

AORN Ergonomic Tool 6: Lifting and Carrying Supplies and Equipment in the Perioperative Setting

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ABSTRACT

Perioperative team members often are required to lift and carry heavy supplies and equipment into and around the OR; this includes lifting equipment such as hand tables, fluoroscopy boards, stirrups, Wilson frames, irrigation containers for lithotripsy, and heavy instrument pans. Lifting heavy objects creates considerable risk for musculoskeletal injuries to the back and shoulders. AORN Ergonomic Tool 6: Lifting and Carrying Supplies and Equipment in the Perioperative Setting can help caregivers evaluate lifting and carrying tasks and take measures to protect themselves from injury. Caregivers can use the revised National Institute for Occupational Safety and Health lifting equation to assess whether a specific lifting task can be performed safely. *AORN J* 94 (August 2011) 173-179. Published by Elsevier, Inc., on behalf of AORN, Inc. doi: 10.1016/j.aorn.2010.09.033

Key words: *musculoskeletal disorders, back injuries, recommended weight limits, workplace safety.*

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Lifting and carrying heavy objects in the perioperative setting presents a high risk for work-related musculoskeletal disorders, such as lower back and shoulder injuries. Periop-

erative personnel lift and carry heavy supplies and equipment repeatedly during a typical work shift. Several factors contribute to the risk of injury from this type of task. These include

- the weight of the object lifted,
- excessive reach,
- the location of the load relative to the person performing the lift (ie, how close the object being lifted is to the person's body), and
- the duration and frequency of lifting.

BIOMECHANICS OF LIFTING

The back can be thought of as a mechanical lever system, with the disc between the fifth lumbar and first sacral spinal segments being the fulcrum of the lever system. Lever systems work by balancing the moment (ie, the product of a quantity times a distance) created on each side of the fulcrum. A moment is created when a load is applied at some distance away from the fulcrum.

The mechanical lever system of the back is affected by internal and external forces that act on the fulcrum. These consist of forces created by gravity, such as

- the moment created by the weight of the object being lifted,
- the moment created by the lifter’s own body weight when bent over (ie, the upper body

mass times the distance of the center of mass from the fulcrum), and

- the muscle forces created by the body to balance the moments.

The further a person bends, the larger the distance of the center of mass of the upper body from the fulcrum and the greater the moment created by the upper body mass.

When a person performs a lifting task, the lever system in the back must be balanced at all times. The extensor muscles of the back must exert large internal forces to create the lifting motion or to hold the spine in a fixed position during the lift. In fact, depending on the person’s posture during the lift, these muscle forces could be 10 to 20 times greater than the actual weight being lifted by the person. It is these large internal

NIOSH LIFTING INDEX VALUE FOR TYPICAL MANUAL LIFTING OF OBJECTS		
Lifting Task	Lifting Index	Level of Risk
3,000 mL irrigation fluid	< 0.2	
Sand bags	0.3	
Linen bags	0.4	
Lead aprons	0.4	
Custom sterile packs (eg, heart or spine)	0.5	
Garbage bags (full)	0.7	
Positioning devices off shelf or rack (eg, stirrups)	0.7	
Positioning devices off shelf or rack (eg, gel pads)	0.9	
Hand table (49" x 28"); largest hand table, used infrequently	1.2	
Fluoroscopy board (49" x 21")	1.2	
Stirrups (two—one in each hand)	1.4	
Wilson frame	1.4	
Irrigation containers for lithotripsy (12,000 mL)	1.5	
Instrument pans	2.0	

No shading Minimal risk—Safe to lift
Light shading Potential risk—Use assistive technology, as available
Heavy shading Considerable risk—One person should not perform alone or weight should be reduced.

Figure 1. Ergonomic Tool 6: National Institute for Occupational Safety and Health lifting index values for typical manual lifting of objects.

muscle forces that create tremendous compression and shearing forces on the spinal discs. Researchers believe that these excessive internal spinal forces on the discs lead to the high incidence of occupationally related lower back pain.¹ When lifting tasks are performed repetitively, the spinal discs may not recover sufficiently to prevent damage, even at moderate levels of spinal loading. Therefore, it is important to determine how much weight is acceptable to lift in different body postures and using different hand positions. AORN Ergonomic Tool 6: Lifting and Carrying Supplies and Equipment in the Perioperative Setting (Figure 1) can help caregivers evaluate lifting and carrying tasks and take measures to protect themselves from injury.

ERGONOMIC TOOL 6

The National Institute for Occupational Safety and Health (NIOSH) has developed an equation for calculating recommended weight limits and a lifting index (LI) for assessing the physical demands of specified manual lifting tasks.^{2,3} To create Ergonomic Tool 6, perioperative nurses identified the objects most frequently lifted during a typical workday, and ergonomists applied the revised NIOSH lifting equation (RNLE) to each object to determine its level of risk. The shading in the tool indicates the level of risk associated with a particular object.

For example, it is safe to lift irrigation fluid bags, sand bags, linen bags, lead aprons, custom sterile packs, full garbage bags, and positioning devices. There is potential risk in lifting a large hand table, fluoroscopy board, two stirrups, a Wilson frame, or large irrigation containers for lithotripsy. There is considerable risk in lifting instrument pans, and these should be carried close to the body to reduce risk (Figure 2).

It is likely that caregivers will identify specific lifting tasks in the perioperative environment that are not listed in the tool. For these tasks, the RNLE can be used to assess whether

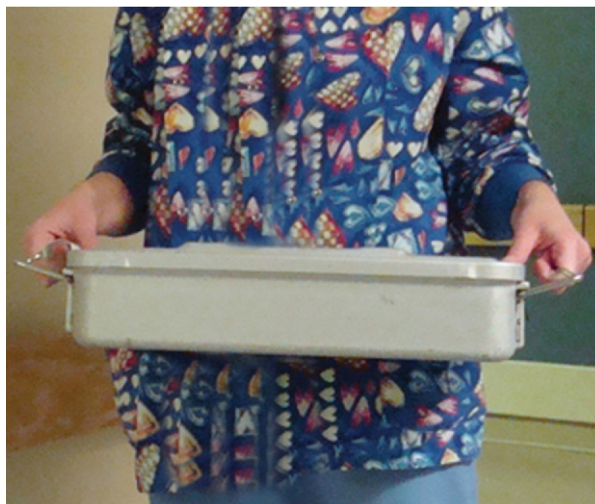


Figure 2. Heavy instrument trays should be carried close to the body to reduce the risk of injury.

the tasks should be performed manually. This can be done by following the directions provided by NIOSH in the applications manual.² Waters et al also provide full details of the lifting assessment tool.³

RATIONALE FOR RECOMMENDATIONS

A series of typical OR lifting tasks were identified and evaluated using the RNLE to determine their potential risk for causing lower back pain resulting from manual lifting of objects in support of patient care. The RNLE is a tool that allows the user to calculate the recommended weight limit (RWL) for a specified two-handed manual lifting task. In addition, the LI for the task can be calculated by dividing the actual weight of the load lifted by the recommended weight limit.

The RWL is the principal product of the RNLE. The RWL is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (eg, up to 8 hours) without an increased risk of developing lifting-related [low-back pain]. By healthy workers we mean workers who are free of adverse health conditions that would increase their risk of musculoskeletal injury.^{2(p4)}

The concept behind the RNLE is to start with a recommended weight that is considered safe for an ideal lift (ie, load constant equal to 51 lb [23 kg]) and then reduce the weight as the task becomes more stressful (ie, as the task-related factors become less favorable). The RWL equation consists of a fixed load constant of 51 lb, which is reduced by factors related to task geometry. The precise formulation of the RNLE for calculating the RWL is based on a multiplicative model that provides a weighting (ie, multiplier) for each of six task variables:

- horizontal distance of the load from the worker (H),
- vertical height of the lift (V),
- vertical displacement during the lift (D),
- angle of asymmetry (A),
- frequency (F) and duration of lifting, and
- quality of the hand-to-object coupling (C).

The weightings are expressed as coefficients that serve to decrease the load constant, which represents the maximum RWL to be lifted under ideal conditions. For example, as the horizontal distance between the load and the worker increases, the RWL for that task would be reduced from the ideal starting weight.

The following list briefly describes the measurements required to use the RNLE. Details for each of the task variables are presented in the *Applications Manual for the Revised NIOSH Lifting Equation* (see the section titled “Obtaining and using the data”).²

- H = “Horizontal location . . . measured from the mid-point of the line joining the inner ankle bones to a point projected on the floor directly below the mid-point of the hand grasps (ie, load center), as defined by the large middle knuckle of the hand.”^{2(p14)} This is measured in centimeters or inches at the origin and the destination of the lift.
- V = Vertical location of the hands above the floor. This is measured in centimeters or

inches at the origin and destination of the lift.

- D = Vertical travel distance of the hands in centimeters or inches between the origin and the destination of the lift.
- A = angular displacement of the load from the worker’s sagittal plane. This is measured in degrees at the origin and destination of the lift.
- F = Average frequency rate of lifting measured in lifts per minute. Duration is defined as follows: short (≤ 1 hour); moderate (> 1 but ≤ 2 hours); or long (> 2 but ≤ 8 hours); it is assumed that appropriate recovery allowances are included.²
- C = Quality of hand-to-object coupling (ie, the quality of the interface between the worker and the load being lifted). This can be described as good (ie, object with optimal design that has handles or hand hold cutouts), fair (ie, object with handles or hand hold cutouts of less than optimal design), or poor (ie, containers of poor design with loose parts or irregular in shape and that are hard to handle) depending on the type and location of the coupling, the physical characteristics of the load, and the vertical height of the lift.²

The term *task variables* refers to the measurable task-related measurements that are used as input data for the formula (ie, H, V, D, A, F, C), whereas the term *multipliers* refers to the reduction coefficients in the equation (ie, HM, VM, DM, AM, FM, CM). The recommended weight limit formula is defined as follows: $RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$ (Table 1).

Lifting index is a term used to calculate the relative estimate of physical stress levels associated with a particular manual lifting task.² “The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the RWL.”^{2(p4)} The LI is the load weight (L),

TABLE 1. Multipliers for Recommended Weight Limit Calculations*

Multiplier	Metric	US Customary
LC = Load constant =	23 kg	51 lb
HM = Horizontal multiplier =	(25 cm/H)	(10 inches/H)
VM = Vertical multiplier =	$1 - (.003 V - 75)$	$1 - (.0075 V - 30)$
DM = Distance multiplier =	$.82 + (4.5/D)$	$.82 + (1.8/D)$
AM = Asymmetric multiplier =	$1 - (.0032A)$	$1 - (.0032A)$
FM = Frequency multiplier =	Average number of lifts per minute, the vertical location of the hands at origin, and the duration of the lifting. A frequency table is available in <i>Applications Manual for the Revised NIOSH Lifting Equation</i> . ¹	
CM = Coupling multiplier =	Good CM = 1.00 if VM < 30 inches or VM ≥ 30 inches Fair CM = 0.95 if VM < 30 inches or 1.00 if VM ≥ 30 inches Poor CM = 0.90 if VM < 30 inches or ≥ 30 inches	Good CM = 1.00 if VM < 75 cm or VM ≥ 75 cm Fair CM = 0.95 if VM < 75 cm or 1.00 if VM ≥ 75 cm Poor CM = 0.90 if VM < 75 cm or ≥ 75 cm

* $RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$.
 1. Waters T, Garg A, Putz-Anderson V. *Applications Manual for the Revised NIOSH Lifting Equation*. NIOSH Publication No. 94-110. Cincinnati, OH: Department of Health and Human Services, National Institute for Occupational Safety and Health; 1994.

the weight of the object lifted, divided by the RWL, or $LI = L/RWL$.

According to NIOSH, the LI may be used to identify potentially hazardous lifting jobs or to compare the relative severity of two jobs for the purpose of evaluating and redesigning them. From the perspective of NIOSH, it is likely that lifting tasks with an $LI > 1.0$ pose an increased risk of lifting-related lower back pain for some fraction of the workforce.³ Lifting jobs should be designed to achieve an LI of 1.0 or less whenever possible.

Some experts believe that worker selection criteria may be used to identify workers who can perform potentially stressful lifting tasks (ie, lifting tasks that would exceed an LI of 1.0) without significantly increasing their risk of work-related injury above the baseline level.^{2,3} Those who endorse the use of selection criteria believe that the criteria must be based on research, empirical observations, or theoretical considerations that include job-related strength testing and/or aerobic capacity testing.²

“Informal” or “natural” selection of workers may occur in many jobs that require repetitive lifting tasks. According to some experts, this may result in a unique workforce that may be able to work above an LI of 1.0, at least in theory, without substantially increasing their risk of lower back injuries above the baseline rate of injury.² Even these experts agree, however, that many workers will be at significant risk for work-related injury when performing highly stressful lifting tasks (ie, lifting tasks that would exceed an LI of 3.0).²

To provide a better understanding of the rationale for the development of the RWL and LI, the *Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks* includes a discussion of the criteria underlying the lifting equation and of the individual multipliers and identifies both the assumptions and the uncertainties in the scientific studies that associate manual lifting and lower back injuries.³ For more detailed information about how to use the RNLE, readers should consult the



Figure 3. Manual lifting of heavy instrument trays should be avoided by using a cart to transport them.

*Applications Manual for the Revised NIOSH Lifting Equation.*²

OR CLINICAL LIFTING CONSIDERATIONS

There may be special circumstances or clinical necessities that require lifting or carrying objects that are too heavy to lift manually. In these cases, manual lifting should be avoided by using a cart to move the object as close as possible to its destination (Figure 3) and then sliding the object rather than lifting it. If this is not possible, it may be necessary to get help with the lift from another coworker. Regardless, it is important to keep the object to be lifted in an optimal vertical height so that the worker does not have to bend or twist his or her trunk to move the object. A guideline for manual lifting has been developed by NIOSH that may be useful for helping to address problem lifting tasks in health care facilities.⁴ The NIOSH guideline provides useful information and a range of example solutions for reducing the risk of manual lifting.

SUMMARY

Lifting of heavy supplies and equipment is performed frequently in the OR. The extended reaches and high weights involved in such lifting require large muscle forces that can create excessive loads on the soft tissues of the spine and shoulder joints. These forces are large enough to cause damage to musculoskeletal tissues that could result in severe lower back or shoulder pain and could lead to permanent disability. It is important, therefore, to determine which tasks may be safe to perform manually and which should be performed with the use of technology, such as patient transfer devices or other ergonomic equipment. This ergonomic tool provides a guideline for making such a determination. As with all ergonomic tools, however, caregivers should continue to rely on their professional experience when making decisions about their use. **AORN**

Editor's note: *The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health or the Veterans Health Administration.*

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