What Is the NIOSH Lifting Equation and How Can It Help?

By 1981, it had been clear for some time that musculoskeletal disorders caused by manual lifting tasks on the job were causing far too many injuries to American workers. That year, the National Institute for Occupational Safety and Health (NIOSH) published a technical report titled Work Practices Guide for Manual Lifting in an effort to reduce the number of injuries caused by unsafe lifting tasks at work.

The conclusion of this nearly 200-page guide was a set of equations that would determine the "maximum permissible limit" and the lower, preferable "action limit" for the weight of a given lifting task. These equations included six variables that evaluators could use to figure out the ultimate limits of a given task.

A decade later, NIOSH researchers revisited this original equation. In 1993, the Institute published its Applications Manual for the Revised NIOSH Lifting Equation (RNLE). Ergonomists still use this expanded algorithm to determine the limits of a safe lifting task today.

The need for such a system remains dire. In 2015, musculoskeletal disorders such as those caused by dangerous lifting tasks made up more than 30 percent of all workplace injuries that required days away from work. This begs an important question.

How Effective is the Revised NIOSH Lifting Equation?

The research is ongoing, but according to multiple studies, the measurements produced by the RNLE can help to determine the risk of low-back pain in workers assigned to lifting tasks. The RNLE has become the industry standard for analyzing workplace tasks involving lifts, and can help managers determine where to invest in mechanical lifting equipment or other ergonomic interventions.

So how can you use the RNLE to evaluate lifting tasks in your workplace? The simplest way is to download the NIOSH Lifting Equation mobile app, which is called NLE Calc. It's available for free on the Apple iTunes store and the Google Play store, courtesy of NIOSH.

To understand what's going on behind the scenes in this app, or to complete your own calculations by hand, keep reading. This is how the RNLE works to provide figures you can use to evaluate the estimated safety of a workplace lifting task.

Unpacking the Revised NIOSH Lifting Equation

When you first glance the RNLE, it's easy to get intimidated. After all, it's algebra. The equation itself looks like a string of gibberish to the untrained eye. Not to complicate matters further, but now's a good time to mention that what we usually call the "NRLE" actually encompasses two interrelated equations.

The first figure that the NRLE produces is the **Recommended Weight Limit**, or RWL, which describes the heaviest load a healthy worker could lift based on how many lifts over the hours of the shift (so up to eight) without increasing the risk of developing low-back pain.

Once you calculate the RWL, you can figure out the **Lifting Index** (LI). This figure is a rough estimate of the stress that a given lifting task will place on the worker's body. The LI is defined as:

$$LI = L/RWL$$

in which L equals the actual load weight, while RWL is the **Recommended Weight Limit** calculated for that task. This means that an LI of one or less indicates a lower risk of physical, potentially damaging stress on the worker. An LI over one indicates an increasing level of stress, and therefore risk of injury. In general, if a task shows an LI of greater than one, employers should consider providing ergonomic lifting equipment to reduce the risk of musculoskeletal disorders.

Okay, but back to the NRLE proper, our means of discovering the RWL, or the maximum recommended weight for the load in a given lifting task. Let's unpack some of the terms so that we can start to make sense of the equation, which is:

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

We've covered the Recommended Weight Limit (RWL), so let's go on to the variables involved in this equation:

- **The Load Constant** (LC) is set at **51 pounds** for this equation. It remains constant (hence the name).

- The **Horizontal Multiplier** (HM) equals **10/H**, in which H, an important variable that the evaluator must plug into the equation, equals the **Horizontal Location**, or the "distance of the hands away from the mid-point between the ankles in inches…" Essentially, H measures the distance away from the worker's body at which he or she must hold the object being lifted.

- The **Vertical Multiplier** (VM) measures the distance from the floor at which the object being lifted is stored. Its individual equation is:

1-(.0075|V-30|)

In this case, V designates another variable, the **Vertical Location**, which is defined as the distance between the hands and the floor during the lift.

Oh, and a little algebra refresher: The parentheses in the VM equation mean you complete that calculation first. The vertical bars indicate "absolute value," or the distance from zero. Essentially, the absolute value serves to make negative numbers into positive numbers, because -5 is still 5 away from 0.

- **The Distance Multiplier** (DM) measures the impact of the vertical distance involved in the lift. Simply put, it introduces the height of the lift into the equation. The Distance Multiplier is determined by the equation:

(.82 + (1.8/D))

- So time for another variable you must input: D describes the **Vertical Travel Distance**, or how many inches the worker's hands move from the origin to the destination of the object being lifted.

- Next, we have to figure out whether the worker will have to lift the load at an angle, maybe starting at the lower right hip and ending at the upper left shoulder, for instance. This type of lift, incidentally, is not recommended, so this multiplier can reduce the final RWL by quite a lot.

  The **Asymmetric Multiplier** (AM) equals:

  ### 1-(.0032A)

  in which A equals the **Asymmetric Angle**.

  So what's the **Asymmetric Angle** (A)? Imagine a square blade of light passing through your body, dividing it into two equal halves. It would pass down right between the eyes, dividing the nose in two; in the torso, it would extend down through the navel in front and the spine in back. It would separate both legs, with each on one side. That blade of light is called the **mid-sagittal plane**.

  The **Asymmetric Angle** (A) equals the number of degrees of movement relative to the mid-sagittal plane. If you stood within the triangular meeting point of two square desks, set at a right angle to each other, for instance, and you had to lift a box from the edge of one to the edge of the other, the Asymmetric Angle would be 90 degrees, and the **Asymmetric Multiplier** for the lift would equal .712 (because .0032 * 90 = .288, and 1 = .288 is .712). As you can see, you just lost nearly 30 percent of the total maximum recommended weight for this lift; asymmetry is not good for safe lifting.

- The **Frequency Multiplier** (FM) accounts for how many times per minute a worker must complete the lifting task in question. This is an important point; the RNLE does not evaluate a single lift at a time, but a lifting task repeated over a period of time. That way, it evaluates the whole job, and managers can use it to determine where best to invest in ergonomic lifting-assistance equipment.

  The Frequency Multiplier is a bit complicated, since it encompasses three variables: The **number of lifts per minute** (F), the **Vertical Location** (V), and the **Work Duration**. If you don't have the NIOSH Lifting Equation App, you'll have to consult the following table to find FM:

Number of Lifts per Minute (F)	Work Duration (Lifts to be Performed Over How Many Hours?)					
	Less/Equal to 1 hr.		1 to 2 hours		2 to 8 hours	
	V < 30”	V ≥ 30”	V < 30"	V ≥ 30"	V < 30"	V ≥ 30"
0.2 or less	1	1	.95	.95	.85	.85
.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
More than 15	.00	.00	.00	.00	.00	.00

Source: Applications Manual for the Revised NIOSH Lifting Equation

- Finally, the **Coupling Multiplier** (CM) measures the effect of the hand-holds on the object being lifted. Evaluators must classify this "coupling" as Good, Fair, or Poor. A Good grip has handles or cut-outs, or applies to smaller objects that the hand can easily wrap around; this rating makes the CM equal **one**. A Fair coupling handles or cut-outs that don't work super-well; maybe they're off-center, or they're badly designed. The designation of Fair makes the CM equal **two**. Finally, the designation Poor describes "containers of less than optimal design," such as sagging bags and objects with sharp edges. A Poor CM rating is worth **three**.

Unpack all of this, and you end up with a head-spinning equation that looks something like:

$$RWL = 51 \times (10/H) \times (1-(.0075|V-30|)) \times (.82 + (1.8/D)) \times (1-(.0032A)) \times FM \times (1, 2, \text{or } 3)$$

Luckily, though, you only have six variables to plug into the equation (H, V, D, A, FM, and the coupling rating). You could determine each of those and complete the equation by hand, but we recommend simply using the NIOSH Lifting Equation App.

How to Use the Results of the RNLE to Reduce the Risk of Musculoskeletal Injury

If you run your calculations and discover a Lifting Index above one, especially far above one, consider supplying lifting equipment to prevent workers from developing low-back pain and other ergonomic injuries.

For instance, Mobile Lift Tables can help raise objects from ground level, then transport them to a higher surface without straining the worker's body. Bin Tippers remove the stress from workers for all lifting-and-emptying tasks. The exact intervention will vary with the job, but the goal remains the same: Remove risky lifting tasks from workers by shifting their burden to machinery.

To learn more about the Revised NIOSH Lifting Equation, find the Applications Manual here. Read more about the NIOSH LIfting Equation App, NLE Calc, and find links for downloads, here.

References:

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