detailed instruction is required and a follow-up to verify that the subject understands the scale.

Tools needed

- Scale constructed and designed by Borg with no additional colors or pictures.
- Subjects can give the response verbally or point it out with finger or mouse.

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So, what kind of training do you need? So, it is for box RPE scale few minutes of instruction is sufficient for the subject to understand the scale and know how to rate overall perceived exertion or specific strain. Whereas, for CR 10 scale we need detailed instruction and follow-up to verify that the subject understand the scale or not because it is not really linear and the verbal expressions are not available for each point. It is a quite lengthy scale. So, we really need to take a detailed measure to train this particular scale to the subject. Now, what are the tools required? Scale constructed and designed by Borg with no additional colors or pictures.

So, subject can give the response verbally or point it out with a figure of finger or the mouse. So, you take the scale in a printed copy or in a soft copy you just ask the person to point it out. So, it is a very very simple tool to actually implement ok. And these tools are very easy to implement with any kind of person literate not literate illiterate layman, construction workers, in the vegetable market, or wherever you actually go ok. These tools are so simple that you can really really implement it very easily and you can get lot of you know understanding about the level of perceived exertion ok. So, these are all about RPE and CR 10 scale developed by Professor Gunnar Borg.

Rodgers Muscle Fatigue Analysis

Assessment of work effort and fatigue

Now, I will take you to the next technique or next tool which talks about the muscle fatigue assessment or analysis. Again it talks about how fatigue your muscles are and how long you can do the activity. Are you able can you continue for longer hours or not.

Introduction

- Muscle fatigue assessment method (MFA) was developed by Rodgers and Williams (1987) to characterize the discomfort described by workers on automobile assembly lines and fabrication tasks.
- Each muscle group is rated for each task of a job based on which priority of change is suggested.
- It can be used for evaluating production tasks having fewer than 12 to 15 repetitions per minute with the same muscle groups.
- Ideal for team evaluations of a task or job.

So, let us take some kind of brief preliminary understanding or introduction about this particular tool.

So, this particular tool is developed by Rogers and William in 1987 to characterize the discomfort and described by workers on an automobile assembly line and fabrication task.

So, initially, when they developed this particular tool they developed in in an assembly line for the automobile manufacturing unit. So, what is the kind of characteristics? So, when you are talking about assembly line in a automobile industry in a fabrication task it mostly by the your digital upper extremities. So, wherever similar kind of situations are available we can use this particular tool to assess the kind of muscle fatigue. So, each muscle group is rated for each task for a job based on which priority of changes is suggested.

It can be used for evaluating production task having fewer than 12 to 15 repetition per minute with the same muscle group ideal for team evaluation of a job or a task. So, this is very important when we would like to do some kind of team activity this particular tool is very very useful and we can get a broader picture of this of this particular activity or of this particular job. So, team evaluation is very easy with this particular tool.

Introduction

- It consists of two tables.
- Table 1 is the “Worksheet for muscle fatigue assessment method” where the three number rating is given for each body part of the selected task.
- Different body parts assessed are
 - Neck
 - Shoulder
 - Back
 - Arm/elbow
 - Wrist/hand/fingers
 - Legs/knees
 - Ankles/feet/toes
- The rating/score is based on the elements like effort intensity, effort duration and frequency of efforts.

So, let us understand this particular tool talks about neck, shoulder, back, arm or elbow, wrist, hand and fingers, legs and knee, ankle, feet and toes.

These all 1, 2, 3, 4, 5, 6, and 7 body parts. So, first I will explain one and you can replicate the same process with all other body parts. So, it consists of two major tables these tables are pre-computed tables. Table 1 is the worksheet for the muscle fatigue assessment method where the three-numbers rating is given for each body part of the selected task. And this rating or score is based on the elements like effort intensity, effort duration, and effort frequency. So, effort intensity, effort duration and effort frequency 1, 2, 3.

These three factors we are going to evaluate for each body part for neck, shoulder, back, arm, elbow, wrist, hand, fingers, legs, knees and ankle, feet, and toes. So, three major component we are going to identify.

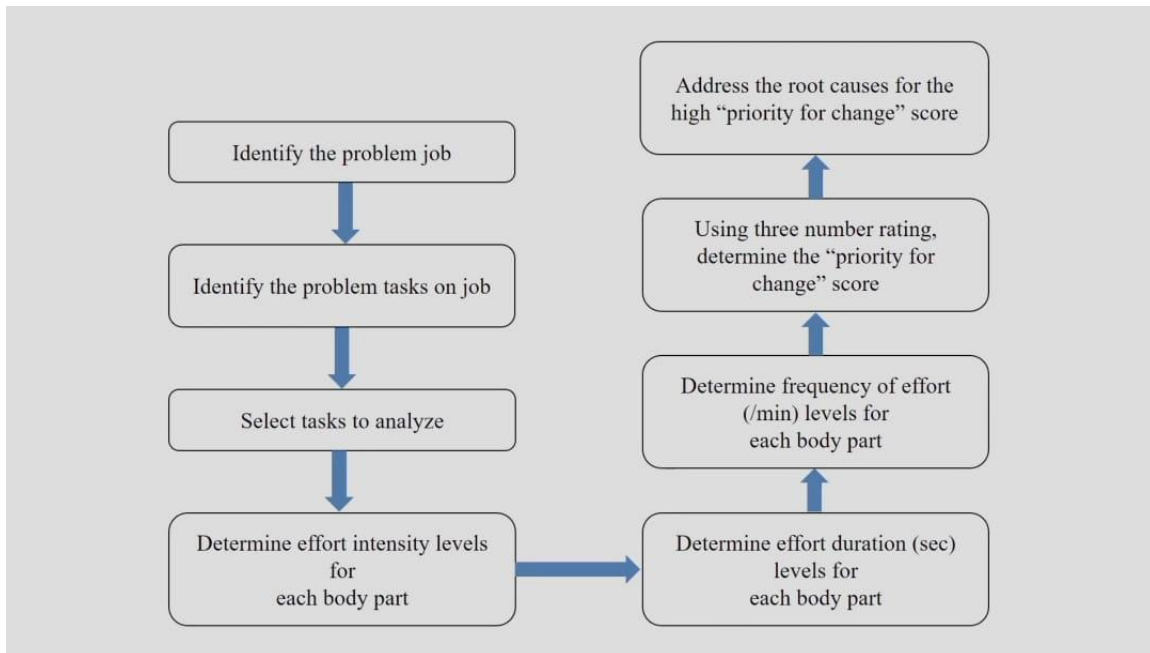
Introduction

- Table 2 is the “Priority for change” table which represents the fatigue level based on the scores generated from Table 1.
- On the basis of the level of fatigue (low, medium, high, very high) observed in table 2, necessary steps can be taken to reduce the fatigue level.

In Table 2, so this this we will be doing from the table 1. In Table 2 the priority for change. So, from the table 1, we will get all these rating and from the table 1 there are pre-computed compositions where we will understand which part of the exertions are immediately required for change.

So, where our intervention can start in the beginning. So, maybe there are 4, 5 changes are required or 2, 3 changes are required. This particular table like table 2 will tell us which is most dangerous and which need to take care in the very very beginning. So, prioritization of your activity that we will be taking from the table 2, from the table 2. We will be explaining each table in the next slides. So, table 2 is the priority for change table which represent the fatigue level based on the scores generated from the table 1.

On the basis of level of fatigue low, medium, high, very high. So, these are the kind of levels we will be identify observed in Table 2 necessary steps can be taken to reduce the fatigue level. So, these necessary steps are actually your intervention, your input to change the activity. So, that we will be doing based on these results.



So, let us understand the process. It is very very simple. It is a linear process. So, first, you have to identify the problem in a particular whatever the jobs you are doing in that you have to identify the problem job. Identify the problem task in that particular job. Select the task you have to select that particular task to analyze.

Determine the effort intensity levels for each body part. So, here actually your task will start using that table 1. Once you define that so, what you have to do? Effort duration that is in seconds level for each body part, effort frequency, and then from all these both in the beginning effort intensity, effort duration and effort frequency from all these 3 numbers you have to go for the table 2 where you will get the numbering and from that you will get the change which task is actually is going to get which body part is going to get the priority. So, that understanding you will get from this level. So, let us understand or let us take an example how do we actually calculate it.

Procedure

Section A: Arm and wrist analysis steps

- Locate upper arm position
- Locate lower arm position
- Locate wrist position
- Wrist twist
- Lock-up posture score in table A
- Ass muscle use score
- Add force/load score
- Find row in Table C

So, in detail procedure, if we talk about in section A, suppose we are talking about arm and wrist analysis step what you have to do? You have to locate your upper arm position, lower arm position, locate the wrist position because these are the parts of your arm wrist portion, wrist twist is there any twist in your wrist, lock up posture the for all these for you have to specify it in the table A, then you have to assess the muscle use score, add the force load score and find the table C.

Procedure

Section B: Neck, trunk and leg analysis steps

- Locate neck posture ✓
- Locate trunk posture
- Legs
- Look-up posture score in Table B
- Add muscle use score
- Add force/load score
- Find column in Table C

For section B that it neck trunk and leg analysis you have to give the you have to understand the neck trunk and leg, then you have to find the table B, then C. So, muscle use score and force code and this find the value from table C.

Region	Effort level <75% of All Workers Can Exert Effort – 4			Scores			Priority
	Light - 1	Moderate - 2	Heavy - 3	Effort	Dur	Freq	
Neck	Head turned partly to side, back or slightly forward	Head turned to side; head hully back; head forward about 20°	Same as Moderate but with force or weight; head stretched forward	1	3	2	
Continuous Effort Duration	< 6 s 1	6 – 20 s 2	20 – 30 s 3		> 30 s 4 (Enter VH for Priority)		
Effort Frequency	< 1 / min 1	1 – 5 / min 2	> 5 – 15 / min 3		> 15 / min 4 (Enter VH for Priority)		

Worksheet for muscle fatigue assessment method

Scenario:

A CNC operator has to check the functioning of the machine every five minutes for safety and quality purpose. The operator has to slightly peek into the machine for a duration of 25 sec to get a proper sight of the workpiece.

Body region : Neck

- Effort level = 1
- Effort duration = 3
- Frequency of effort = 2

Neck score = 132

- Same process is continued for the remaining body parts.

Now, first, understand after this particular thing we need to understand that what exactly happening in this particular level. So, first is your effort level, how do we do? There are four category light, moderate, heavy and very heavy that is the effort level 4.

So, there are some there are some verbal descriptions. So, what it talks about? If it is light it says head turned, now I am talking about only for neck, for hand, for leg, for trunk there are definitions are different that is available in the next slide ok. So, right now I am talking about only neck. So, when I am talking about neck if it is light what it says head turned partially partly to side back or slightly forward, only slightly it is changed. So, if it is moderate head turned to the side head little towards back, holy back, and head forward about 20 degrees.

So, any such condition cause the number 2. For case of 3 if it if it talk about heavy in that case same as moderate, but with force and weight head are stretched forward. So, if you know your head is stretched forward so some load is there on your head then it can be 3. Now, the number 4 what it says there is no such description, only it says if less than 70 percent 75 percent of all workers can exert this effort then it is you know 4. That means only some people in a position to complete this job that means it is very, very tedious or very, very strong you need lot of effort. So, it only says if it is only less than 75 percent because you know we expect in a whole population your 100 percent of people will be doing that particular job.

However, if it is only less than 75 percent of all workers can complete that job then only we take it as 4. So, normally if we go to the industry we get values 1, 2, or 3 this 4 is very, very rare. Now, this talks about effort level. In the next portion that is the continuous effort

duration. So, continuous effort duration if it is less than 6 seconds then it is 1, 6 to 20 seconds it is 2, 20 to 30 seconds it is 3 and if it is more than 30 seconds then definitely it is 4.

In case of effort frequency if it is less than 1 per minute so 1 task less than 1 or 1 task per minute if it is 1 to 5 per minute, 5 to 15 per minute, and 15 more than 15 per minute. If that is so then 1, 2, 3, 4. So, like that, we get 3 varieties of rating. One is for effort level, second is for your continuous effort duration, third is for your effort frequency. So, this is possible for this type of rating can be possible for everybody parts all the 7 portions.

So, here for an example in a CNC operator what they have tried to do is first is your neck that is the effort level is 1 that they identified, continuous effort duration that they identified 3. So, here 3 then frequency effort is 2 that they identify. This is for an example. So, total neck score is 1, 3, 2, 1, 3, 2.

Now, same thing can be obtained for different body parts. In the next table, these all are pre-computed table. Only what you have to do based on your situation you have to identify the position you have to get the rating.

Job		Analyst					
Task		Date / /					
Region	Effort Level < 75% of All Workers Can Exert Effort - 4			Scores			Priority
	Light - 1	Moderate - 2	Heavy - 3	Effort	Dur	Freq	
Neck	Head turned partly to side, back or slightly forward	Head turned to side; head fully back; head forward about 20°	Same as Moderate but with force or weight; head stretched forward				
Shoulders	Arms slightly away from sides; arms extended with some support	Arms away from body, no support; working overhead	Exerting forces or holding weight with arms away from body or overhead	R	R	R	R
Back	Leaning to side or bending arching back	Bending forward, no load; lifting moderately heavy loads near body; working overhead	Lifting or exerting force while twisting; high force or load while bending	R	R	R	R
Arms / Elbow	Arms away from body, no load; light forces lifting near body	Rotating arms while exerting moderate force	High forces exerted with rotation; lifting with arms extended	L	L	L	L
Wrists / Hands / Fingers	Light forces or weights handled close to body; straight wrists; comfortable power grips	Grips with wide or narrow span; moderate wrist angles, especially flexion; use of gloves with moderate forces	Pinch grips; strong wrist angles; slippery surfaces	L	L	L	L
Legs / Knees	Standing, walking without bending or leaning; weight on both feet	Bending forward, leaning on table; weight on one side; pivoting while exerting force	Exerting high force while pulling or lifting; crouching while exerting force	L	L	L	L
Ankles / Feet / Toes	Standing, walking without bending or leaning; weight on both feet	Bending forward, leaning on table; weight on one side; pivoting while exerting force	Exerting high force while pulling or lifting; crouching while exerting force; standing on tiptoes	L	L	L	L
Continuous Effort Duration		< 6 s 1	6 - 20 s 2	20 - 30 s 3	> 30 s 4 (Enter VH for Priority)		
Effort Frequency		< 1 / min 1	1 - 5 / min 2	> 5 - 15 / min 3	> 15 / min 4 (Enter VH for Priority)		

Let us see this. So, this is for neck, shoulder, back, arm and elbow, wrist, hand and finger, legs, ankle, feet, and toes. So, these all verbal description, these all verbal descriptions are present based on these descriptions, based on your situation you have to get the marking, the 1, 2, 3 those levels.

So, for each one, so for last example for neck we received a value 1, 3, 2. So, for this also maybe suppose here as it is shoulder, so we have right and left division, for arm also you have left and left division like that it is possible. So, you need to get the ranking for each part. Suppose for here 2, 1, 2 or here 2, 1, 1. So, something all these type of rating you will be getting from this particular table. Here it is a worksheet, so you can name the job that you are going to analyze and name the specific task that you are going to analyze which date and name of the person who is actually analyzing. This is a typical worksheet for your muscle fatigue assessment or analysis.

Category Scores Grouped by Priority for Change in the Order of Effort, Continuous Effort Duration and Frequency	Table 2: Priority for change score			
	Low(L)	Moderate(M)	High(H)	Very High(VH)
	111	123	223	323
	112	132	313	331
	113	213	321	332
	211	222	322	4xx, x4x, xx4*
	121	231		
	212	232		
	311	312		
	122			
	131			
	221			
	*A category of 4 for Effort Level, Continuous Effort Duration or Frequency is automatically Very High (VH)			

Now, let us see from the table 2 how do we get an understanding that is this particular job is light, moderate or high, or very high. So, all these combinations 1, 1, 1, 1, 1, 2, 1, 1, 3, 2, 1, 1, 1, 2, 1, 2, 1, 2 all these combinations if you get then it says the effort level that total activity, the priority level is kind of low. Whereas, if it is these categories then it is moderate, these categories it is high, and if anything in combination of these categories, so any existence of any point of 4 always it is very, very high.

So, then it is 4. So, very high. So, L, M, H, and VH. So, once we get these numbers in this particular table we can say, so 1, 3, 2 where we are? 1, 3, 2 that means this particular marking. So, we can say this is moderate.

Now, 2, 1, 2, 2, 1, 2 where it is? 2, 1, 2 is here. So, it says light. So, I can say low. Okay. Then 2, 1, 1, 2, 1, 1 again it is low. So, so we can say it is low. So, like that, we can keep on giving numbering. So, moderate, light, light like that we will give numbering to all these portions, and then we can decide which one is in our priority list.

So, from here we get the categorization of the priority for the change. So, that way we use this particular scale to understand where is the major problem and how do we rectify it and once we rectify it again we use this or implement this particular tool and try to see after rectification or after change in the design or after change in the or modification in the design is there any improvement or not. Suppose this particular case neck is having 1, 3, 2. So, that means moderate. So, for this case, I should start my intervention over here. Now, once the design is changed the process there is a change in the process or some intervention happen.

If it is coming down to any one of these value that means your intervention is successful. Whereas if it goes somewhere here that means your intervention is not successful. It may happen this particular case for neck has gone down somewhere here. However, some other body parts suppose leg or ankle has come here.

So, in that case, also it is not successful. In total, it should come down after the intervention. Also, you need to take care that productivity is not getting hampered due to the changes in these kind of design. So, that also you need to take care of as you need to take care simultaneously. So, this is the way how do we implement muscle fatigue assessment or analysis tool for the industrial analysis or evaluation of particular job or task in case of physical muscle fatigue.

Advantages

- Simple to use.
- Evaluates all body muscle groups.
- Interactions are evaluated to estimate fatigue.
- Identifies fatigue-producing patterns of work and shows how to improve them.
- Several strategies can be suggested for improving the task during the analysis.

Now, again what are the advantages as you understood it is very very simple to use. Evaluates all body muscle groups, interactions are evaluated to estimate the fatigue identity because it talks about three major component.

One is your effort level, second is your continuous effort duration not only effort level not at the point of the balance. Effort level is not just once it talks about how long it is being continued. So, time is also being considered and how frequently. So, all these three factors are in consideration.

So, actually, you are getting a holistic result for the fatigue. So, interactions are evaluated to estimate this fatigue and identifies the fatigue-producing patterns of work, and show how to improve them and several strategies can be suggested for improving the task during that particular analysis.

Disadvantages

- Judgement is required as its a semiquantitative method.
- On site job information has to be collected by the analyst.
- Tasks have to be analyzed separately.
- Muscle cycles are to be focused instead of task cycles.
- Less effective if done by one analyst rather than a team of people on the production floor.

There are some disadvantages. So, judgment is required as it is a semi-quantitative method because few things like continuous effort duration definitely you can measure specifically, effort frequency also you can measure frequently, whereas the effort level is a kind of perception, it is perceived, it is a subjective. So, it is really not completely quantitative method, it is a semi-quantitative method.

So, judgment is required. One site job information has to be collected by that particular analyst because if you do not have those information you will not be able to do the job or do the analysis. Tasks have to be analyzed separately. So, you have to first understand the task, you have to analyze that particular task then only you can go ahead. Muscle cycles are to be focused instead of the task cycle, not the task cycle, you have to mainly talk about the muscle cycles, and less effective if done by one analyst rather than a team of people on a particular production floor.

As I mentioned this is very good tool when we are talking about the understanding of the team effort. So, productivity also can be taken care when we are doing in a team. So, this

if you are not doing in a team then it becomes very difficult for to get a correct data. You can do however there may be some kind of bias and you will not get the actual figure.

Approximate training and application times	<ul style="list-style-type: none">• 1-2 hours are required for learning the rating method.• Analysis part will take 15-30 min for a trained analyst.
Tools needed	<ul style="list-style-type: none">• Paper, pencil and stopwatch• Videotapes showing continuous footage of job demands.• Psychophysical scale.

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1 to 2 hours are required for learning this particular rating method and analysis can take to 15 to 30 minutes. Now again it depends how quickly the person, the researcher understand it and can in a position to implement it.

Paper, pencil, and stopwatch is required. Of course, nowadays on the spot analysis are not being done, always what we do we try to videotape the whole process and we do the analysis after coming back to the laboratory. So, that way it is not very difficult instruments that you require, very simple instrument which is easily available with everyone and every researcher can really use this particular tool to analyze the situation. So, these all about the muscle fatigue assessment and also these are all about Borg 2 scales RPE scale, and CR 10 scale. So, these are the 2 major ways how to actually evaluate the fatigue, physical fatigue and there are many other techniques available specifically when we go for the instrumentation there are many other techniques.

By that, these are the 2 pens and paper methods that you can use to assess the fatigue at the physical level. So, that is all for today. Thank you.