Manual Material Handling:
Why Do We Need Limits?

This summer, we were treated to a grand display of how the human body works. The Summer Olympic Games featured the world’s best athletes showcasing how the body, and specifically the spine, allows them to bend, stretch and perform dynamic motion. But what can we learn about the human capacity for work (in the industrial environment) from the results of the superb strength and conditioning that we watched from London this summer?

In the field of ergonomics, we know three primary risk factors contribute to musculoskeletal disorders in all joints of the body:
• awkward posture;
• high force;
• high frequency and long duration.

When these risk factors combine, the potential for developing an ergonomic injury (a musculoskeletal disorder) increases. Eliminate one or more of them, and the chance of injury is reduced. We use this concept in other areas of safety, like noise and chemical exposure. It works the same: if we keep the cumulative level of risk under the threshold of injury (within our limits), we are effectively managing our ergonomic risk.

So, back to the Olympics. What about weightlifting?

If the human body can be trained to lift significant weight (force) over and over again (frequency), will exposing our joints to heavy physical activity help reduce the risk of injury in the workplace?

A physical job performed 30 to 50 hours per week is rarely governed by the same expert supervision and frequency calculations as an Olympic training schedule. Such supervision and calculations are specifically designed to minimize the chance of over-stressing a joint, which results in an injury. Frequency is closely monitored, as is the third ergonomic risk factor, posture.

Biomechanically, joint mobility comes at the cost of joint stability and vice versa. With respect to manual material handling, when we lift a load, we use muscles in the low back as part of a lever system. Because the muscles in our low back are only about 2 in. from the spine, the farther a load is away from the body, the more stress transfers to the low back and the amount of work required increases. Think about snow on the branch of a tree; the further the snow is away from the trunk, the more the branch bends under its weight.

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How Much Is Too Much to Lift?
As safety professionals, we are often asked, “How much is too much to lift?” Or “How many is too many repetitions?” And “How far is too far a reach?”

These are important questions for you to be able to answer because, under OSHA’s general duty clause, as an employer, you are required to furnish each employee with employment and places of employment free from recognized hazards causing or likely to cause death or serious physical harm. This means you need to identify and control those work areas that you can control.

The question about how much is safe to lift applies to many different industries. For example, stacking boxes on a pallet, loading bags of chemicals into a hopper, handling bundles of roof shingles and even carrying your recycling bin out to your curb all involve some kind of lifting.

As a corporate ergonomist or plant safety professional, consider your specific industry, task and environment before making recommendations to improve lifting tasks. Since it is estimated that 80% of the population has experienced back pain or discomfort in their working lives, these are questions we will inevitably need to answer if we are to optimize workforce performance.

Calculating the Limit: NIOSH Lifting Equation

Olympic weightlifters train for years to perform at the level they do. In fact, during a Snatch or Clean & Jerk, the spine posture comes within 2º or 3º of catastrophic injury. In the industrial work environment, we would rather not get that close. NIOSH developed a model that determines whether a lifting task is safe. The result of the NIOSH lifting equation is the recommended weight limit (RWL), a weight that 99% of males and 75% of females should be able to lift safely.

Under perfect circumstances, for example, when lifting an object with good handles only once in a certain posture, the highest possible RWL is 51 lb. To get the RWL, other factors are also considered, including horizontal distance, vertical location at the beginning of the lift (floor level is the least desirable) and whether twisting occurs during the lift.

Using the NIOSH Lifting Equation in a Meaningful Way

The equation makes it is easy to identify opportunities for design improvements. By working with the numbers, you can quantify the risk reduction that results from raising a load from the floor (0 in.) to table height (30 in.) or from reducing the width of a conveyor belt to minimize...
reach distance. The equation is equally useful for identifying ergonomic solutions, as well as ergonomic challenges.

**Working Beyond Our Limits**

Perhaps you have lifting tasks at your site in which the actual weight lifted is more than three times the recommended limit. Often, the next question is how much more training your operators will need to reduce the risk of back injury. However, the best training programs in the world will not increase NIOSH’s RWL. Behavior-based training programs and lifting aids, such as back belts, should never be the first choice when trying to make a lifting task easier. For example, McGill (1993) concluded that back belts instill a false sense of security during a lifting task, and they provide no benefit for employees who have never had a back injury.

The recommendation is to apply the biomechanical principles incorporated in the NIOSH lifting equation to get your RWL as close to the ideal 51 lb as possible. Use the equation to identify which variable is lowering your limit. It becomes easy to reduce risk when you have the answer key.

**Pushing vs. Pulling: Which Is Better?**

With lifting limits addressed by the NIOSH lifting equation, significant material handling challenges still exist with pushing and pulling of carts. Design features of carts may significantly affect our capabilities to maneuver them. And which is more desirable: pushing or pulling? Are there limits to how much weight should be loaded on to a cart?

The answers are never as simple as we would like them to be. We must first understand the objective of an operation and consider several variables. One of the best-known pushing/pulling analysis tools is the research completed by Stover Snook, who developed a series of tables using people’s perceived performance capabilities. These tables consider several aspects of the push/pull task, such as hand height, distance and frequency. In addition to Snook’s research, we must consider additional variables that influence our strength capability during a push/pull task, including body postures (hand, elbow and back), grip type, the number of hands used in the task and the load position.

Posture plays an important role in our ability to generate force. For example, the elbow joint is able to generate the most force at 90°. As this angle increases, our ability to generate force decreases. Consider pulling a wagon; most people use one arm to pull a wagon with the elbow joint at 180°. In this posture, you can generate only 60% of your maximum force, meaning your muscles will need to do much more work to pull the same load. Poor back posture can also reduce force generation. When pulling a wagon, the back is typically twisted, placing higher shear and compression forces on the back and more stress on the spinal discs.

Extreme wrist postures can also reduce grip force by more than 50%. We can generate more force by grasping an object with our entire hand (power grip) than by grasping it with our fingertips (pinch grip). This is especially important when designing the handle of the load pushed or pulled.

Also consider the number of hands used in the push/pull task. We can generate almost three times the amount of strength when using two hands to push straight out versus one hand. Do not forget to examine the position of the hands and the load. Are they in front of the body? Behind the body? Out to the side? Going back to the wagon example, the hand and the load are behind the body (out of our natural position), so our strength capabilities are lower than if our hands and the load were in front of us.

There is no absolute answer to the pushing/pulling conflict since many variables must be considered. Remember to review the critical characteristics of the task—body postures, grip type, number of hands used and load position—before making a final decision.

**The Podium**

It is important to build a conceptual bridge between the athletic performance of an Olympian and the work performance of your industrial athlete. Both have physical limits to work within; the difference is that the Olympian has the time, science and sponsorship to carefully expand those limits, often beyond what most thought possible. When considering the work environment and the industrial athlete, a safety professional can benefit tremendously from having knowledge about the limits to human capability, particularly when it comes to manual material handling. Armed with this knowledge, your ergonomics program will be on its way to the Olympic medal podium.

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