Ergonomics Research Techniques

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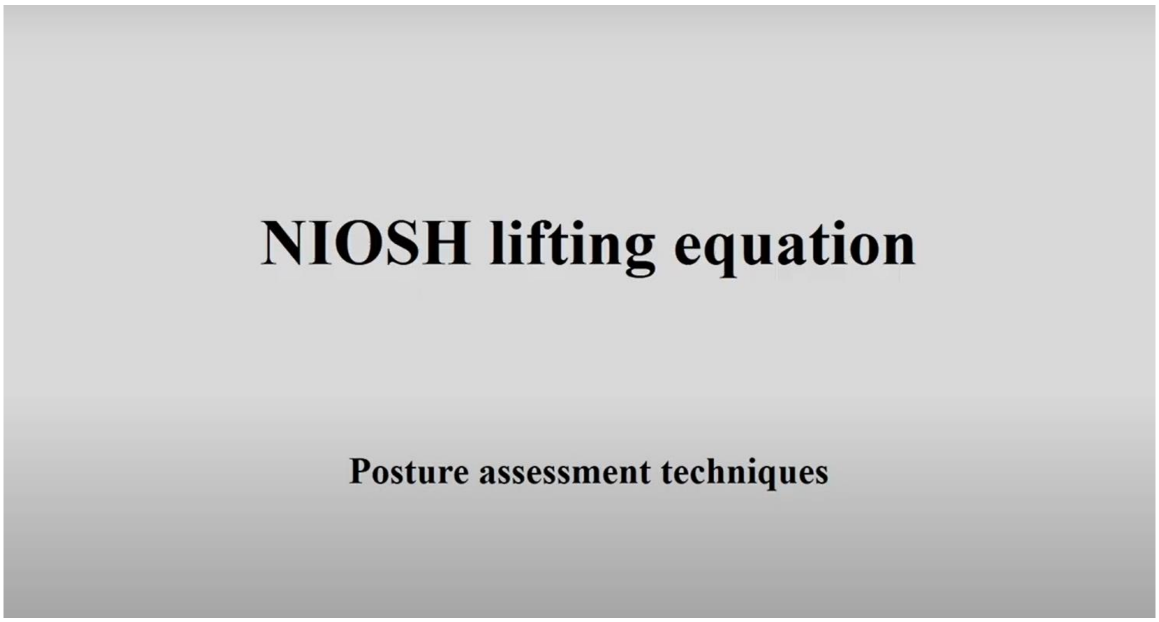
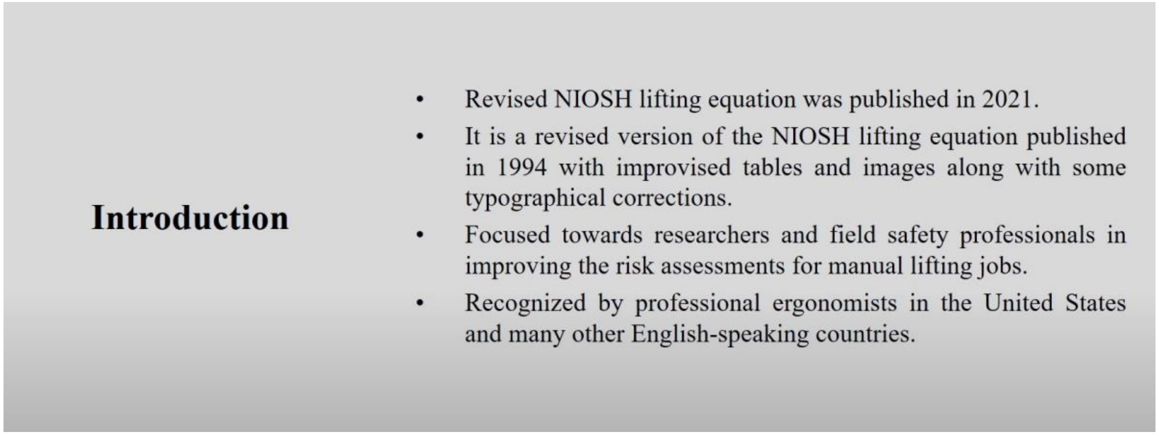
Week – 04

Lecture - 14

Lec 14: National Institute for Occupational Safety and Health (NIOSH) Lifting equation



Welcome back. Today we will talk about NIOSH lifting equation. National Institute of Occupational Safety and Health, they have given a description about what is the recommended weight limit when you are doing the lowering or any lifting job. So, we will be talking about recommended weight limit and the lifting index. So, let us begin with the process and some description about this particular tool.



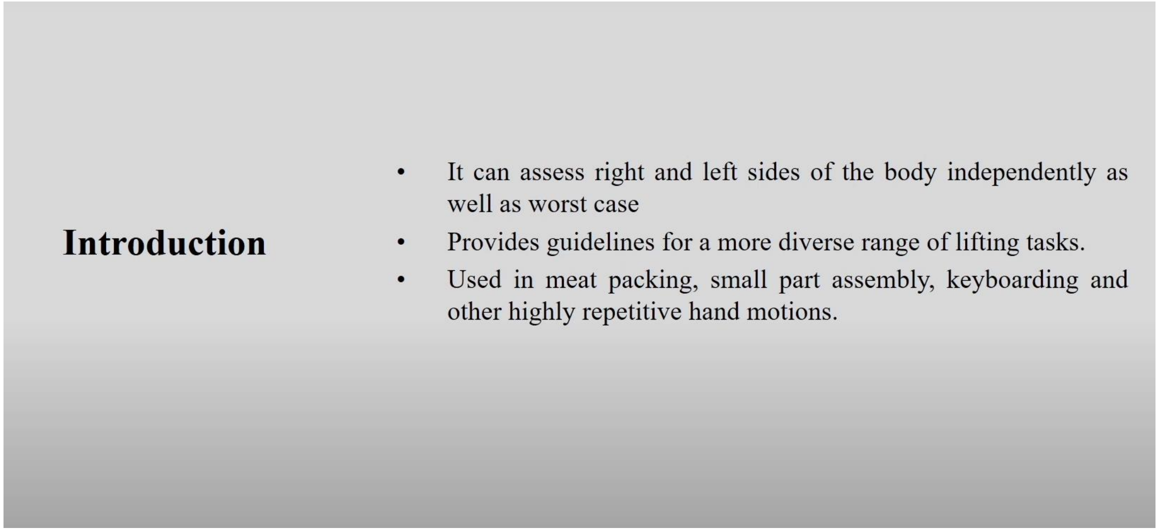
This is very much useful tool when we are talking about manual material handling in a particular scenario.

Specifically, when we are in a manufacturing unit or in a load carriage section or somewhere where load handling is important by human not with the automated system. So, those cases this particular tool is very much important. It talk about the what is the recommended weight limit for a person to work in certain duration for a certain duration. So, that his or her back is not going to get any kind of injury.

So, you can continue this for your shift. So, that type of calculation you will be doing depending on the vertical height, depending on the kind of movement they are doing, depending on the kind of posture the person is holding based on that this particular tool will give you the value of recommended weight limit which you can do the lifting and lowering. So, no pulling or pushing it talks about only lifting and lowering. So, we call it. So, initially it was a NIOSH lifting equation, but in 2000 after some certain years it has been again revised and finally, the final revision has came on very recently and that is 2021 and it is called revised NIOSH lifting equation.

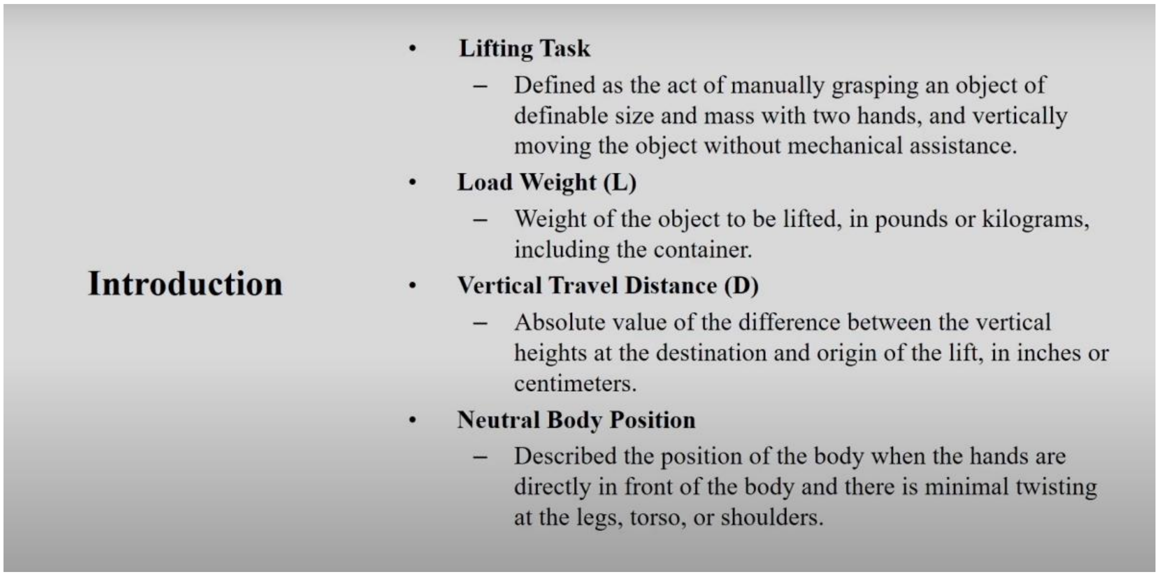
It is revised version of the NIOSH lifting equation which is published originally in 1994 with improvised tables and images along with some typographical corrections. So, there were some small small errors those thing they have corrected. Focused towards researchers and field safety professionals in improving the work risk assessments for manual lifting job. So, as I mentioned it only talks about manual lifting and lowering job. It is again recognized by professional ergonomists in the United States and many other English-speaking countries.

Now, here concern is why we are talking about English-speaking countries because initially it was derived those areas in Western countries. Now, it is being accepted by all other places, but there are some limitations when you are translating it that was that is why it says mainly for all English-speaking countries this tool is well accepted. Even in India we use this particular tool for our lifting calculation.



It can assess right and left sides of the body independently as well as any worst case. So, you do it right separately and left separately or you can do whichever is the extreme bad.

So, you can take any one of them. It provides a guidelines for a more diverse range of lifting task used in meat packing, small part assembly, key boarding and any other highly repeated it hand motions with lifting. So, those cases we can use this particular tool.



Now, let us understand when we are talking about lifting job or manual lifting task how do we define it and what are the varieties of factors that we are going to consider while doing or reading this particular tool. So, let us start with the definition of lifting task.

So, it is defined as the act of manually grasping an object. So, you are holding the particular object manually of definable size and mass. So, the size and mass need to be defined with two hands and vertically moving the object without any mechanical assistance. So, that is why I said whenever the lowering or lifting task is without any automation so, such job where you are using your both hand, you are grasping the object or the weight with your both hand and you are doing the vertical lifting from one place to another height or from one place to another height. So, only vertical lifting.

So, that is the lifting task we will be considering for this particular equation. Any other task apart from this definition we will not be able to consider for NIOSH lifting equation. So, before you go for this particular tool, use of this particular tool what you need to do? You need to check that your task that you are going to or you are planning to assess is matching the definition of this lifting task or not. Once it match then only you can go ahead with using of New York lifting equation. Now let us take the important variables or name of the factors which we are going to measure and we are going to get the value of recommended weight limit.

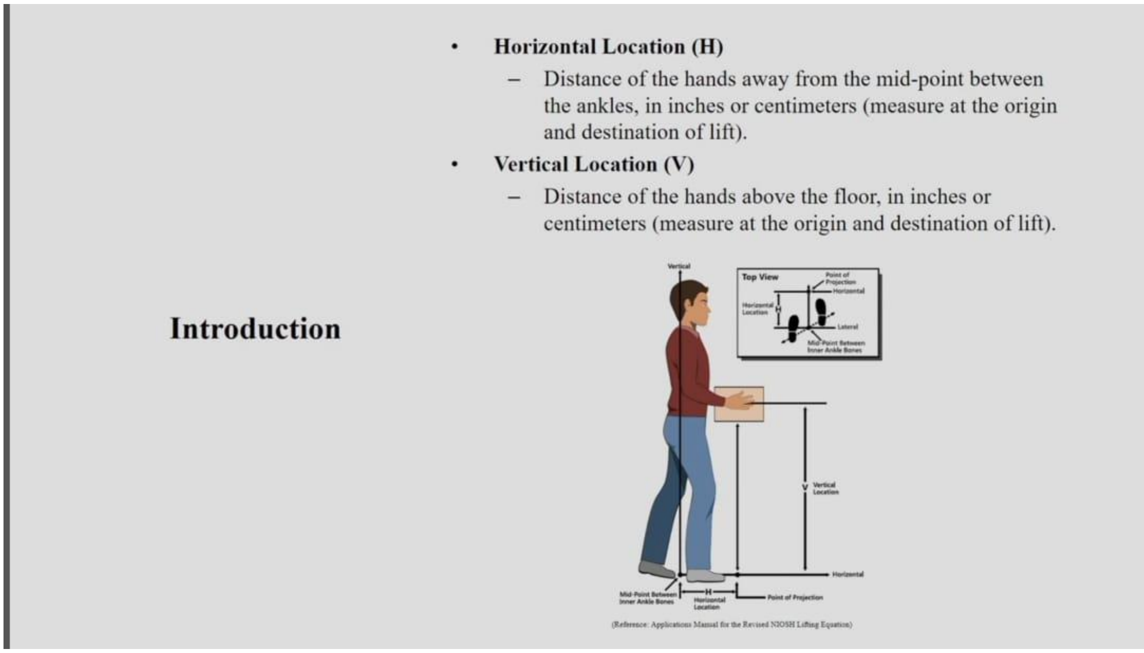
The first value is load weight. So, weight of the object to be lifted either in pound or in kilograms including the container. So, if something is there in a container with that container what is the total weight of the object that you have to measure and you have to tell that that is the load weight for NIOSH lifting equation and you can only measure with either with pound or in kilogram. Next important variable or factor is vertical travel distance. So absolute, so here it is very important for lifting and lowering.

So whatever the vertical distance travel, so that is why it is absolute value, no plus or minus. So absolute value of the difference between the vertical heights at the destination and the origin of the lift in inches or in centimeters. So we have a PS unit and SI unit in place. So that is why it is saying the absolute value of the difference between the vertical heights and at the destination and the origin. So probably origin is here and destination is here.

So in that case this only the value that you are going to get or if it is the origin and this is the destination that means it is lowering from here it is coming down. So that only the that particular number that particular absolute value. So that is the vertical travel distance. Next point is neutral body position. So it is described the position of the body when the hands are directly in front of the body and there is minimal twisting at legs, torso, and shoulder.

So you are standing straight and your both hands is in front of your body. So that is the neutral body position. So that means your body is aligned in your body midline. You are not twisting on either side not in the left side or right side neither your shoulder nor your torso nor your legs. So all are in symmetrically as aligned with your body midline.

So that we will be calling it as the neutral body position. That is the reference point and from there we will be measuring the deviation or asymmetry angle that I am coming in the next slides.



Then horizontal location. We talked about vertical distance travel. Now we are talking about horizontal location and horizontal vertical location.

So first let us understand the horizontal location. So distance of the hands away from the midpoint between the angle in inches or centimeters measures at the origin and the destination of the lip. So you can understand. So this is your body midline. So this is one point of your ankle.

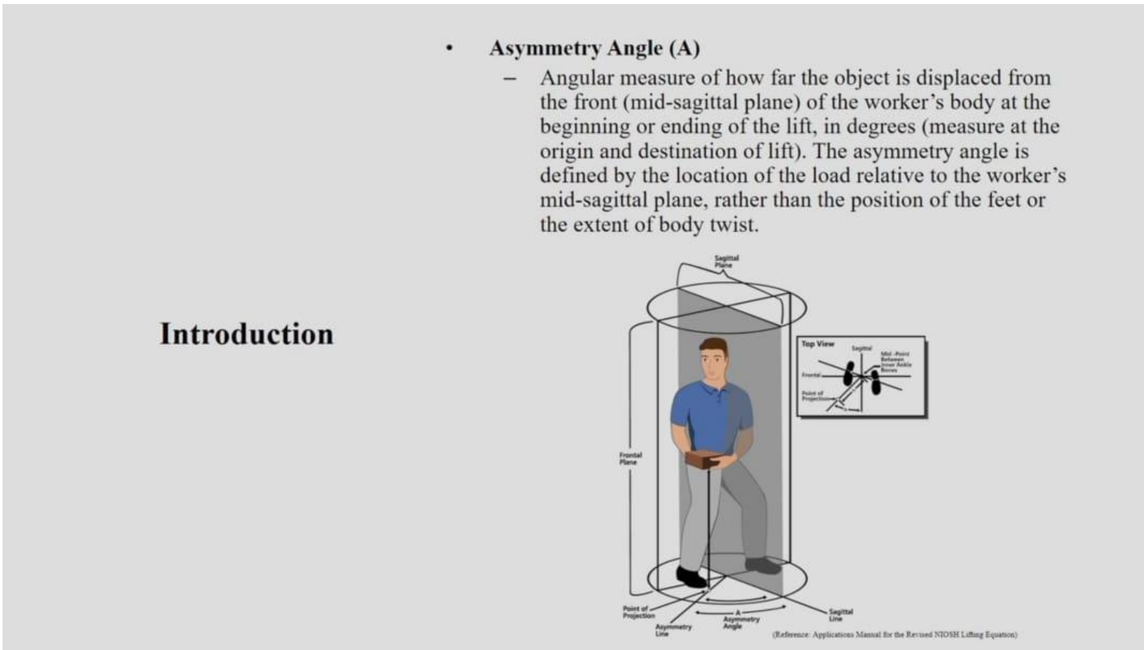
This is one point of your ankle. So this is the midpoint of your ankle. And here is the position of your hand. So your horizontal location is this. This is your horizontal location.

So distance of hands away from the midpoint between the ankle. So if you have two midpoints, so two ankles prepositioned here. So midpoint is here and what is the position of your hand. So distance from here to here. So first you have to identify where your ankles are located and where is your hand is located.

So first you find out the position of your ankle then get the midpoint and from there you measure the distance of your hand. So that is your horizontal location. Next point is vertical location. So distance of hands above the floor in inches. Distance of hands above the floor.

So from if this is your floor and this is your hand position. So this is your vertical location. This is your vertical location. It's very important. So while doing the measurement sometimes we get very much confused between these values.

So you have to be very very careful. So this is horizontal location and this is vertical location fine clear. Let us move to the next point.



Now is the asymmetry angle. We understood what is our neutral position.

So on a sagittal plane if we are moving then what is the angle formulation. So first let us read it out. So angular measure of how far the object is displaced from the front that meet sagittal plane of the worker's body at the beginning or ending of the lift in the in degrees. So the angle measures at the origin and the destination of lift so minus it. The asymmetry angle is defined by the location of the load relative to the worker's mid-sagittal plane rather than the position of the feet or extended extent of body twist.

So that way you are doing. So here from this particular figure you can understand this is your midline and the person has been moved from this is the destination like this and this. So it is moving from this to this. So what is happening this is your sagittal line this is your sagittal line. So first you have to draw the sagittal line and one direction the person is moving so and this is the your asymmetry line. So this is the angle is being formed by your body and we will be calling it as asymmetry angle.

So point is first is very important for you to identify the neutral position so that you can understand what is your sagittal line and then or on the sagittal plane what is your body midline. And from there which angle it is getting formed okay so then you measure that angle and then you do the correct value of the angular measurement it is decided in degree. You measure it in degree. So from this type of figure, you can refer and you can get the value of your asymmetry angle. So it is a kind of cylinder when human being is standing in a place it is a kind of cylinder you have sagittal plane you have frontal plane.

So you just look at your sagittal midline sagittal plane line and then you see what is the angular movement you are forming in which direction only that value you take as the asymmetry angle.

Introduction

- **Lifting Frequency (F)**
  - Average number of lifts per minute over a 15 minute period.
- **Lifting Duration**
  - Three-tiered classification of lifting duration specified by the distribution of work-time and recovery-time (work pattern). Duration is classified as either short (1 hour), moderate (1–2 hours), or long (2–8 hours), depending on the work pattern.
- **Coupling Classification**
  - Classification of the quality of the hand-to-object coupling (e.g., handle, cut-out, or grip). Coupling quality is classified as good, fair, or poor.
- **Significant Control**
  - Significant control is defined as a condition requiring precision placement of the load at the destination of the lift. This is usually the case when (1) the worker has to re-grasp the load near the destination of the lift, or (2) the worker has to momentarily hold the object at the destination, or (3) the worker has to carefully position or guide the load at the destination.

Now coming to the next few important variables first is lifting frequency. So average number of lifts per minute over a 15-minutes period here it is very important you have to take the recording for 15 minutes then you have to convert that value into lift per minute. It is not that you check that per minute how many lifts are happening. First, you have to record it for 15 minutes, and from that particular 15-minute data you have to convert it into per-minute data.

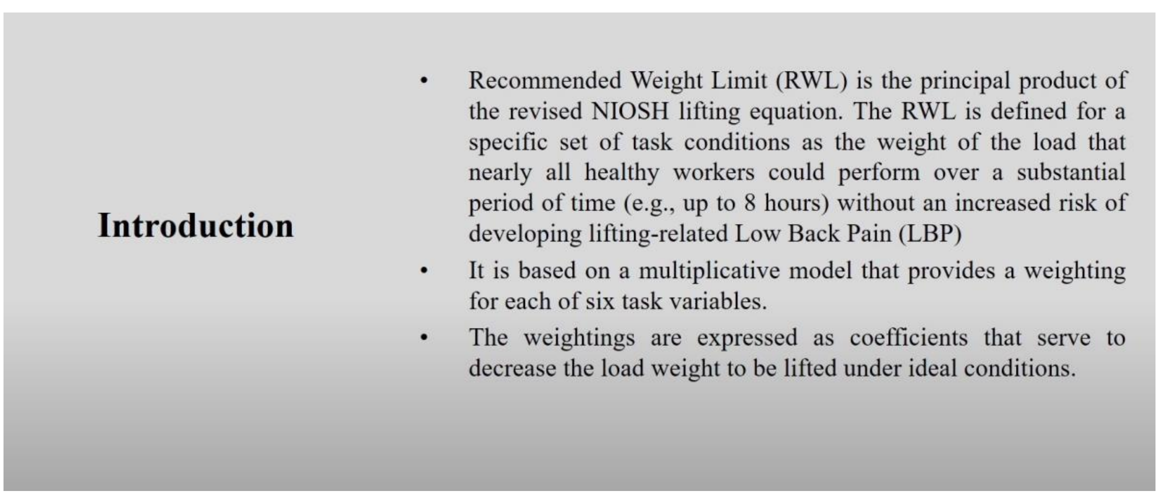
So average number of lifts per minute over a 15 minutes period so that is the lifting frequency. Coming to the next variable in lifting duration. So three tired classification of lifting duration specified by the distribution of work time and recovery time. So we call it as work pattern. So duration is classified as either short that means 1 hour job, moderate 1 to 2 hours or long 2 to 8 hours depending on the work pattern.

So that way so three major classification short, moderate, and long. Short is 1 hour, moderate is 1 to 2 hours, long is 2 to 8 hours. So you have lifting duration. Next variable is coupling classification. Now coupling is very very important why if your coupling is not good when you are handling any load that means if it is not good then you are using lot of strength or extra strength of from your body of the same weight.

Suppose it is a 5 kg weight. If coupling is good then you have less strain on your body whereas if coupling is not good it is definitely more than that you know whatever you are exerting. So coupling identification for any load handling as we discussed in MSE you definitely can refer that in MSE manual handling chart in that case you identified that you know how the coupling is important. If coupling is bad then whole activity you may not continue for longer hours. So here also in NIOSH lifting equation coupling is a very important impacting factor. So what is the coupling? The classification of the quality of hand to object coupling that is the handle cut out or grip.

So coupling can be classified as three good, fair, and poor. Now here as I mentioned that it is descriptive, it is subjective. So there are definitions so from that you can know from your experience you can go for good, fair and poor. Now significant control. What is the kind of control you have in that particular job? So significant control is defined as a condition requiring precision placement of the load at the destination of the lift.

This is usually case when the worker has to re-grasp the load near the destination of the lift or the worker has to momentarily hold the object at the destination or the worker has to carefully position or guide the load at the destination. You have a load on your you know you are holding a particular load and positioning is very important, you are looking at the thing so checking and inspecting and positioning. Such cases or worker has to re-grasp it you have to hold you are holding then again you are holding it properly maybe slipping or something. So those cases. So what is the kind of control you have on the load? So you have to have such kind of identification while doing this particular assessment.



Now recommended weight limit that we are going to get after this whole classification or whole evaluation. So let us understand that particular terminology. So recommended weight limit is the principal product of the revised NIOSH lifting equation. The RWL or recommended weight limit is defined for a specific set of task condition as the weight of the load that nearly all healthy workers very important nearly all healthy workers could perform over a substantial period of time. For example, it is expected always the work shift is for 8 hours so it is expected that they will be able to continue it for 8 hours without an increased risk of developing lifting-related related any low back pain.

So NIOSH lifting equation actually assess the risk of lower back pain or low back pain. So what these RWL is this definition is very important. This definition is if you do not understand this definition then you will not understand the what is the value of this particular tool. So recommended weight limit. So recommended weight limit is defined for a specific set of task.

It is not for everything. The task that you are going to analyze for that specific set of task condition. So other conditions are specified as the weight of the load that all nearly all healthy workers could perform over a substantial period of time without an increased risk of developing lifting-related work low back pain. Maybe low back pain can come from any other reason but for this lifting there will be no low back pain that is the recommended weight limit. So it is based on the multi-clative model of provides model that provides the weighing of each of the 6 task variable that we are going to discuss and the weighing are expressed as coefficient that serve to decrease the load weight to be lifted under ideal condition.

Equation

RWL = LC X **HM** X **VM** X **DM** X **AM** X **FM** X **CM**

LC	=	Load constant
H	=	Horizontal location of the object relative to the body
V	=	Vertical location of the object relative to the floor
D	=	Distance the object is moved vertically
A	=	Asymmetry angle or twisting requirement
F	=	Frequency and duration of lifting activity
C	=	Coupling or quality of the workers grip on the object

So that is the recommended weight limit and this is the formula that we are going to get the recommended weight limit the value of the recommended weight limit.

So before we go for this calculation let us we almost studied few of these variable we will see how do we calculate these variables. So main these are the factors first is the load constant. So we have the load constant then we have H as the horizontal location multiplier HM V denotes the vertical location of the object relative to the floor and it will give the vertical multiplier the distance the object is moved vertically so vertical distance travel. So that is the vertical distance travel multiplier that is DM asymmetry angle asymmetry angle multiplier AM frequency and duration of lifting activity that is the frequency multiplier and final one is the coupling factor and it gives the coupling multiplier. So and if we multiply all these factors we will get the recommended weight limit for a certain task in a certain condition.

So this is very important.

Equation

		Metric	U.S. Customary
Load constant	LC	23kg	51Ib
Horizontal multiplier	HM	(25/H)	(10/H)
Vertical multiplier	VM	1 - (.003|V-75|)	1 - (.0075|V-30|)
Distance multiplier	DM	.82 + (4.5/D)	.82 + (1.8/D)
Asymmetric multiplier	AM	1 – (.0032A)	1 – (0.0032A)
Frequency multiplier	FM	From frequency multiplier table	From frequency multiplier table
Coupling multiplier	CM	From coupling multiplier table	From coupling multiplier table

Now these are the if you are using metric unit these are the values so load constant is 23 kg or 51 pound and these are the formula you can use for horizontal multiplier vertical multiplier distance multiplier asymmetry multiplier frequency multiplier and coupling multiplier. So we have some pre-computed table from there also we can get the calculation or the multiplier value either you calculate using these formulas these formula you can use for the calculation or from a pre-computed table you can get the value. So I will take you for each multiplier separately now.

Equation

- Each multiplier can be computed from the appropriate formula and in some cases, it will be necessary to use linear interpolation to determine the value.
- If the measured frequency is not a whole number, the appropriate multiplier must be interpolated between the frequency values in the table that are closest to the actual frequency.

So each multiplier can be computed from the appropriate formula and in some cases it will be necessary to use linear interpolation to determine the value. If the measured frequency is not a whole number the appropriate multiplier must be interpolated between the frequency value in the table that are closest to the actual frequency.

Lifting Index (LI)

- The LI is a term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task.
- The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit.

$$LI = \frac{Load\ weight}{Recommended\ Weight\ Limit} = \frac{L}{RWL}$$

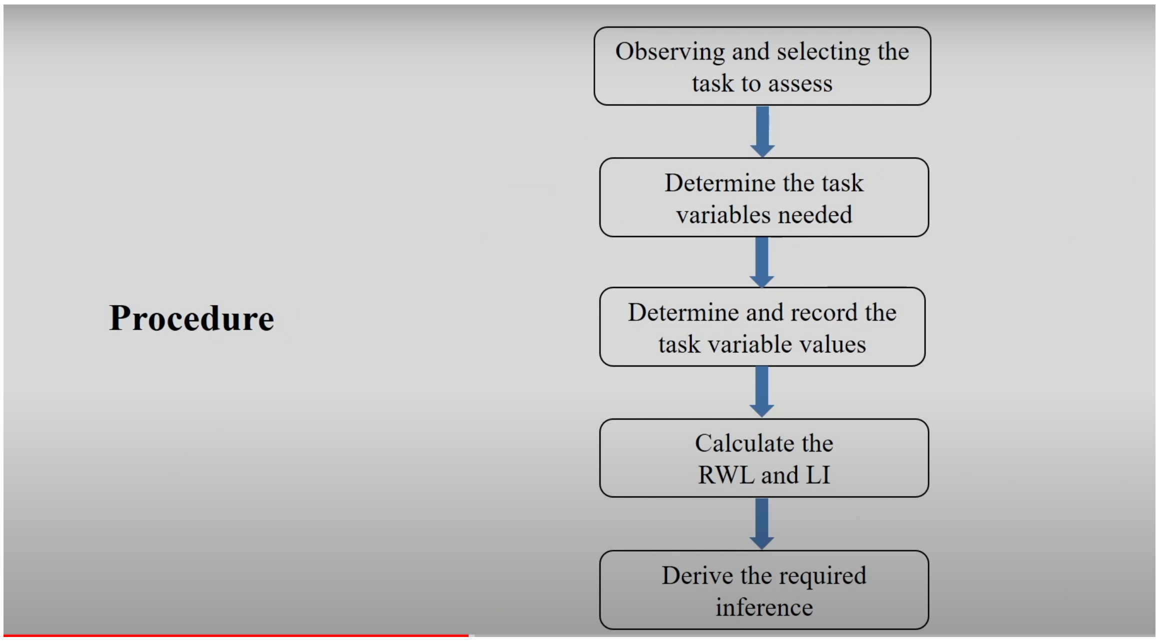
- If

  $LI > 1.0$ High Risk

  $LI < 1.0$ Nominal Risk

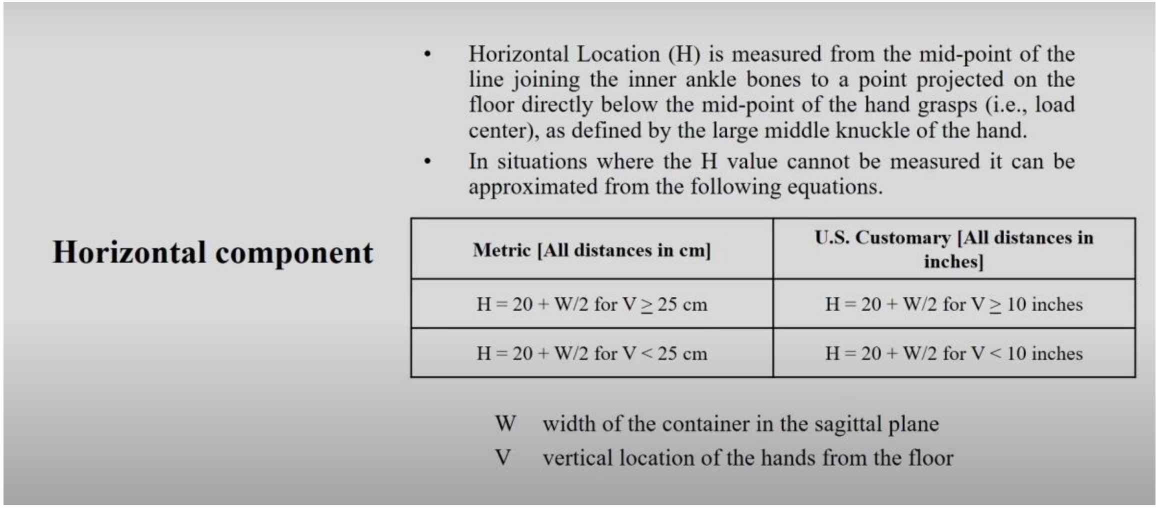
Once we get recommended weight limit then we can convert it to get an understanding that is this load is correct or not we will calculate the lifting index what is the actual load right now in situation we are handling divided by the weight recommended weight limit. So if it is more than 1 definitely there is a risk if it is near less than 1 or equal to 1 then it is normal risk there is not a problem much. So what is lifting index the lifting index is a term that provides a relative estimation of the level of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit. So lifting index we denote is as LI, LI is equal to L divided by RWL, L divided by RWL, so that is the lifting index.

Suppose for example your recommended weight limit is 45 kg for a particular job and right now your current load weight is suppose. I am talking 90 kg okay then your lifting index is equal to 90 divided by 45 that means 2. So 2 is greater than 1 that means it is extremely dangerous this has very high risk whereas if your load instead of this 9 if it is somewhere around 22 kg or 20 kg or something then your lifting index becomes 20 divided by 45 definitely it is less than 1. So then it is nominal risk fine. So this way you can calculate the lifting index.



So what is the procedure? So first is the observation of the task and selecting the task which you are going to assess, determine the task variables which is required, determine and record the task variable values, calculate the RWL and lifting index and derive the required inference.

So if lifting index is more than 1 definitely you need to do some kind of intervention, design changes or you know worksheet some changes you need to do so that lifting index comes down. So that is the way how we use NIOSH lifting equation for any kind of ergonomics intervention.



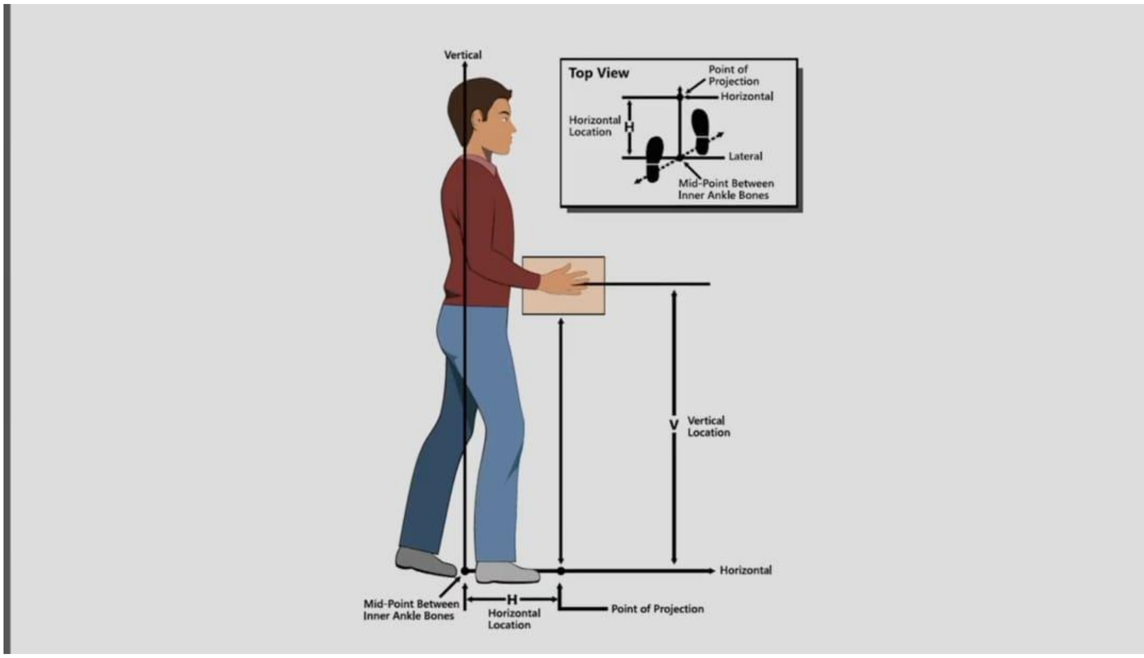
So let us take each component separately now. Till now I hope you understood whatever we have discussed about this particular thing.

Now we will be talking about each you-you-know component separately. So horizontal location that denotes as H is this demarcation like H, V, D these are constant okay you cannot change it according to your wish. These names are very important demarcations. So horizontal location is or H is measured from the midpoint of the line joining the inner ankle bone. So you have to be very, so you know from the anatomy you need to answer what is the inner ankle bone, that protrusion in your ankle. So that particular bone to a point of projected on the floor directly below the midpoint of the hand grasp as defined by the larger middle knuckle of your hand.

So this one, so from here. So if you are holding your object so this is your mid knuckle point. So from here, you have to go down on the floor and that particular point and that the midpoint of your two ankle bone you have to measure that distance. So in the situation where the H value cannot be measured, it can be approximated from the following equation. So if you are not in a position to measure it exactly then you can do such kind of approximation so for if you are using metric system then you can use this formula. If you are using the pound or FPS unit you can use this particular formula.

Here W is equal to width of the container in the sagittal plane. So width of the container, so suppose you are holding a sack. So maybe sack is this side so that is the width of the or if it is this then width and the V is the vertical location of your hand from the floor. So that way you can measure it. It absolutely like depend. If you are not in a position to locate your ankle position, knuckle position, some cases working condition sometimes it is difficult.

So for such cases, you can use this formula if you are using SI unit, you can use this formula if you are using FPS unit. So for whole equation at the very beginning you either you choose SI unit or FPS unit that is the recommended thing because otherwise it will be mixed and you will not get the value.



So this is the horizontal component. So I explained this particular figure earlier that if this is the mid ankle point then you connect it, you find the mid value and here the knuckle point and connect it here.

So this is the horizontal location and this is the vertical location fine.

Horizontal component

- If the horizontal distance is less than 10 inches (25 cm), then H is set to 10 inches (25 cm).
- Objects can be carried or held closer than 10 inches from the ankles, but in most cases the object cannot be lifted without encountering interference from the abdomen or hyperextending the shoulder.
- 25 inches (63 cm) is considered the maximum value for H as for short people beyond which is impossible to handle, particularly when lifting asymmetrically.
- In addition to this, objects at a distance more than 25 inches from the ankles normally cannot be lifted vertically without some loss of balance.

Now under horizontal location, we have horizontal component we have something more also to understand. So if the horizontal distance is less than 10 inches or 25 centimeters then H is set to 10 inches okay. If it is less than 10 or 10 then it is 10. So you have to set it.

So any value less than 10 then you can ignore you can get the value of 10. So objects can be carried or held closer than 10 inches from the ankle but in most cases the object cannot be lifted without encountering interference from the abdomen or hyper extending the shoulder. So it is not possible you know you cannot be so close then your abdomen is going to obstruct. So you cannot lift it like this. Definitely, it has to be like this. So that is why it is saying that 10 inches that is the kind of human width that they are considering.

So 25 inches that is the 63 centimeter is considered the maximum value for H. Also if something you are lifting 25 so it is very difficult. If you are doing it definitely you are going to bend it. You cannot lift anything in this way. It is not possible.

Extending your shoulder till this and you are lifting it is not possible. So anything beyond 25 inches is considered the maximum value for H as for short people beyond which it is impossible to handle particularly when lifting any asymmetric object. In addition to this object at a distance more than 25 inches from the ankle normally cannot be lifted vertically without some loss of balance. So these are some from some practical positioning these considerations are need to be taken care. Now you may start enquiring things that where we are doing something more than that.

But typically those cases are little beyond of this type of calculation. Hypothetically maybe we can have some situation but when we do it in industry definitely such hypothetical conditions is not possible to continue for some practical job. So these are the so definitely if you get some measurement beyond these values you will see that somewhere something is wrong so you should recheck these values. So it is expected this should be within these ranges. So these are the guidelines where you can if you get some data more than that more than these values you will see that somewhere some measurement mistakes are there so you can rectify them.

Horizontal Multiplier

- The Horizontal Multiplier (HM) is 10/H for H measured in inches and HM is 25/H for H measured in centimeters.
- If H is less than or equal to 10 inches (25 cm) then the multiplier is 1.0
- The HM value decreases with an increase in the H value.
- At H equals 25 inches (63 cm) then the multiplier is reduced to 0.4.
- If H is greater than 25 inches then the multiplier (HM) is taken as zero.

The horizontal multiplier is equal to 10 divided by H for H measured in inches and 25 divided by H if it is measured in centimeter.

If H is less than or equal to 10 inches then the multiplier is 1 and h that horizontal multiplier value decreases with an increase in the horizontal value. If the horizontal value is increasing horizontal multiplier value is decreasing at H equals to 25 inches then the multiplier is reduced to 0.4 and if h is greater than 25 inches then multiplier is taken as the 0. So 0 means the whole value recommended weight limit is coming as 0 that means in such condition you cannot lift any object. So if any one of the multiplier among the all 6 variables if any one of the multiplier becomes 0 that means in that condition you are not supposed to lift any object.

So if the multiplier values are coming down that means your recommended weight limit also is coming down. So that is the kind of interference that you have to draw. This is here.

Horizontal Multiplier

H in	HM	H cm	HM
≤ 10	1.00	≤ 25	1.00
11	.91	28	.89
12	.83	30	.83
13	.77	32	.78
14	.71	34	.74
15	.67	36	.69
16	.63	38	.66
17	.59	40	.63
18	.56	42	.60
19	.53	44	.57
20	.50	46	.54
21	.48	48	.52
22	.46	50	.50
23	.44	52	.48
24	.42	54	.46
25	.40	56	.45
> 25	.00	58	.43
		60	.42
		62	.40
		> 63	.00

Now this is the horizontal multiplier table.

So you can do the calculation or you can use this pre-computed table. This is for inch and this is for centimeter. You have the multiplier table. So you can see if it is less than or equal to 10 inches then value is 1. If it is more than 25 inches the value is 0. If you are using inch, if you are using centimeter, if it is less than equal to 25 then it is value is 1 and if it is more than 63 then value is 0.

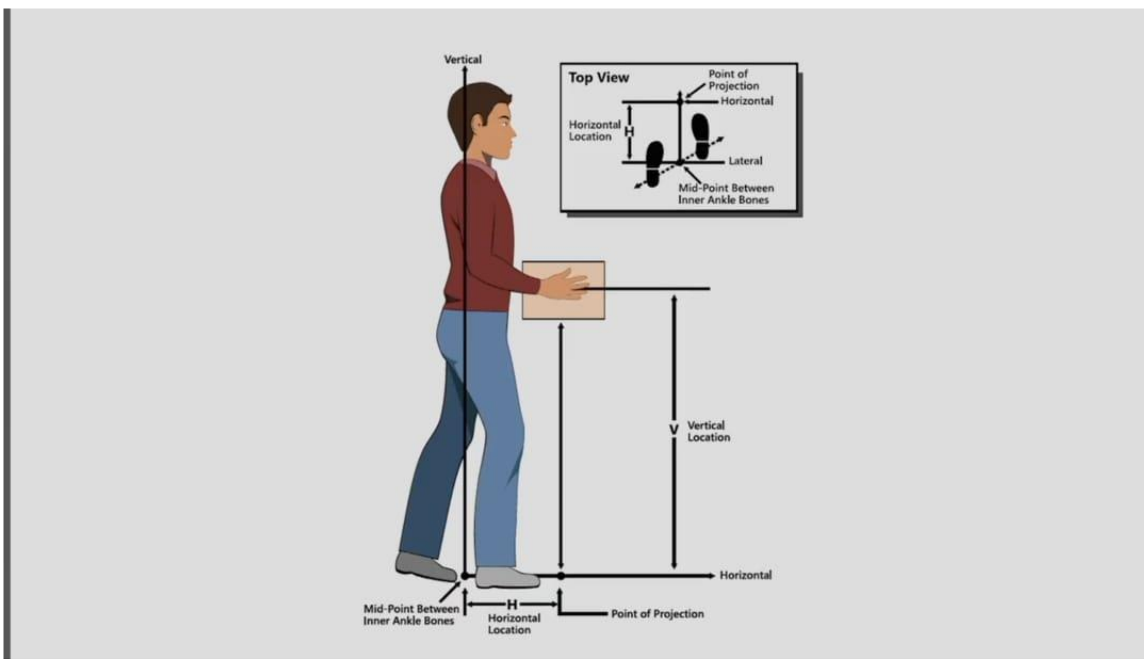
So this multiplier table also you can use.

Vertical component

- Vertical location (V) is defined as the vertical height of the hands above the floor.
- V is measured vertically from the floor to the mid-point between the hand grasps as defined by the large middle knuckle.
- V is limited by the floor surface and the upper limit of vertical reach for lifting (i.e., 70 inches or 175 cm).
- The vertical location should be measured at the origin and the destination of the lift to determine the travel distance (D).

Next is vertical component. Horizontal component is clear. Now we are going for the vertical component. So vertical location or V is defined as the vertical height of the hands above the floor. So here also we take reference of the mid-knuckle point. So V is measured vertically from the floor to the midpoint between the hand grasp as defined by the large middle knuckle and V is limited by the floor surface and the upper limit of the vertical reach for lifting is 70 inches or 175 centimeters.

So that is the maximum possible lift. The vertical location should be measured at the origin and the destination of the lift to determine the vertical distance travel. So for vertical distance travel that is the D for that, you have to measure the vertical distance from the origin and the destination.



So this is this particular thing we describe.

So this is your position of your object. This is the mid-knuckle point. This is your surface location and this particular height this point you have to take it as the vertical location.

Vertical Multiplier

- To determine the Vertical Multiplier (VM), the absolute value or deviation of V from an optimum height of 30 inches (75 cm) is calculated.
- A height of 30 inches above floor level is considered "knuckle height" for a worker of average height (66 inches or 165 cm).
- VM is (1−(.0075 [V−30]) for V measured in inches, and VM is (1−(.003 [V−75]) for V measured in centimeters.
- If V is equal to 30 inches (75cm) the VM will be 1.0.
- The value of VM decreases linearly with an increase or decrease in height from knuckle height.
- If V is greater than 70 inches (175 cm) then VM is taken as zero.

Now coming to the multiplier. To determine the vertical multiplier the absolute value or deviation of V from an optimum height of 30 inches is calculated. A height of 30 inches above floor is considered knuckle height for a worker of average height. So normally we take as the worker's average height is 165 centimeters for them the knuckle height should be 66 inches.

So that that much only we can say as the 30 inches we take this particular value. So VM that is the vertical multiplier using this particular formula for V measured in inches and for centimeter this formula we can use to measure in centimeter. If V is equal to 30 inches or 75 centimeter then vertical multiplier becomes 1. The value of vertical multiplier decreases. The value of vertical multiplier decreases nearly with an increase or decrease in height from knuckle height. If V is greater than 70 inches or 175 centimeter then the multiplier this if you calculate this particular and all this then it is approximately 0.

So as I said if the vertical distance or sorry vertical position or vertical location keep on increasing then what is happening? We are taking some task which is nearly impossible to lift or lower.

Vertical Multiplier

V in	VM	V cm	VM
0	.78	0	.78
5	.81	10	.81
10	.85	20	.84
15	.89	30	.87
20	.93	40	.90
25	.96	50	.93
30	1.00	60	.96
35	.96	70	.99
40	.93	80	.99
45	.89	90	.96
50	.85	100	.93
55	.81	110	.90
60	.78	120	.87
65	.74	130	.84
70	.70	140	.81
> 70	.00	150	.78
		160	.75
		170	.72
		175	.70
		> 175	.00

So for those cases, vertical multiplier VM is going to be nearly 0. So this is the pre-computed table. If you are using inch then this is and if you are using centimeter then it is.

This is the part you can use. You can see if it is more than 70 inches then multiplier is 0. If you are using centimeter it is more than 175 centimeter then also multiplier is 0. And as I mentioned recommended weight limit is the multiplication of all these multipliers. So any one of the multiplier if it is 0 then recommended weight limit means that also becomes the value becomes 0. That means it is impossible for someone to lift or lower any object in that particular condition.

Distance component

- The Vertical Travel Distance variable (D) is defined as the vertical travel distance of the hands between the origin and destination of the lift.
- For lifting, D can be computed by subtracting the vertical location (V) at the origin of the lift from the corresponding V at the destination of the lift.
- For a lowering task, D is equal to V at the origin minus V at the destination.
- D is assumed to be at least 10 inches (25cm), and no greater than 70 inches [175cm].
- If the vertical travel distance is less than 10 inches (25 cm), then D should be set to the minimum distance of 10 inches (25 cm).

Now distance component that is the distance travel. What is the vertical distance travel? So the vertical distance travel distance that is the D is defined as the vertical travel distance of the hands between the origin and destination of the lift or lower. Here it is the absolute value. For lifting D can be computed from the subtracting the vertical location at the origin of the lift from the corresponding V at the destination of the lift. For lowering task D is equal to V at the origin minus V at the destination.

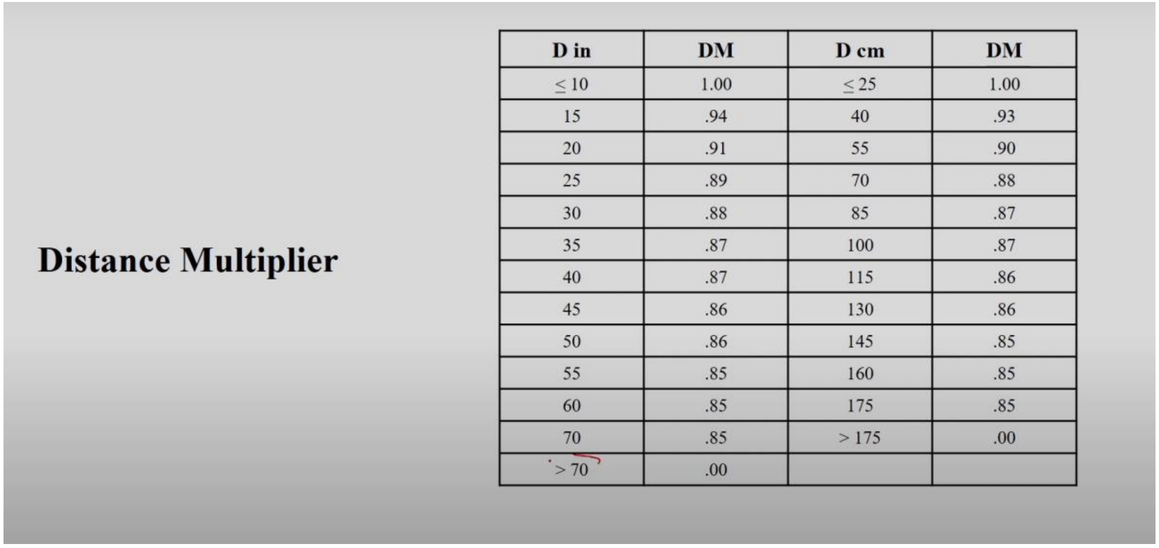
So D is assumed to be at least 10 inches. Here is again assumption it need to be at least 10 inches and not greater than 70 inches. If it is more than 70 inches or near to 70 inches again it becomes kind of 0. So if the vertical distance is less than 10 inches then D should be set at the minimum distance of 10 inches and 25 centimeters like it is a corresponding value.

Distance Multiplier

- The Distance Multiplier (DM) is (.82+(1.8/D) for D measured in inches, and DM is (.82+(4.5/D)) for D measured in centimeters.
- For D less than 10 inches (25 cm) D is assumed to be 10 inches (25 cm), and DM is 1.0.
- The Distance Multiplier decreases gradually with an increase in travel distance.
- The DM is 1.0 when D is set at 10 inches, (25cm); DM is 0.85 when D=70 inches (175 cm).
- DM ranges from 1.0 to 0.85 as the D varies from 0 inches (0 cm) to 70 inches (175 cm).

So distance multiplier you can calculate using this for D measured in inches and for this D measured in centimeter.

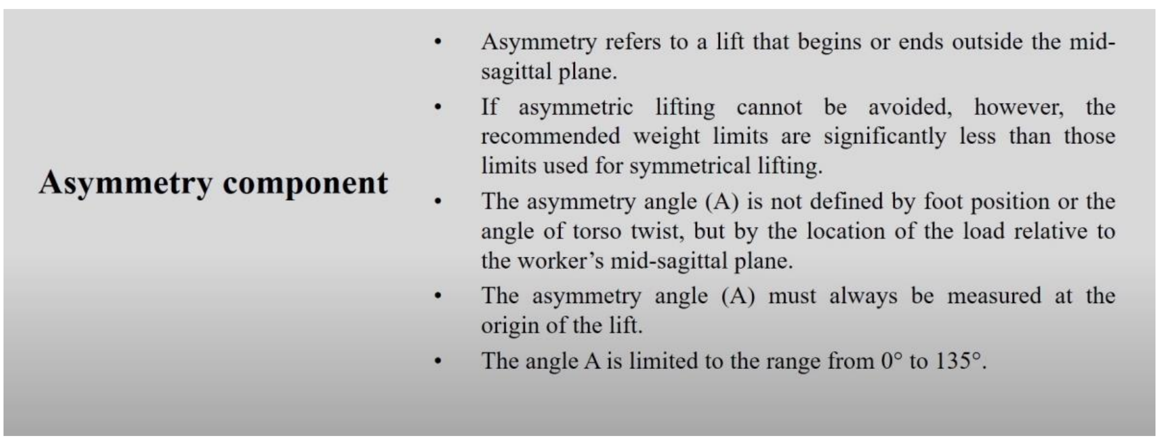
For D less than 10 inches it is assumed that 10 inch it is the value the multiplier value is 1. The distance multiplier decreases gradually with an increase in the travel distance. If the travel distance is increasing so difference is increasing the multiplier is decreasing and it says that DM is 1 when D is set as 10 inches and you know when it is 10 inches and when it is slowly increasing then it becomes 0.



D in	DM	D cm	DM
≤ 10	1.00	≤ 25	1.00
15	.94	40	.93
20	.91	55	.90
25	.89	70	.88
30	.88	85	.87
35	.87	100	.87
40	.87	115	.86
45	.86	130	.86
50	.86	145	.85
55	.85	160	.85
60	.85	175	.85
70	.85	> 175	.00
> 70	.00		

So we will take this value from this particular table.

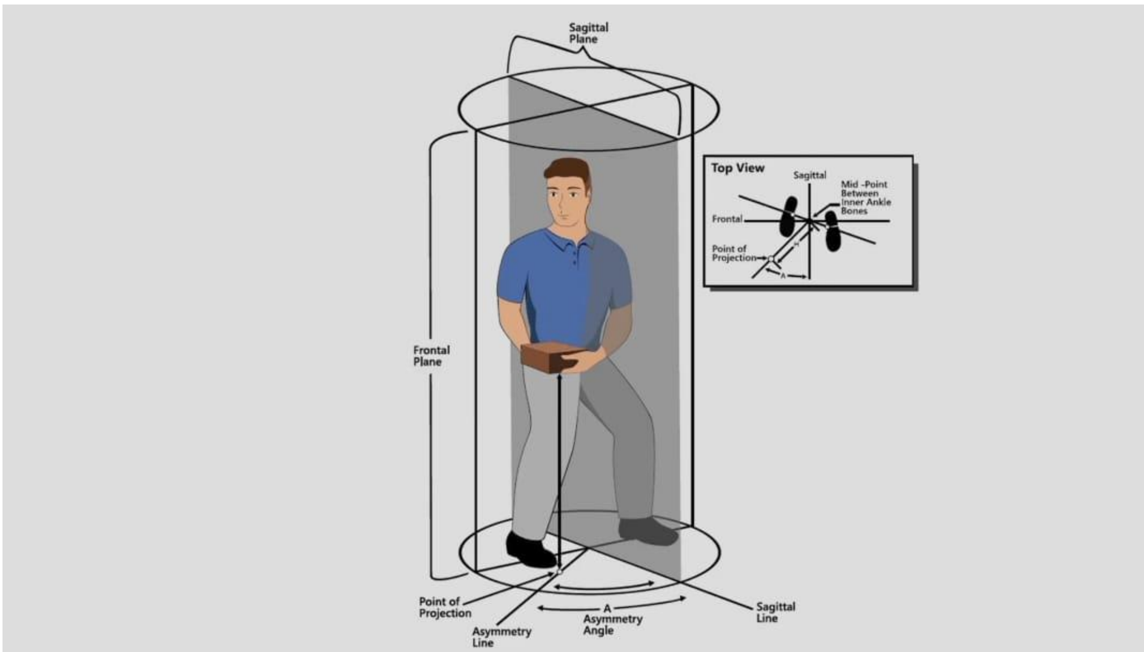
See if it is more than 70 inches then value is 0. If more than 175 centimeter then again value is 0. So you have to be very careful when you are doing this. So you can use this table or you can use the earlier formula to get your distance multiplier. It is very similar for each multiplier the calculations are quite similar you have to remember the formula.



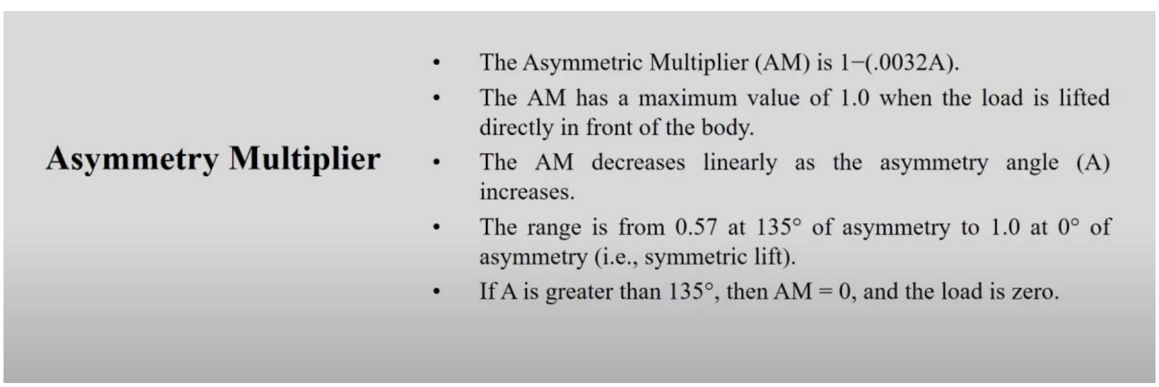
Now asymmetry angle or asymmetry component.

So asymmetry refers to a lift that begins or ends outside the mid-sagittal plane. If you are doing it in this mid-range then no problem. Okay, it is 1. Okay, multiplier is 1. Whereas if you are doing it this position or this position so if your position initial position is this and you are lifting it here.

So this particular angle right. So if that angle increases then again multiplier decreases similar concept. So if asymmetry lifting cannot be avoided however the recommended weight limits are significantly less than those limits used for the symmetrical lifting. So the asymmetry angle is not defined by the foot position or the angle of the torso twist but by the location of the load relative to the worker's mid-sagittal plane that we described earlier. The asymmetry angle must always be measured at the origin of the lift and the angle A is limited to a range that is 0 to 135. It is not possible to go beyond 135 that is not possible for someone to lift any or lower any object. So that is the maximum limit.



So from this, I explained this particular figure. So this is the asymmetry angle.



So, again the measurement how do we measure it? So, the asymmetry multiplier is 1 minus 0.003 to that particular angle. So, the asymmetry angle multiplier has a maximum value of 1 when the load is lifted directly in front of the body so that is the symmetrical position and it is 0 when it is in maximum position that is the 135 degrees. If it is 135 degree or more than that then the AM value becomes 0. If it is 0 means there is no movement it is moving from here to here so you are in a mid-sagittal plane then the value is 1.

Asymmetric Multiplier

A deg	AM
0	1.00
15	.95
30	.90
45	.86
60	.81
75	.76
90	.71
105	.66
120	.62
135	.57
> 135	.00

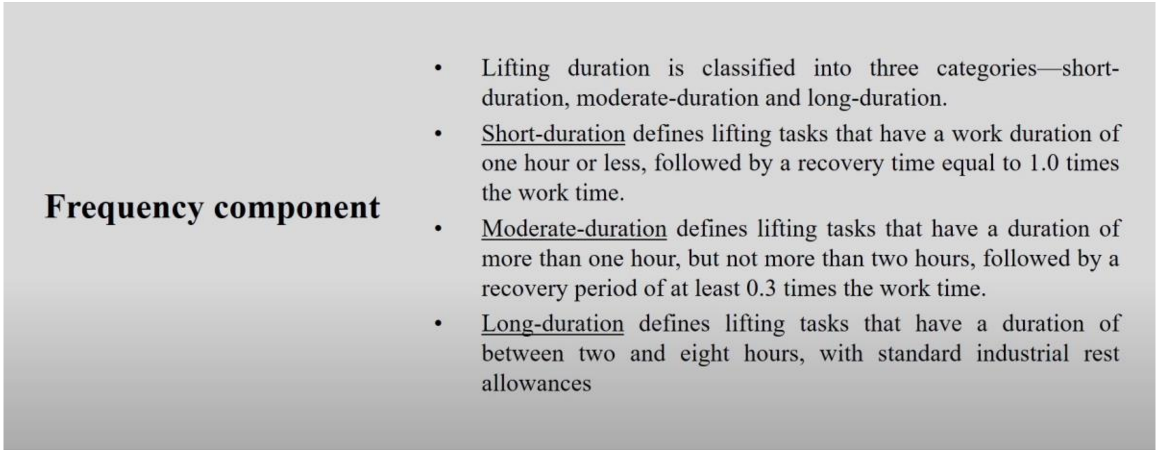
So, this is the table that you can use.

Frequency component

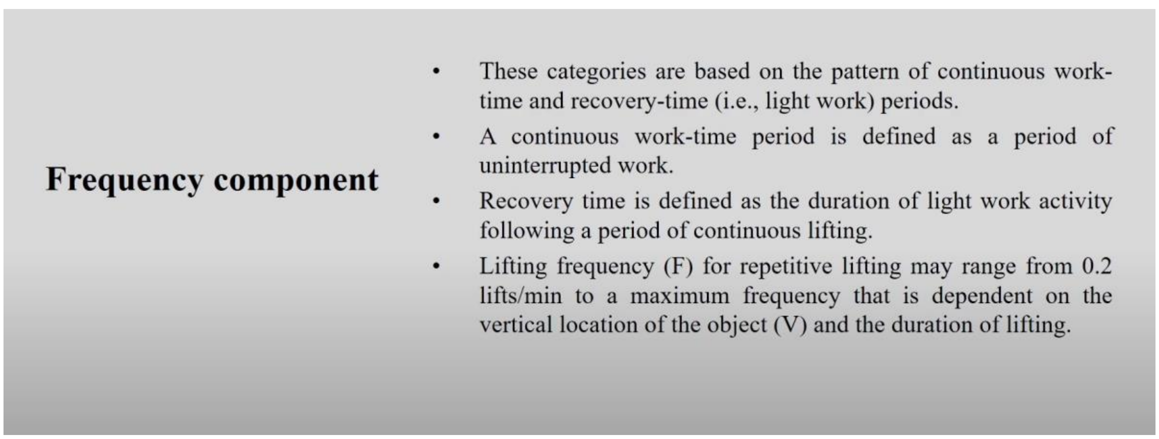
- The frequency multiplier is defined by
  a) the number of lifts per minute (frequency),
  b) the amount of time engaged in the lifting activity (duration), and
  c) the vertical height of the lift from the floor
- Lifting frequency (F) refers to the average number of lifts made per minute, as measured over a 15—minute period.
- If significant variation exists in the frequency of lifting over the course of the day, analysts should employ standard work sampling techniques to obtain a representative work sample for determining the number of lifts per minute.

Then frequency, the frequency multiplier is defined by three ways, the number of lifts per minute, the amount of time engaged in the lifting activity, and the vertical height of the lift from the floor. So lifting frequency refers to the average number of lifts made per minute as measured in 15 15-minutes time duration. So, your observation period is 15 minutes you convert it into 1-minute lifting. If significant variation exists in the frequency of lifting over the course of that particular day analyst should employ standard work sampling technique to obtain a representative work sample.

So it absolutely comes from your method that how you are doing. So if it is extremely different or what you can do, you can do for this period and you can do for this period if it is too much different. So that way also you can segregate and you can do a proper sampling.



So lifting duration is classified into three categories short, moderate and long that I describe and this is the definition of these three things. So short duration defines lifting tasks that have a work duration of 1 hour followed by a recovery time which is equal to 1 times of the work time. Migrate defines lifting tasks that have a duration of more than 1 hour but not more than 2 followed by a recovery period of at least 0.3 times of the work time and long duration defines lifting tasks that have a duration of between 2 to 8 hours with standard industrial rest allowances. So, this way you can define the lifting duration.



These categories are based on the pattern of continuous work time and recovery period or recovery time. So a continuous work time period is defined as a period of uninterrupted work.

Recovery time is defined as the duration of light work activity following a period of continuous lifting. Lifting frequency that is F for repetitive lifting may range from 0.2 lifts per minute to a maximum frequency that is dependent on the vertical location of the object and the duration of lifting.

Frequency Multiplier

- The FM value depends upon the average number of lifts/min (F), the vertical location (V) of the hands at the origin, and the duration of continuous lifting.
- For lifting tasks with a frequency of less than .2 lifts per minute, set the frequency equal to .2 lifts/minute.
- Values of V are in inches.
- For lifting less frequently than once per 5 minutes, set F=.2 lifts/minute.

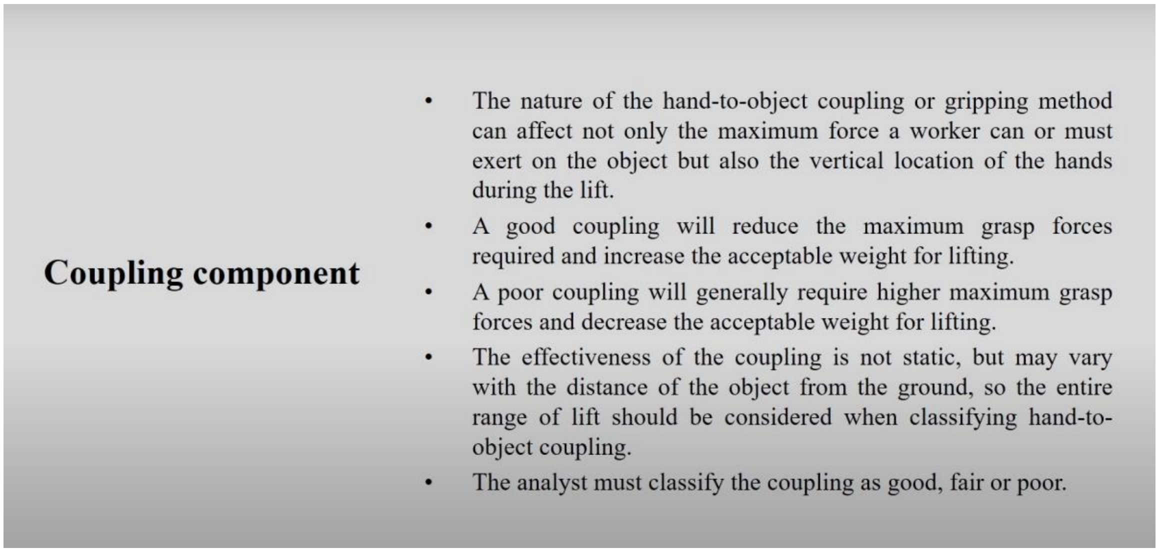
The frequency multiplier value depends upon the average number of lifts per minute that is the F, the vertical location of the hands on the origin and the duration of continuous lifting.

So these are the impacting factor. So for lifting task with a frequency of less than 0.2 lifts per minute set as the frequency equal to 0.2 lifts per minute. So, values for v are in inches and for lifting less frequently than once per 5 minutes that is the set is equal to f is equal to 0.2 lifts per minute. And this is the value.

Frequency Multiplier

Frequency Lifts/min (F)‡	Work duration					
	≤ 1 Hour		> 1 but ≤ 2 Hours		> 2 but ≤ 8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤ 0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
➤ 15	.00	.00	.00	.00	.00	.00

So you can see you have 3 variety over here what is the duration. Based on that your frequency table will, so you have 2 impacting factor, one is your hour and one is your vertical distance. So this you can use and you can get your frequency multiplier or frequency value.



Now the last important factor that is the coupling component or coupling factor. The nature of the hand-to-object coupling or gripping method can affect not only the maximum force of a worker can or must exert on the object but also the vertical location of the hand during lifting.

So, if it is very heavy, automatically the vertical location decreases, because it is pulling down. So, a good coupling will reduce the maximum grasp force required and increase the acceptable weight of the lifting. A poor coupling will generally require higher maximum grasp forces and decreases the acceptable weight for the lifting. The effectiveness of the coupling is not static, effectiveness is not static but may vary with the distance of the object from the ground. So, the entire range of lift should be considered when classifying the hand to hand object coupling, very important.

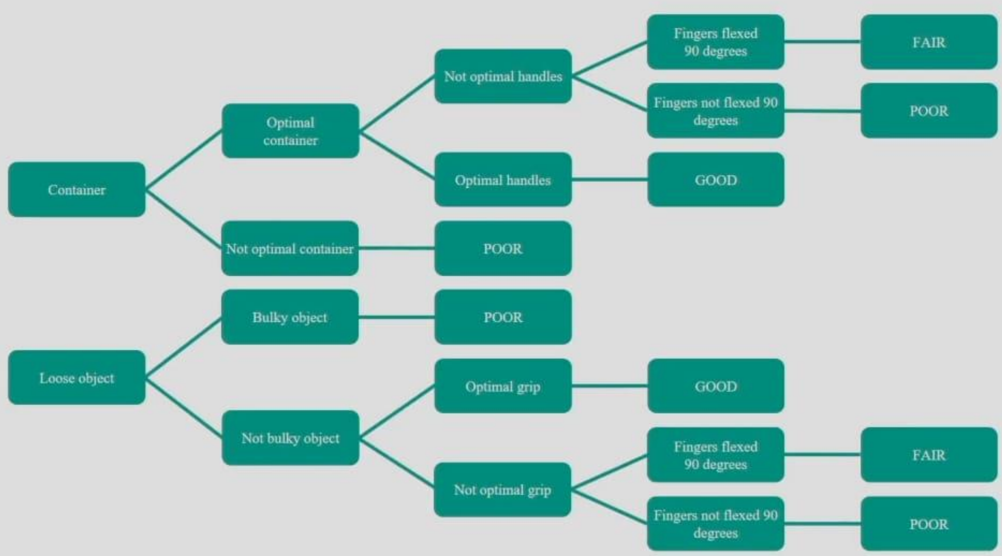
If you are not talking about hand-to-hand coupling, then you will not be able to define it properly. Here experience comes, skill, how to analyze it, that is very important. The analyst must classify the coupling as good, fair, and poor.

Coupling component

Hand-to-Container Coupling Classification

	Good	Fair	Poor
Containers (i.e. boxes, crates, etc.)	Handles or handhold cutouts of optimal design [see notes 1 to 3 below]	Handles or handhold cutouts of less than optimal design [see notes 1 to 4 below]	Less than optimal design, loose parts, or irregular (i.e. bulk, hard to handle, sharp edges) [see note 5 below]
Loose parts or irregular objects (i.e. castings, and supply materials)	Comfortable grip (i.e. hand can easily wrap around the object) [see note 6 below].	Grip in which hand can flex about 90 degrees [see note 4 below].	Non-rigid bags (i.e. bags that sag in the middle)

This is the kind of definition that you can follow for your coupling, hand-to-container coupling classification, what is good, what is fair, and what is poor, it is clearly defined, so you can use this particular definition.



Decision tree for Coupling quality

How do you take decision for the coupling quality? So, it is a kind of guideline, it is a kind of guideline that you can use. So, if it is a container or if it is a loose object, if it is a container, you can take this path and if it is a loose object, then you can take this path.

So if optimal container, not optimal, if optimal, then optimal handle, not optimal. So that way you can get the result, good, fair, and poor. Here also if it is loose object, then also you get an understanding of good, fair, and poor. So this is a very good guideline that you can use. And this guideline you can use maybe for other tool also where it is not defined properly or you are a learner. So, this is not only for NIOSH lifting equation, this particular guideline for understanding the coupling quality, you can take for the other tool where it is not defined.

Coupling Multiplier

Coupling type	Coupling multiplier	
	V < 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

So, coupling factor, now here again coupling factor is connected with your vertical, like vertical distance. So that is a V component. So, if it is less than 30 inches, if it is, you know, it is good, then this is value is 1. If it is poor, then the value is 0.9. So this way you based on your vertical distance, the coupling factor also changes.

JOB ANALYSIS WORKSHEET

DEPARTMENT ______________________
JOB TITLE ______________________
ANALYST'S NAME ______________________
DATE ______________________

JOB DESCRIPTION ______________________

STEP 1. Measure and record task variables

Object Weight (lbs.)		Hand Location (in.) Origin		Hand Location (in.) Destination		Vertical Distance (in.)	Asymmetry Angle (degrees) Origin	Asymmetry Angle (degrees) Destination	Frequency Rate Lifts/min.	Duration Hours	Object Coupling
L (avg.)	L (max.)	H	V	H	V	D	A	A	F		C

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC HM × VM × DM × AM × FM × CM

ORIGIN RWL = ☐ × ☐ × ☐ × ☐ × ☐ × ☐ × ☐ = ☐ Lbs.

DESTINATION RWL = ☐ × ☐ × ☐ × ☐ × ☐ × ☐ × ☐ = ☐ Lbs.

STEP 3. Compute the LIFTING INDEX

ORIGIN Lifting Index = $\frac{\text{Object Weight (L)}}{\text{RWL}}$ = ________ = ☐

DESTINATION Lifting Index = $\frac{\text{Object Weight (L)}}{\text{RWL}}$ = ________ = ☐

(Reference: Applications Manual for the Revised NIOSH Lifting Equation)

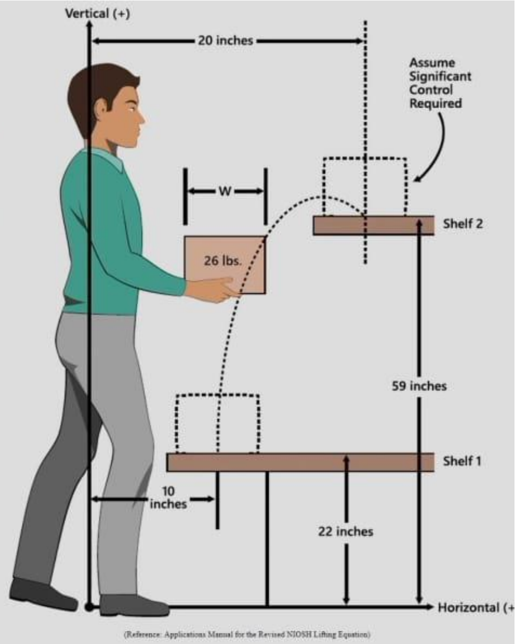
Now, this is the job analysis worksheet. Of course, it is being referred from the actual publication. So, what you can do you can give the all description over here and you can have all the variables, you know, measured over here. And from once you do that, go back to the multiplier, the formula or the table, get all the, recommended weight limit for origin separately for destination also separately. And then you can do the calculation of your drifting index, actual weight divided by recommended weight limit. We are coming next for your example.

Example:

Consider a worker inspecting compact containers for damage on a low shelf, and then lifting them with both hands directly in front of the body from shelf 1 to shelf 2 at a rate of 3/min for a duration of 45 minutes. For this analysis, assume that (1) the worker cannot take a step forward when placing the object at the destination, due to the bottom shelf, and (2) significant control of the object is required at the destination. The containers are of optimal design, but without handles.

Given

L	=	26 lbs	H	=	10 in
V	=	22 in	D	=	37 in
A	=	0	F	=	3 lifts/min
C	=	Fair			
Duration	=	0.75 hrs			



So, this is an example where these values are given. These values are given, it is being explained here. So, I will just read the example. Consider a worker inspecting compact containers for damage on a low shelf and then lifting them with both hands directly in front of the body, directly in front of the body.

So that means there will be no asymmetry angle. So it is here, it is getting lower. So directly in front of the body from a shelf 1 to shelf 2 at a rate of 3 per minute for a duration of 45 minutes. So, for this analysis, assume that the worker cannot take a step forward when placing the object at the destination due to the position of the bottom shelf and the significant control of the object is required at the destination because what is happening, you have to position it very carefully, it may fall then. The containers are optimal or are of optimal design but without any handle. So, these are the things given.

From this explanation, you got all these L, lifting constant, then your V, A, C, duration, hand like H, D, and F. All these things you got.

Example:

H = 10 in
HM = 1.0

V = 22 in
VM = 0.94

Horizontal multiplier

H in	HM	H cm	HM
≤ 10	1.00	≤ 25	1.00
11	.91	28	.89
12	.83	30	.83
13	.77	32	.78
14	.71	34	.74
15	.67	36	.69
16	.63	38	.66

Vertical multiplier

V in	VM	V cm	VM
0	.78	0	.78
5	.81	10	.81
10	.85	20	.84
15	.89	30	.87
20	.93	40	.90
25	.96	50	.93
30	1.00	60	.96

So, what you do, you go for the values. So, you calculate over here H, then what is horizontal multiplier, V, then what is vertical multiplier, here I will tell you something. So, from the formula, you got a value of 0.94. So, if you do not go by formula, suppose you are taking this particular table, then maybe you can take this value because this is also a value, this is also a value. So you can go for this.

Example:

D = 37 in
HM = 0.87

A = 0 degrees
AM = 1.0

Distance multiplier

D in	DM	D cm	DM
≤ 10	1.00	≤ 25	1.00
15	.94	40	.93
20	.91	55	.90
25	.89	70	.88
30	.88	85	.87
35	.87	100	.87
40	.87	115	.86

Asymmetry multiplier

A deg	AM
0	1.00
15	.95
30	.90
45	.86
60	.81
75	.76

Now for D, then A, A I should say, so you are doing it in front of your body, so there is no asymmetry multiplier because it is not asymmetry multiplier, there is no asymmetry angle.

So, asymmetry angle is 0, that is why the value of asymmetry multiplier is 1. Then F, V and from all these thing, you get this value and for coupling also you get this multiplier value.

Example:

JOB ANALYSIS WORKSHEET

STEP 1. Measure and record task variables

Object Weight (lbs.)		Hand Location (in.) Origin		Hand Location (in.) Destination		Vertical Distance (in.)	Asymmetry Angle (degrees) Origin	Asymmetry Angle (degrees) Destination	Frequency Rate Lifts/min.	Duration Hours	Object Coupling
L (avg.)	L (max.)	H	V	H	V	D	A	A	F		C
26	26	10	22	20	59	37	0	0	3	.75	Fair

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC × HM × VM × DM × AM × FM × CM

		LC	HM	VM	DM	AM	FM	CM	=
ORIGIN	RWL =	51	1.0	.94	.87	1.0	.88	.95	34.9 Lbs.
DESTINATION	RWL =	51	.50	.78	.87	1.0	.88	1.0	15.2 Lbs.

STEP 3. Compute the LIFTING INDEX

ORIGIN $\text{Lifting Index} = \dfrac{\text{Object Weight (L)}}{\text{RWL}} = \dfrac{26}{34.9} = .8$

DESTINATION $\text{Lifting Index} = \dfrac{\text{Object Weight (L)}}{\text{RWL}} = \dfrac{26}{15.2} = 1.7$

Now once you do this, so at origin you put all these things, so they are doing it pound, so that is why 51 pound and here also load constant is 51 pound.

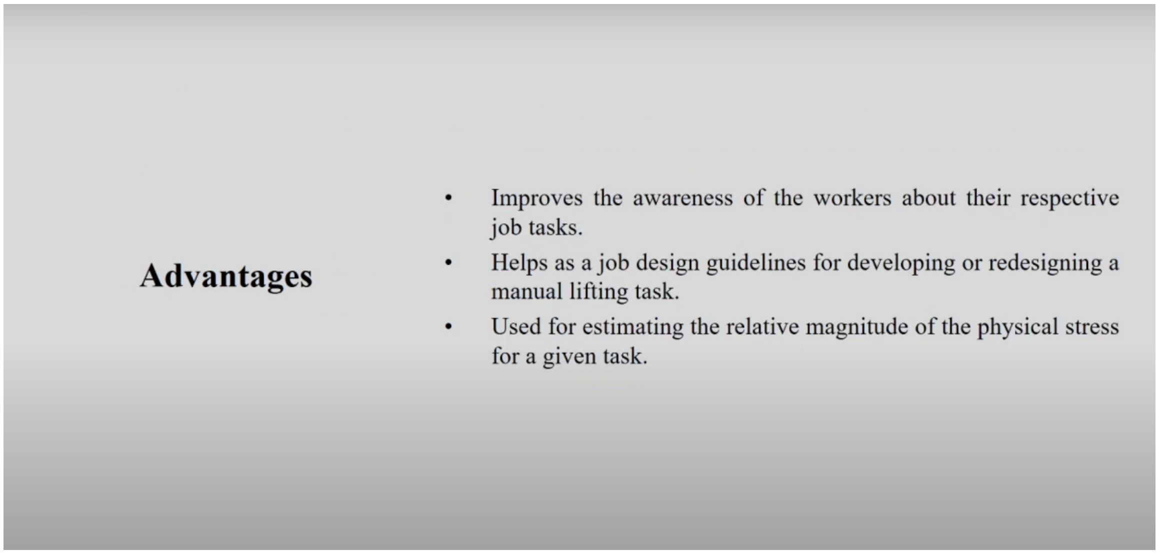
So at origin, the weight limit is 34.9 pounds and at the destination, it is 15.2 pounds. So at origin, the value becomes 0.8, whereas at destination the value is 1.7. So, we need to take a decision that how do we do the changes, so that the whole process becomes safe for that particular person while doing this job to know how we can do the changes, so there is no risk for low back pain.

So, here it is not a concern, whereas here it is a concern. So definitely we need to check which is the component is causing the more problem. So, if you see, this is 0.5, this is 0.78, 0.87, 1, 1 definitely there is no problem, this is also quite close to point, close to 1, this is also quite close to 1.

Here these are the two factors which may cause problem, among that this is the main problem because it says 0.5, so it is causing the, lowering the recommended weight limit. So, for destination you need to check how you can work on the horizontal value, horizontal distance, horizontal location. Then so the positioning of the positioning of your, this particular destination. So, from that you may have some kind of calculation or redesigning of your alignment, redesigning of the whole workplace may enhance this particular value and which will reduce this value and which will come near to 1.

Maybe not exactly 1 but near to 1, then only your intervention is successful. So here no intervention is required, however, you need an intervention over here. So you need to see how you can do the design changes at the destination place so that the values have, are changing. So, this is how we use the recommended weight limit and lifting in this for our analysis.

So, this is the whole process.



Now let us go for the advantage and disadvantage. So first is advantage, improves the awareness of the worker. So, you are aware, it is not only the analyst who is doing the job is aware, the worker who is working he or she is also aware. Improves the awareness of the workers about their respective job task. It helps as a job design guidelines for developing and redesigning a manual lifting task and also it is used for estimation of the relative magnitude of the physical stress for a given task.

It is a relative magnitude it is not the exact value.

Disadvantages

- Cannot assess the physical stress of the one-handed manual lifting tasks.
- It is not applicable for activities like holding, pushing, pulling, carrying, walking and climbing which are considered as the non-lifting tasks.
- It does not include factors to account for unpredicted conditions, such as unexpectedly heavy loads, slips, or falls.
- It was not designed to assess tasks involving one-handed lifting, lifting while seated or kneeling, or lifting in a constrained or restricted work space.

However, it has some disadvantages. It cannot assess the physical stress on the one-handed manual lifting task. You need both hands to work. It is not applicable for the activities like holding, pushing, pulling, carrying, walking, and climbing, only lifting and lowering.

It does not include factors to account for unpredicted conditions such as unexpectedly heavy load, slips, or fall. You cannot describe it over here. It was not designed to assess the task involving one-handed lifting, no lifting while seated, kneeling, or lifting in a constrained or restricted workplace. For such cases, this tool is not useful. In a very standard case, this tool is only useful. So, these are the disadvantages of this particular equation.

Limitations

The Revised NIOSH Lifting Equation does not apply if any of the following occur:

- Lifting/lowering with one hand
- Lifting/lowering for over 8 hours
- Lifting/lowering while seated or kneeling
- Lifting/lowering in a restricted work space
- Lifting/lowering unstable objects
- Lifting/lowering while carrying, pushing or pulling
- Lifting/lowering with wheelbarrows or shovels
- Lifting/lowering with high speed motion (faster than about 30 inches/second)
- Lifting/lowering with unreasonable foot/floor coupling (<0.4 coefficient of friction between the sole and the floor
- Lifting/lowering in an unfavorable environment (i.e., temperature significantly outside 66–79° F (19–26° C) range; relative humidity outside 35–50% range)

So, these limitations, this revised NIOSH lifting equation does not apply if any one of this following condition occurs. So, lifting, lowering with one hand, lifting, lowering more than

8 hours, so you will not be able to describe it while seated or kneeling. So, I am repeating the same thing. In a restricted workplace, unstable object, the object if it is unstable, carrying, pulling, pushing you cannot explain, wheelbarrows or shovels you cannot explain, high-speed motion you cannot explain, unreasonable foot or floor coupling, so there also you will not be able to explain and in an unfavorable environment like you know temperature is significantly outside the zone. So if it is extreme cold or it is extreme hot, those cases, this lifting equation may not work.

So, before you start using this particular tool for analyzing your task, please check these list of limitations. If it is not following under any such condition, then definitely you can use it. So that is all for NIOSH lifting equation. It is very useful tool. So I suggest you take an example whatever is available in your nearby location or your nearby research area and practice it because you know initial days understanding those points and a position are very important.

If you do not understand those positions, you will not be able to get the correct measured value. Okay, that is all for NIOSH lifting equation. We will take up some other tool in our next class. Thank you.