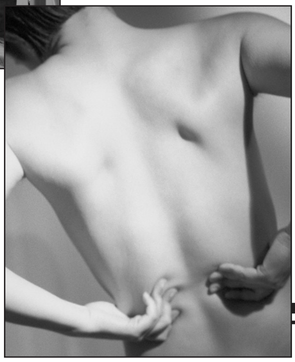

AORN Guidance Statement:

Safe Patient Handling and Movement in the Perioperative Setting

AORN

Association of periOperative Registered Nurses

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Introduction to Safe Patient Handling and Movement in the Perioperative Setting

High-risk patient handling tasks can lead to work-related musculoskeletal disorders (MSDs) for perioperative registered nurses and other members of the perioperative team. These disorders often have serious consequences. Staff members who experience pain and fatigue are less productive, more likely to make mistakes, and more susceptible to further injury. Nurses who are injured, or who are afraid of being injured, may seek other employment or even leave the profession. These factors may contribute to staffing shortages, high turnover, and increased costs for health care facilities.

In 2005, the Workplace Safety Task Force was charged by AORN President Sharon McNamara, RN, MS, CNOR, to prepare a guidance document to support ergonomically healthy workplaces. The goals of the task force were to identify high-risk tasks performed in the perioperative area and to develop evidence-based solutions to minimize the risk of MSDs among perioperative team members. Task force members included representatives from AORN; the National Institute for Occupational Safety and Health (NIOSH); the Patient Safety Center of Inquiry at the James A. Haley Veterans Administration Medical Center (VMAC) in Tampa, Fla; and the American Nurses Association.

Seven clinical tools, or algorithms, were developed by the task force to guide ergonomic workplace safety in the perioperative setting. These clinical tools incorporate current ergonomic safety concepts, scientific evidence, and the use of technology such as safe patient handling equipment. The seven clinical tools, the rationale for their development, and the calculations supporting them were combined into a single document, the "AORN guidance statement: Safe patient handling and movement in the perioperative setting."

The guidance statement is reprinted in its entirety in this publication. Also included is an original article detailing the development of the guidance statement introduces the work of the task force and the process used to analyze the problem of MSDs in the perioperative setting. Throughout the next year, other articles will be published in the *AORN Journal* to explain the use of the clinical tools and provide assistance in implementing them in practice. AORN believes that increased knowledge and widespread acceptance of safe ergonomic practices will help to promote a safer perioperative work environment and protect perioperative team members—as well as their patients—from work-related injury.

PLEASE NOTE: The views expressed in these materials are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs or the National Institute for Occupational Safety and Health.

Development of the *AORN Guidance Statement: Safe Patient Handling and Movement in the Perioperative Setting*

Audrey Nelson, PhD, RN, FAAN; Thomas R. Waters, PhD; Deborah G Spratt, RN, BSN, MPA, CNAA, CNOR; Carol Petersen RN, MAOM, CNOR; Nancy Hughes, MHA, RN

Introduction

High-risk patient handling tasks lead to work-related musculoskeletal disorders (MSDs) for perioperative registered nurses and other members of the perioperative team. A task force including representatives from AORN, the National Institute for Occupational Safety and Health (NIOSH), the Patient Safety Center of Inquiry at the James A. Haley Veterans Administration Medical Center (VMAC), and the American Nurses Association (ANA) was formed to identify high-risk tasks performed in the perioperative area and to develop evidence-based solutions to minimize MSDs. This is the first in a series of articles to describe ergonomic solutions for high-risk patient handling tasks in the perioperative clinical setting.

Background/Statement of Problem

Perioperative registered nurses and the perioperative team are routinely faced with a wide array of occupational hazards in the perioperative setting that place them at risk for work-related MSDs.[1-3] MSDs are one of the most frequently occurring and costly types of occupational issues affecting nurses.[2,4,5] Nurses working in the private sector had 11,800 MSDs reported in 2001. The majority (nearly 9,000) were back injuries.[5] More than a third (36%) of the injuries requiring time away from work were back injuries.[5] One recent study found that more than half of all nurses (52%) complain of chronic back pain. Another study revealed that 12% of nurses planning to leave the profession indicated back injuries were either a main or contributing factor.[6] A different study identified that concern for personal safety in the health care environment was the reason given by 18.3% of the RNs for leaving the profession.[7] While back injuries are one of the most common occupational injuries in the health care industry, one study found that injuries of the shoulder and neck were more likely to prevent nurses from doing their work than low back pain.[6,8-10] When the demands of the job (eg, physical demands, work environment, workplace culture) are incompatible with the capacity of the worker, the risk of MSDs is increased.[1,2,11] The connection between risk factors and MSDs is stronger when exposures are intense and prolonged and when there are several risk factors present at the same time.[12]

The consequences of MSDs are severe. Employees who experience pain and fatigue are less productive, less attentive, more prone to make consistent mistakes, and more susceptible to injury, and they may be more likely to affect the health and safety of others. Nurses suffering from disabling back injuries and fear of being injured have contributed to the number of nurses leaving the profession, thus increasing the nursing shortage. Workplaces with high incidences of MSDs report increases in lost/modified workdays, higher staff turnover, increased costs, and adverse patient outcomes.[7,13-15] The purpose of this project was to identify high-risk tasks in perioperative nursing practice and to design ergonomic solutions to eliminate or reduce occupational risk to workers in these clinical settings.

AORN regards the well-being of the perioperative team members as paramount to the provision of safe patient care. The physical demands of the perioperative environment expose perioperative health care providers to high-risk tasks that put them in jeopardy of MSDs. A safe workplace is necessary to have a positive impact on the health and well-being of both the patient and the health care provider. AORN is committed to providing resources for the development of a safe perioperative work environment. For this reason, the Association contacted Audrey Nelson, PhD, RN, FAAN, to develop a plan to address the unique risks associated with perioperative practice.

Methods

An expert panel was convened to address risk factors for musculoskeletal disorders for registered nurses and other members of the perioperative team. Due to the complexity of the issues, the interdisciplinary panel included experts in perioperative nursing, ergonomics, biomechanics, engineering, industrial hygiene, and injury prevention. The professional nurse representatives included clinical, administrative, education and research perspectives. The expert panel included partnerships from the National Institute for Occupational Safety and Health, the James A. Haley Veterans Administration Medical Center Patient Safety Center of Inquiry (Tampa, Fla), the American Nurses Association, and AORN.

The panel met over an 18-month period in face-to-face meetings, conference calls, and electronic communications until panel members were able to achieve consensus. Through systematic assessment of task demands, direct measurement of weights and forces involved in the tasks, and direct observation of work tasks and equipment, the panel applied ergonomic principles to develop clinical tools for utilization in the perioperative area with the goal of reducing work-related MSDs.

The clinical tools were developed based on professional consensus and evidence from research and were pilot-tested in several facilities. Initially, the team developed a comprehensive list of tasks performed by OR nurses that were physically demanding or contained physically demanding elements. The range of tasks was evaluated and condensed into a list of seven specific tasks of interest. After the seven tasks were identified, the team developed ergonomic tools using the following process.

1. All members of the expert panel discussed each task and provided input into how the task was performed.
2. The professional nurses on the team identified the various physical task requirements of the selected task.
3. Based upon this initial assessment, the technical experts on the team then selected the most important risk factors associated with the task (eg, pushing, pulling, lifting), selected the most appropriate criteria for determining recommended exposure limits for the identified risk factors, and developed weight and force limits for the specific tasks that appear in the decision logic for each tool.

The process used by the ergonomists to develop the weight or force limits involved

- selecting the appropriate physical constraint criteria,
- evaluating the various tasks, and
- calculating strength and lifting capability limits based on the selected constraints.

For each tool, the developers provided a rationale for the selected criteria and how weight and force limits were calculated. Empirical data were used to derive the recommended maximum forces and weights for manual handling for a wide range of tasks performed in the OR work environment. These ergonomic tools were based on consensus and ergonomic criteria typically used in assessing the physical demands of manual handling activities.

Identification of High-Risk Tasks

The first step in the process was to identify high-risk tasks performed in the perioperative setting. High-risk tasks include job demands that push the limits of human capabilities—eg, heavy loads, sustained awkward positions, bending and twisting, reaching, fatigue or stress, force, or standing for long periods of time. It is the combination of frequency, duration, and stress of these tasks that predispose nurses to MSDs. Furthermore, the perioperative setting has some unique challenges due to the use of anesthesia rendering patients unable to assist in movement and needing further protection from injury. Several high-risk tasks have been identified in operating room settings, including the following.

Lateral transfer from stretcher to OR bed[2,3,13]

Few would argue that one of the highest risk patient handling tasks is patient transfer. Patient transfers can start with the patient in a sitting position (ie, vertical transfer) or when the patient is supine (ie, lateral transfer).[16] Lifting and moving patients is a frequent occurrence in the perioperative setting. Patients are transferred to and from transport carts and the OR bed. Patients are repositioned once they are on the OR bed. The perioperative setting poses a unique challenge in that many of the patients are completely or partially dependent due to general or regional anesthesia or sedation. Patients who are unconscious cannot move or feel pain and must be protected from injury. This often requires members of the perioperative team to manually lift the patient or the patient's extremities several times. The position required, and the size and weight of the patient, may increase the risk for MSDs to perioperative team members. This problem is exacerbated with large or obese patients.

Repositioning patients on OR beds[2]
To access key body parts, the patient often must be repositioned on the OR bed. Further, the perioperative nurse monitors patient body alignment and tissue integrity during long procedures and may need to reposition the patient.

Lifting and holding legs, arms, head for prepping[2,13]
Preparing a limb for surgery generally requires the limb to be raised in order to complete circumferential skin preparation. The limb can be suspended by a person holding the limb or by using a holding device. When the limb is held manually during the entire skin prep, it is usually done by one person while a second person performs the skin prep. In some instances, if the limb is small or only the distal portion needs to be prepped, the person performing the skin prep also may hold the limb. If a holding device is used, the limb still needs to be lifted to complete the prep on the area resting on the holder. The person lifting the extremity needs to hold the limb far from his or her body to maintain asepsis. The size of the limb, length of time held, posture necessary to hold the extremity, and physical ability of the person doing the holding all contribute to the ability of the caregiver to safely perform this task.

Prolonged standing[2]
Perioperative registered nurses also are prone to pain and fatigue from static posture during surgical procedures. The sterile perioperative team members are most likely to stand in one place for extremely long periods of time. The sterile team members must maintain the integrity of the sterile field, which prevents them from changing levels by sitting in a chair that is lower than the sterile field to rest and then standing up again. Both acute and chronic back, leg, and foot pain are frequent complaints resulting from standing in one place for long periods of time.

Holding retractors for extended periods of time[2]
In addition to standing for long periods of time, perioperative team members performing in the role of first assistant may be required to hold retractors or body parts for long periods of time. Manual retraction provides exposure of the operative site and is accomplished by gripping and pulling on a retractor or using the hand to retract or steady organs. This manual retraction often results in awkward posture. The height of the surgical field in relation to the person providing retraction influences the risk for MSDs.[17] Prolonged standing, trunk flexion, neck flexion, and arms held higher than the optimal working height place perioperative team members at risk for MSDs.

Lifting and carrying supplies/equipment[2,3,13]
Perioperative personnel frequently are required to carry unsterile and sterile supplies, instrument trays, and other equipment. The weight of an instrument set can vary, but sets can weigh as much as 40 pounds. Sterile instrument sets are wrapped in impervious nonwoven material or contained in closed, hard-surfaced container systems. Both methods can present lifting and carrying problems. Heavy wrapped instrument sets have no handles and are difficult to carry. Container systems have handles but may increase the weight of the tray. In an effort to keep cost down and conserve storage space, instrument trays may be loaded with too many instruments to be safely carried. Removing large instrument sets that have been flash sterilized places the staff at risk for injury. To maintain sterility of the sterilized items, a person must lift and hold the sterile instrument pan away from his or her body. The weight of the pan and the height of the person removing the pan contribute to the degree of MSD risk to the individual.

Pushing, pulling, moving equipment on wheels[2,3,13]
Perioperative nurses and other perioperative personnel are frequently required to move (ie, by pushing or pulling) heavy equipment (eg, OR beds, portable microscopes, portable C-arm imaging machines) several times during the day. These machines are very expensive and often must be shared between several individual operating rooms. OR beds are very heavy and difficult to move by themselves, even without a patient. When an OR bed is moved with a patient on it, the risk of injury increases for both the worker and the patient.

Review Process

Once the expert panel had completed its work, an extensive peer review process was undertaken to refine the ergonomic solutions. The reviewers included nationally known experts in ergonomics, biomechanics, engineering, industrial hygiene, and injury prevention. The panel also obtained administrative reviews from NIOSH, ANA, and the Veterans Health Administration

(VHA), as well as technical review from NIOSH. To ensure that the document could be generalized across diverse clinical settings, the reviewers included perioperative nurses working in all phases of the perioperative setting (ie, preoperative, intraoperative, postoperative areas). Surgery and other invasive procedures are performed in multiple settings that require patient transfer, patient positioning, lifting and holding body parts, lifting and carrying equipment and supplies, pushing/pulling equipment, standing for long periods of time, and holding retractors. These setting include, but are not limited to, inpatient operating rooms, ambulatory surgery centers, office-based surgery centers, and interventional procedure units.

A total of 88 clinical and ergonomic experts were sent requests for review and comment based on their ergonomic expertise or perioperative clinical and/or management experience. The panel was asked to review the document from their individual area of expertise for clinical applicability, technical accuracy, relevance, and usefulness. An organized process included the use of a formal comment form and a specific time frame. Comments were collated and evaluated by the task force for acceptance, and the document was modified as appropriate.

Overview of Solutions

The task force created solutions for each high-risk task identified in perioperative settings. Using principles of ergonomics, scientific evidence, and clinical trials conducted at the VA Patient Safety Center of Inquiry, the following solutions were developed. A brief description of each of the seven tools is included in this article.

The **Algorithm for Safe Lateral Transfer** from the stretcher to and from the OR bed was developed to standardize decision making about the number of staff and type of technology needed to perform this task safely.

The **Algorithm for Safe Positioning/Repositioning the Patient** on the OR bed to and from the supine position was developed to standardize decision making about the number of staff and type of technology needed to perform this task safely.

The **Guidelines for Safe Lifting and Holding Legs, Arms, and Head for Prepping** were developed to identify safe time limits for one-handed and two-handed lifts for each body part.

The **Algorithm for Prolonged Standing** was developed to standardize decision making about the time limits and type of technology needed to perform the task safely.

The **Algorithm for Retraction** was developed to standardize decision making about the type of technology and techniques needed to perform the task safely.

The **Guidelines for Lifting and Carrying Supplies and Equipment** were developed based on the NIOSH Lifting Index.[18,19] This tool includes recommendations for 14 common types of equipment used in the OR. These guidelines were based on weight lifted, horizontal distance, vertical location origin and destination, and distance carried and indicate the level of risk (ie, minimal risk, potential, or considerable) for each task.

The **Guidelines for Safe Pushing, Pulling and Moving Equipment on Wheels** were developed, based on Liberty Mutual's push force limits for several devices commonly used in the OR, to standardize the number of staff and types of technology needed to perform the task safely.

Future Plans

The final document, "AORN guidance statement: Safe patient handling and movement in the perioperative setting," was reviewed by NIOSH, ANA, VHA, and AORN and was subjected to extensive peer review on a national level. It also will undergo pilot testing; the next step is to test the tools and algorithms in different types of perioperative settings. The variety of facilities that perform surgery or other invasive procedures include metropolitan inpatient hospitals, trauma hospitals, rural hospitals, freestanding ambulatory surgery centers, hospital-based ambulatory surgery facilities, and office-based surgery centers. Organizations testing the tools will be asked to evaluate the applicability, acceptance, and availability of the recommended technology.

The wide adoption of safe ergonomic practices will help to promote a safe perioperative work environment and protect perioperative team members. To that end, AORN will seek educational opportunities and endorsement by other perioperative disciplines. This article serves as the first in a planned series to provide detailed justification for each solution identified in the guidance statement.

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AORN Guidance Statement: Safe Patient Handling and Movement in the Perioperative Setting

Description of the Problem

Perioperative registered nurses and the perioperative team are routinely faced with a wide array of occupational hazards in the perioperative setting that place them at risk for work-related musculoskeletal disorders.[1-3] Musculoskeletal disorders are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, or spinal discs associated with actions such as overexertion, repetitive motion, and bodily reaction.[4,5] The US Department of Labor does not include injuries caused by slips, trips, falls, motor vehicle accidents, or similar accidents in their definition of musculoskeletal disorders.[4] Musculoskeletal disorders are one of the most frequently occurring and costly types of occupational issues affecting nurses.[2,6,7] More than a third (ie, 36%) of the musculoskeletal injuries that nurses reported requiring time away from work were back injuries.[8] Among the nurses working in the private sector, nearly 9,000 had back injuries.[8,9] One study revealed that 12% of nurses planning to leave the profession indicated that back injuries were either a primary or contributing factor to their decision.[10] While back injuries are one of the most common occupational injuries in the health care industry, injuries of the shoulder and neck were more likely to prevent nurses from performing their work than low back pain.[10-13] The US Department of Health and Human Services report on nursing identified concern for personal safety in the health care environment as the reason given by 18.3% of nurses for leaving the profession.[14]

When the worker's physical ability, task, workplace environment, and workplace culture are not compatible, there is an increased risk of a musculoskeletal disorder.[1,2,15] The connection between physical risk factors and musculoskeletal disorders is greater when exposures are intense and prolonged and when several occupational risk factors are present at the same time.[16] Examples of physical stressors encountered in health care include

- forceful tasks,
- repetitive motion,
- awkward posture,
- static posture,
- moving or lifting patients and equipment,
- carrying heavy instruments and equipment, and
- overexertion.[1-3,11,12,14,17-26]

The perioperative setting poses unique challenges related to the provision of patient care and completion of procedure-related tasks. This highly technical environment is equipment intensive and necessitates the lifting and moving of heavy supplies and equipment during the perioperative team member's work period. Many of the patients having surgical or other invasive procedures are completely or partially dependent on the caregivers due to the effects of general or regional anesthesia or sedation. Patients who are unconscious cannot move, sense discomfort, or feel pain, and they must be protected from injury. This may require the perioperative team to manually lift the patient or the patient's extremities several times during a procedure. The following are among the high-risk tasks specific to perioperative nurses identified that will be addressed in the following discussion of ergonomic tools:

- transferring patients on and off OR beds,[2]
- repositioning patients in the OR bed,[2]
- lifting and holding the patient's extremities,[2]
- standing for long periods of time,[2]
- holding retractors for long periods of time,[2]
- lifting and moving equipment,[2] and
- sustaining awkward positions.

Transferring, lifting, and handling patients has been identified as the most frequent precipitating trigger of back and shoulder problems in nurses.[2,27] Certain patient handling tasks (eg, patient transfers) have been identified as high risk for musculoskeletal injuries to health care workers.[27] Lifting and moving patients is a frequent activity in the perioperative setting; for example, caregivers transfer patients to and from transport carts (eg, stretchers) and the OR bed many times during a typical work shift.

Health care providers often reposition patients once they are on the OR bed to provide appropriate exposure of the surgical site. This high-risk activity requires team members to physically lift and maneuver the patient or a patient's extremity while simultaneously placing a positioning device. The patient's weight may not be evenly distributed; the extremity's mass may be bulky and asymmetric, and it may be difficult to hold the extremity close to the health care provider's body during positioning maneuvers.[28] Additionally, concern for the patient's airway, maintaining his or her body alignment, and supporting the extremities may make it difficult for team members to position themselves in an ergonomically safe position, thus exacerbating physical demands.

Several unique aspects of high-risk patient handling tasks associated with prepping a patient's limb have been identified.[29] Preparing an extremity for surgery generally requires it to be elevated to allow complete circumferential skin preparation. The limb can be suspended by a person holding the limb or by placing the limb in a holding device. In some instances, the limb may be held manually during the entire skin prep while a second person performs the skin prep. The person performing the skin prep may also hold the limb if the limb is small or if only the distal portion needs to be prepped. To maintain asepsis, the person lifting the extremity is forced to hold the limb extended away from his or her body. The size of the limb, length of prep time, posture necessary to hold the extremity, and the physical capability of the person holding the limb all contribute to the ability of the caregiver to safely suspend the limb for the required prep. The following questions should be considered when determining how to safely raise and hold a limb.

- Does the limb need to be raised for the entire surgical skin prep?
- Does the limb need to be lifted by scrubbed or unscrubbed personnel?
- Is the person holding the limb strong enough to perform the task?
- Is there an alternative practice that can be adopted?
- Is there equipment that could be used to support the task?
- Is it possible to hold a heavy limb safely without risk of injury to the nurse or the patient?[29]

Perioperative registered nurses are prone to pain and fatigue from static posture during surgical procedures. The entire perioperative team spends a significant amount of time on their feet during the course of a shift; however, sterile perioperative team members may be required to stand for much longer periods of time. The sterile team members must maintain the integrity of the sterile field, which precludes them from changing levels. They should not alternate between sitting in a chair that is lower than the sterile field and a standing position. Acute and chronic back, leg, and foot pain are frequent complaints resulting from standing in one place for long periods of time. The following factors should be considered during surgical or other invasive procedures. Are the sterile members of the team

- at the appropriate height for the level of the OR bed?
- adopting awkward positions to work effectively?
- positioned in close proximity to the patient to perform required tasks?
- stretching and relaxing muscles regularly?[29]

Perioperative nurses and other perioperative personnel are frequently required to push or pull heavy equipment (eg, OR beds, portable microscopes, video carts). This equipment is very expensive and often must be shared between several individual operating rooms. Unoccupied OR beds are very heavy and difficult to move. Moving an occupied OR bed is not recommended because the risk of injury increases for both the worker and the patient.

Perioperative personnel and central processing personnel are frequently required to carry sets of surgical instruments. Instrument set weights vary and may weigh as much as 40 pounds. Instrument trays are wrapped with impervious nonwoven material or contained in a ridged container system. Both packaging methods can present lifting and carrying problems. Wrapped instrument sets that are too heavy may pose an additional problem because they have no handles and are awkward to carry. Rigid container systems often have handles that make carrying easier, but the weight of the container itself adds to the total weight of a full tray. In an effort to keep costs down and conserve storage, space instrument trays may be inappropriately prepared and too heavy to lift or carry safely. Instrument sets that are flash sterilized require staff members to aseptically remove the hot trays from the sterilizer. The weight of these trays and the height of the person removing them from the sterilizer in relation to the height of the sterilizer chamber contribute to the degree of risk to that individual.

The consequences of musculoskeletal disorders are severe. Employees who experience pain and fatigue are less productive and attentive, more prone to make mistakes, more susceptible to further injury, and may be more likely to affect the health and safety of others. Nurses suffering from disabling back injuries or the fear of getting injured have contributed to the number of nurses leaving the profession, thus increasing the nursing shortage. Workplaces with high incidences of musculoskeletal disorders report increases in lost or modified workdays, higher staff member turnover, increased costs, and adverse patient outcomes.[14,29,30]

Description of the Process

The 2005–2006 Workplace Safety Task Force was charged by AORN President Sharon McNamara, RN, MS, CNOR, to prepare a guidance document for ergonomically healthy workplaces. In addition, the task force was charged with forming a collaborative arrangement with the National Institute for Occupational Safety and Health (NIOSH) and the American Nurses Association (ANA) to work together to discuss, design, and advance the agenda of healthy work sites for perioperative professionals, to include ergonomic safety. This document was developed by AORN with the assistance of a panel of experts from the Patient Safety Center of Inquiry, Tampa, Fla; the James A. Haley Veterans Administration Medical Center (VMAC); the NIOSH Division of Applied Research and Technology Human Factors and Ergonomics Research Team; and ANA.

Members of the task force examined current research, literature, and patient care practices to evaluate and make recommendations to promote patient and caregiver safety when performing activities in a perioperative setting. While there are several high-risk tasks specific to perioperative nurses, the task force identified seven key activities as the starting point for developing recommendations. Some of these recommendations are based upon current technology that can be immediately implemented. Others, such as use of ceiling lifts in operating rooms, are in development or are projected patient handling innovations. This group will continue to examine what is available and encourage manufacturers to develop new and innovative technologies to achieve the optimal safety of the patient and the caregiver. Development of this equipment is critical for successful implementation of these ergonomic tools.

The ergonomic tools developed for this guidance document are based on previous work by Audrey Nelson, PhD, RN, FAAN; experts within the Veterans Administration (VA); and nationally recognized researchers.[28] The ergonomic tools for safe patient handling and movement have been designed with the goal of eradicating job-related musculoskeletal disorders in perioperative nurses. The ergonomic tools and algorithms were developed based on professional consensus and evidence from research. Plans are under way for pilot tests in several facilities.

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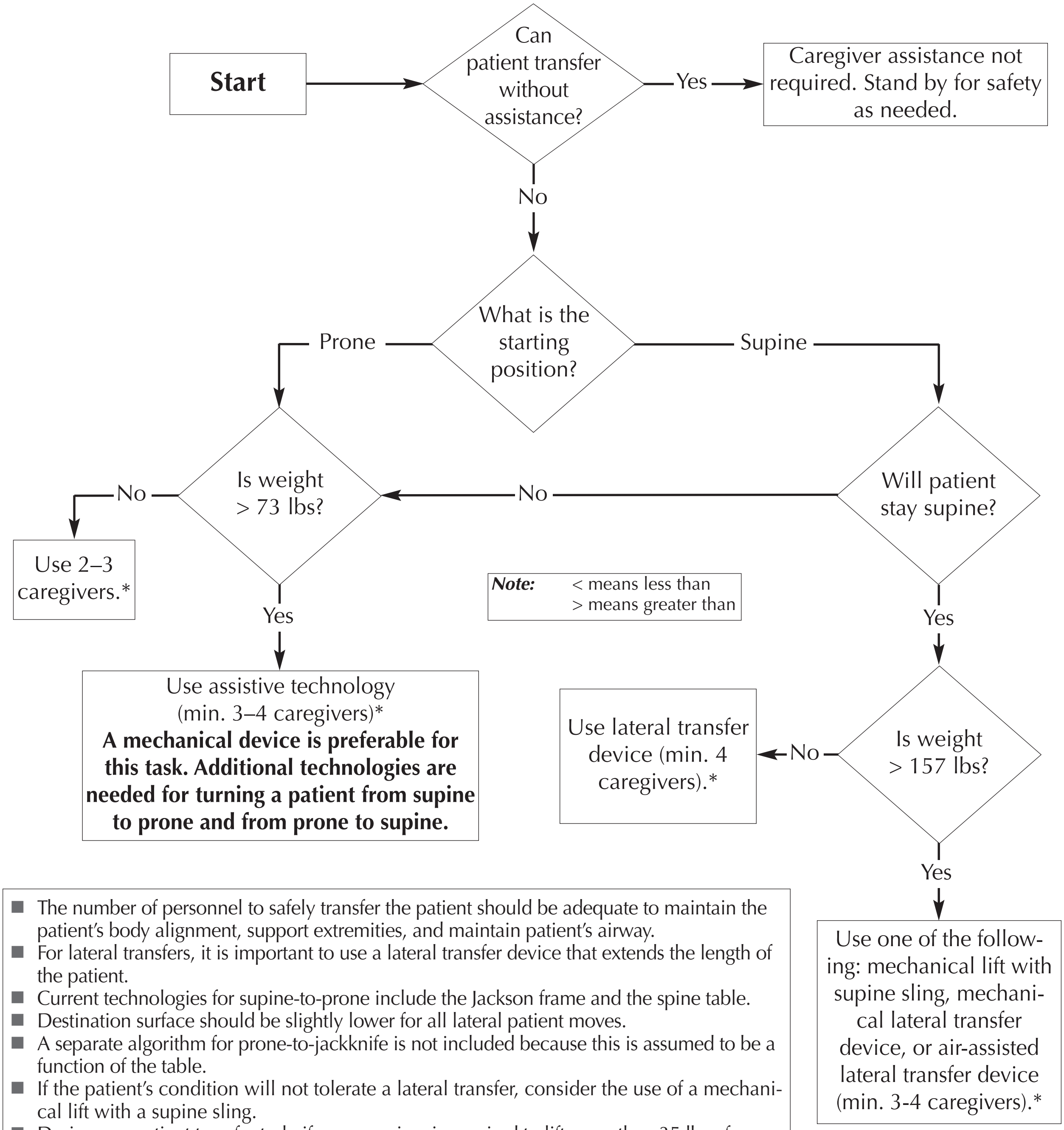
Ergonomic Tool #1

LATERAL TRANSFER FROM STRETCHER TO AND FROM THE OR BED



- The number of personnel to safely transfer the patient should be adequate to maintain the patient's body alignment, support extremities, and maintain patient's airway.
- For lateral transfers, it is important to use a lateral transfer device that extends the length of the patient.
- Current technologies for supine-to-prone include the Jackson frame and the spine table.
- Destination surface should be slightly lower for all lateral patient moves.
- A separate algorithm for prone-to-jackknife is not included because this is assumed to be a function of the table.
- If the patient's condition will not tolerate a lateral transfer, consider the use of a mechanical lift with a supine sling.
- During any patient transfer task, if any caregiver is required to lift more than 35 lbs of a patient's weight, assistive devices should be used for the transfer.
- While some facilities may attempt to perform a lateral transfer simultaneously with positioning the patient in a lateral position (ie, side-lying), this is not recommended until new technology is available.
- The assumption is that the patient will leave the operating room in the supine position.

* One of the caregivers may be the anesthesia provider.

Ergonomic Tool #1: Lateral Transfer From Stretcher To and From the OR Bed

Transferring a patient to and from the OR bed is one of the first actions of the perioperative team. The AORN "Recommended practices for positioning the patient in the perioperative practice setting" recommends that the perioperative registered nurse perform a preoperative assessment for patient-specific positioning needs.[31] Based on that assessment and using **Ergonomic Tool #1**, the patient will be transferred to and from the OR bed in an ergonomically safe manner.

Supine to Prone Transfer

Assuming that one caregiver or anesthesia care provider supports the patient's head and neck during supine to prone transfers, the patient's remaining body mass equals 91.6% of his or her total body mass.[32] Using the approach for lifting and holding, a maximum two-handed load to achieve 75% US adult female design goal equals 22.2 lbs (10.1 kg).* Typically one of the four caregivers moving a patient is the anesthesia care provider who maintains the airway and supports the patient's head. Two caregivers plus the anesthesia care provider can safely transfer a patient weighing up to 48.5 lbs (22.0 kg) from supine to prone position. Three caregivers, plus an anesthesia care provider, can safely transfer a patient weighing up to 72.7 lbs (33.0 kg). If the patient's weight is greater than 73 lbs, it is necessary to use assistive technology and a minimum of three to four caregivers. Although this has been identified as a gap in technology, a mechanical device is preferable for this task and should be developed.

Supine to Supine Transfer

The desirable approach for lateral transfer of a patient involves use of a lateral transfer device (eg, friction-reducing sheets, slider board, and air-assisted transfer device). If only a draw sheet is used without a lateral transfer device, the care provider exerts a pull force up to 72.6% of the patient's weight.[33] Assuming that one caregiver or anesthesia care provider supports the patient's head and neck to maintain the airway during lateral transfers, the remaining mass of the patient's body equals 91.6% of his or her total body mass.[32] Research indicates that for a pulling distance of 6.9 ft (2.1 m) or less, where the pull point (ie, starting point for the hands) is between the caregiver's waist and nipple line, and the task is performed no more frequently than once every 30 minutes, the maximum initial force required equals 57 lbs (26 kg) and the maximum sustained force needed equals 35 lbs (16 kg).[34] Therefore, each caregiver can safely contribute a pull force required to transfer up to 48 lbs (35 lbs/0.726 as referenced above). For one caregiver, plus the anesthesia care provider, maximum patient weight equals 52.6 lbs (48lbs/0.916 as referenced above). Two caregivers plus the anesthesia care provider can safely transfer a patient up to 104.8 lbs (48 x 2)/0.916 as referenced above). Three caregivers plus the anesthesia care provider can safely transfer a patient up to 157.2 lbs (48 x 3)/0.916 as referenced above). If the patient is > 157 lbs, use an appropriate mechanical lifting device—ie, mechanical lift with supine sling, mechanical lateral transfer device, or air-assisted lateral transfer device—and a minimum of three to four caregivers.

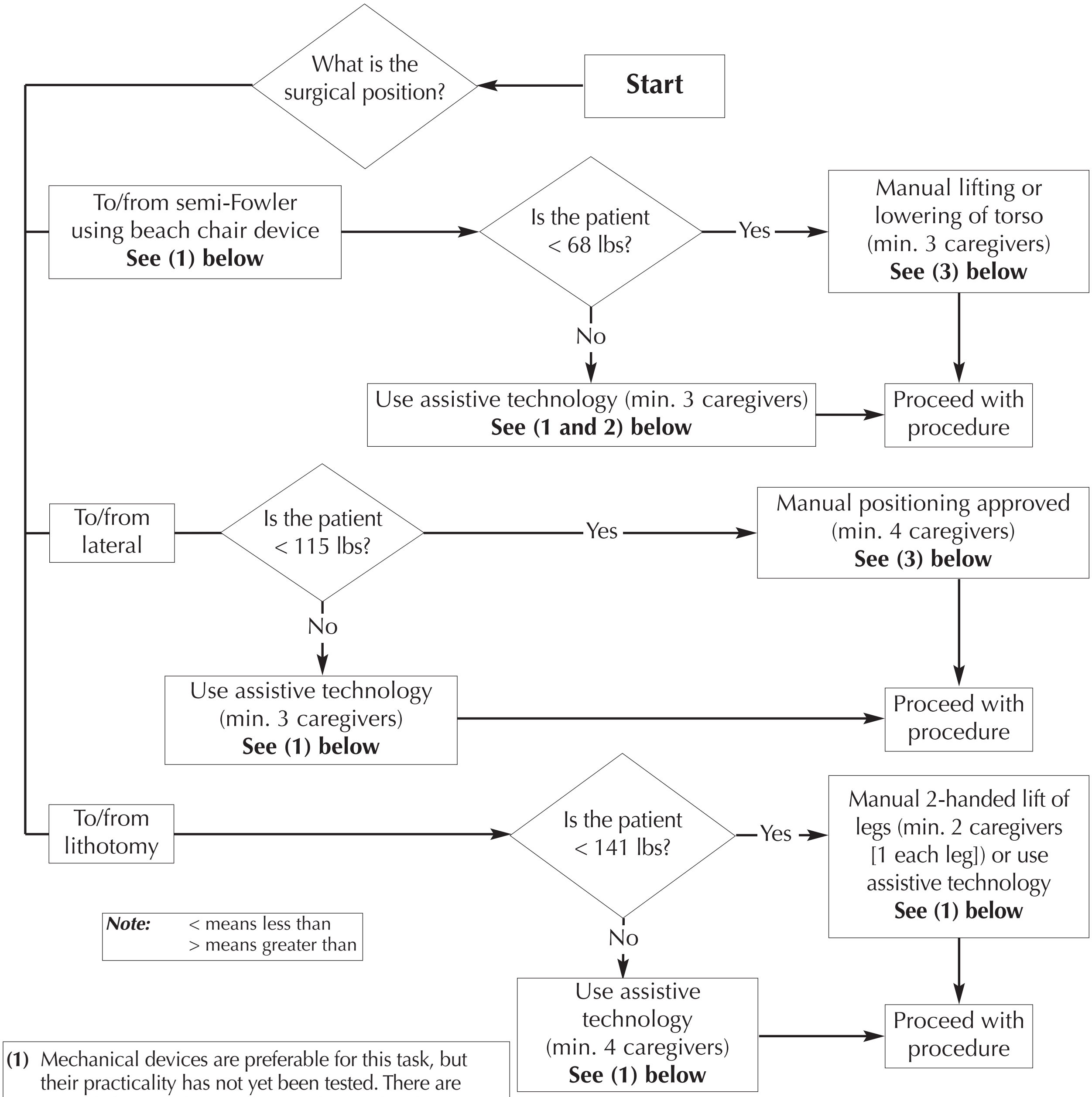
*Calculation of Design Goal

To accommodate the design goal of 75% of the US adult female working population, **maximum load for a one-handed lift** is calculated to be 11.1 lbs (5.0 kg), assuming a worst-case scenario where the patient load may be handled at full arm's length. This is determined by calculating the strength capabilities for the 25th percentile US adult female maximum shoulder flexion moment (25th percentile strength = 31.2 Nm, based on mean of 40 Nm and standard deviation of 13 Nm, therefore 25th percentile = 31.2 Nm)[35] and the 75th percentile US adult female shoulder to grip length (75th percentile length = 630 mm, based on mean of 610 mm and standard deviation of 30 mm).[36] Therefore, maximum one-handed lift is calculated as 31.2 Nm divided by 0.63 m, which equals 49.5 N, or 11.1 lbs.

Maximum load (for one person) for a two-handed lift (22.2 lb/10.1 kg) is calculated as twice that of a one-handed lift. According to Rohmert, muscle strength capabilities diminish as a function of time.[37] Therefore, maximum loads for two-handed holding of body parts are presented for one-, two-, and three-minute durations. After one minute, muscle endurance has decreased by 48%; by 65% after two minutes; and after three minutes of continuous holding, strength capability is only 29% of initial lifting strength.

Ergonomic Tool #2

POSITIONING/REPOSITIONING THE PATIENT ON THE OR BED INTO AND FROM THE SUPINE POSITION



(1) Mechanical devices are preferable for this task, but their practicality has not yet been tested. There are special slings and straps that can be used with mechanical devices. For example, turning straps can be used to turn a patient to and from lateral or supine, or limb support slings can be used to lift the legs to and from lithotomy. More research is needed.
(2) Use the automatic semi-Fowler positioning feature of an electric table if available.
(3) One of these caregivers could be the anesthesia provider to hold the head and maintain the airway.

- During any patient handling task, if any caregiver is required to lift more than 35 lbs of a patient's weight, an assistive device should be used.
- The number of personnel to safely position the patient should always be adequate to maintain the patient's body alignment.
- A separate algorithm for prone-to-jackknife is not included because this is assumed to be a function of the table.

Ergonomic Tool #2: Positioning and Repositioning the Patient on the OR Bed Into and From the Supine Position

The AORN "Recommended practices for positioning the patient in the perioperative practice setting" require that "the perioperative nurse should actively participate in monitoring patient body alignment and tissue integrity based on sound physiologic principles." It further states, "an inadequate number of personnel and equipment can result in patient injury."[31] **Ergonomics Tool #2** provides evidence-based guidelines to assist the perioperative registered nurse and other team members to position and reposition the patient on the OR bed in a safe manner for the patient and the team.

Moving the Patient Into and Out of a Semi-Fowler Position

The mass of a patient's body from the waist up, including the head, neck, and upper extremities, equals 68.6% of the patient's total body weight.[32] Added to this is the estimated weight of the equipment (20 lbs/9.1 kg). To accommodate at least 75% of the US adult female working population, the maximum load for a two-handed lift is 22.2 lbs (10.1 kg). This is determined based on 25th percentile US adult female shoulder strength capabilities[35] and 75th percentile US adult female arm length.[36] Therefore, three caregivers together could lift up to 66.6 lbs (10.3 kg), which equates to a 68-lb (30.1 kg) patient.* Mechanical devices and a minimum of three caregivers are preferable if the patient weighs more than 68 lbs. An example of an appropriate mechanical device is the automatic semi-Fowler positioning feature of an electric OR bed. Further research to address gaps in technology is recommended.

Positioning the Patient Into and From the Lateral Position

Positioning or repositioning a patient into or out of a lateral position involves push/pull forces rather than lifting forces. Assuming that one caregiver or anesthesia care provider supports the patient's head and neck during lateral positioning, the patient's remaining body mass equals 91.6% of total body mass.[32] Based on the Liberty Mutual tables (see **Table 3** under **Ergonomic Tool #7**) for a pulling distance of 6.9 ft (2.1 m) or less, with a pull point (ie, starting position of the hands) between the caregiver's waist height and nipple line, performed no more frequently than once every 30 minutes, maximum initial force equals 57 lbs (26 kg), and maximum sustained force equals 35 lbs (16 kg).[34] Therefore, two caregivers, plus an anesthesia care provider maintaining the patient's airway, can safely position a patient weighing up to 76 lbs (34.5 kg) (35 lbs x 2 care providers/0.916 as referenced above). Three caregivers plus an anesthesia care provider can safely position a patient weighing up to 115 lbs (52.2 kg) (35 lbs x 3 care providers/0.916 as referenced above). If the patient's weight exceeds 115 lbs, lateral positioning devices are needed. Further research is needed to enhance technology to address this task.

Positioning the Patient Into and From the Lithotomy Position

When lifting and holding body parts, the maximum load for a two-handed lift is 22.2 lbs (10.1 kg). Each complete lower patient extremity, including thigh, calf, and foot, weighs 15.7 % of the patient's total body mass. Therefore, one caregiver can safely perform this task if the patient weighs 141 lbs (64.1 kg) or less because each leg is estimated to be less than 22.2 lbs.[33]

Caregivers attempting to lift the patient's legs using two hands can each safely lift one leg for patients weighing less than 141 lbs. Patients weighing more than 141 lbs require assistive technology or four caregivers (ie, two to lift each leg). A mechanical device such as support slings can be used to lift the legs to and from the lithotomy position. Further research is needed to enhance availability of technology to address this task.

*$\textbf{Maximum patient weight (68 lbs)} = \dfrac{\text{(Maximum 2-handed lift (22 lbs) x 3 caregivers) – equipment weight (20 lbs)}}{\text{Percentage of patient weight above the waist (0.686)}} = 68 \text{ lbs}$

Ergonomic Tool #3: Lifting and Holding Legs, Arms, and Head for Prepping in a Perioperative Setting

Introduction

AORN's "Recommended practices for skin preparation of patients" states that "when indicated, the surgical site and surrounding area should be prepared with an antiseptic agent. The prepared area of skin and the drape fenestration should be large enough to accommodate extension of the incision, the need for additional incisions, and all potential drain sites."[38] To accomplish this task, a member of the perioperative team may need to hold the extremity so that the appropriate body part is prepared in the required manner.

Ergonomic Tool #3 shows the calculations for average weight for an adult patient's leg, arm, and head as a function of whole body mass, ranging from slim to morbidly obese body type. Weights are presented both in US (lbs) and metric (kg) units. Maximum lift and hold loads were calculated based on 75th percentile shoulder flexion strength and endurance capabilities for US adult females, where the maximum weight for a one-handed lift is 11.1 lbs and a two-handed lift, 22.2 lbs.

Ergonomic Tool #3

LIFTING AND HOLDING LEGS, ARMS, AND HEAD FOR PREPPING

Patient Weight lbs (kg)	Body Part	Body Part Weight lbs (kg)		Lift 1-hand	Lift 2-hand	Hold 2-hand <1 min	Hold 2-hand < 2 min	Hold 2-hand < 3 min
<120 lbs (< 54 kg)	Leg	< 19 lbs	(9 kg)					
	Arm	< 6 lbs	(3 kg)					
	Head	< 10 lbs	(5 kg)					
120-160 lbs (54-73 kg)	Leg	< 25 lbs	(11 kg)					
	Arm	< 8 lbs	(4 kg)					
	Head	< 13 lbs	(6 kg)					
160-200 lbs (73-91 kg)	Leg	< 31 lbs	(14 kg)					
	Arm	< 10 lbs	(5 kg)					
	Head	< 17 lbs	(8 kg)					
200-240 lbs (91-109 kg)	Leg	< 38 lbs	(17 kg)					
	Arm	< 12 lbs	(6 kg)					
	Head	< 20 lbs	(9 kg)					
240-280 lbs (109-127 kg)	Leg	< 44 lbs	(20 kg)					
	Arm	< 14 lbs	(6 kg)					
	Head	< 24 lbs	(11 kg)					
280-320 lbs (127-145 kg)	Leg	< 50 lbs	(23 kg)					
	Arm	< 16 lbs	(7 kg)					
	Head	< 27 lbs	(12 kg)					
>360 lbs (>163 kg)	Leg	> 57 lbs	(26 kg)					
	Arm	> 18 lbs	(8 kg)					
	Head	> 30 lbs	(14 kg)					

No shading: OK to lift and hold; use clinical judgment and do not hold longer than noted.
Heavy shading: Do not lift alone; use assistive device or more than one caregiver.

The shaded areas of the table indicate whether it would be acceptable for one caregiver to lift the listed body parts or hold the respective body parts for 0, 1, 2, or 3 minutes with one or two hands. Respecting these limits will minimize risk of muscle fatigue and the potential for musculoskeletal disorders. Perioperative registered nurses must use clinical judgment to assess the need for additional staff member assistance or assistive devices to lift and/or hold one of these body parts for a particular period of time.

Rationale and Calculations for Ergonomic Tool #3

***Note:** These are guidelines for the average weight of the leg, arm, and head based upon the patient's weight. Nurses should use their clinical judgment to assess the need for additional staff member assistance or assistive devices to lift and/or hold one of these body parts for a particular period of time. The maximum weight for a one-handed lift is 11.1 lbs and for a two-handed lift, 22.2 lbs.*

Patient weight is divided into seven categories (see **Ergonomic Tool #3**), ranging from very light to morbidly obese. Normalized weight for each leg, each arm, and head is calculated as a percentage of body weight where each complete lower extremity (ie, upper arm, forearm, hand) weighs 5.1% of total body mass and the head plus neck combined weighs 8.4% of total body mass.[32] All weights are presented in both pounds and kilograms, rounded to the nearest whole unit.

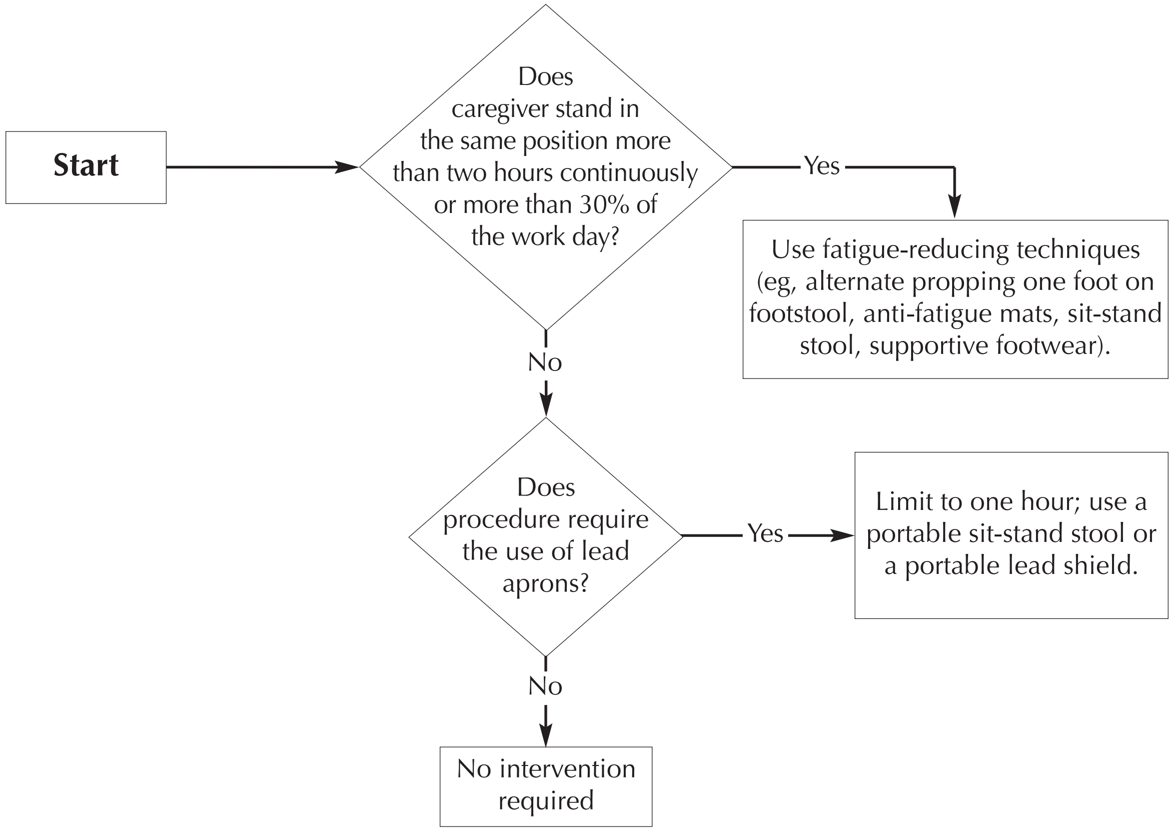
To accommodate 75% of the US adult female working population, maximum load for a one-handed lift is calculated to be 11.1 lbs (5.0 kg). This is determined by calculating the strength capabilities for 25th percentile US adult female maximum shoulder flexion moment (the mean equals 40 Newton meters; standard deviation equals 13 Nm)[35] and 75th percentile US adult female shoulder to grip length (the mean equals 610 mm, the standard deviation equals 30 mm).[36] Maximum loads for one person for a two-handed lift (ie, 22.2 lbs/10.1 kg) are calculated as twice that of a one-handed lift. Muscle strength capabilities diminish as a function of time; therefore, maximum loads for two-handed holding of body parts are presented for 1, 2, and 3 minute durations.[37] After 1 minute, muscle endurance has decreased by 48%, decreasing by 65% after 2 minutes, and after 3 minutes of continuous holding, strength capability is only 29% of initial lifting strength. If the limits in **Ergonomic Tool #3** are exceeded, additional staff members or assistive limb holders should be used.

Ergonomic Tool #4: Prolonged Standing

Perioperative team members who are scrubbed or first assisting for long periods of time may be susceptible to injuries caused by static load.[39-44] Prolonged standing, trunk flexion, and neck flexion are all components of static load.[45,46] **Ergonomic Tool #4**, which appears on the following page, assists perioperative team members to take protective action to decrease the stress caused by prolonged standing.

Ergonomic Tool #4

PROLONGED STANDING



General recommendations

- Caregiver should wear supportive footwear that has the following properties:
  - does not change the shape of the foot;
  - has enough space to move toes;
  - shock-absorbing, cushioned insoles;
  - closed toe; and
  - height of heel in proportion to the shoe.
- Caregivers may benefit from wearing support stockings/socks.
- Anti-fatigue mats should be on the floors.
- Anti-fatigue mats should be placed on standing stools.
- The sit-stand chair should be set to the correct height before setting the sterile field so caregivers will not be changing levels during the procedure.*
- Be aware of infection control issues for nondisposable and anti-fatigue matting.
- Accommodations for pregnancy were considered, but the two-hour limit on prolonged standing covers this condition.
- Scrubbed staff should not work with the neck flexed more than 30 degrees or rotated for more than one minute uninterrupted.
- Two-piece, lightweight lead aprons are recommended.
- During the sit-to-stand break, staff should look straight ahead for a short while.

* "Recommended practices for maintaining a sterile field," in *Standards, Recommended Practices, and Guidelines* (Denver, Colo: AORN, Inc, 2007) 665-672.

Ergonomic Tool #5: Retraction

Sterile perioperative team members or those performing in the role of first assistant may be required to hold retractors or body parts for long periods of time, in addition to standing for long periods of time. Manual retraction used to provide exposure of the operative site for the surgeon often requires first assistants to stand in an awkward posture for long periods of time to grip and pull a retractor or to use their hands to retract or steady organs (eg, heart). The height of the surgical field in relation to the person providing retraction influences the risk for musculoskeletal injury.[47] Prolonged standing, trunk flexion, neck flexion, and arms held higher than the optimal working height place perioperative team members at risk for a musculoskeletal injury.

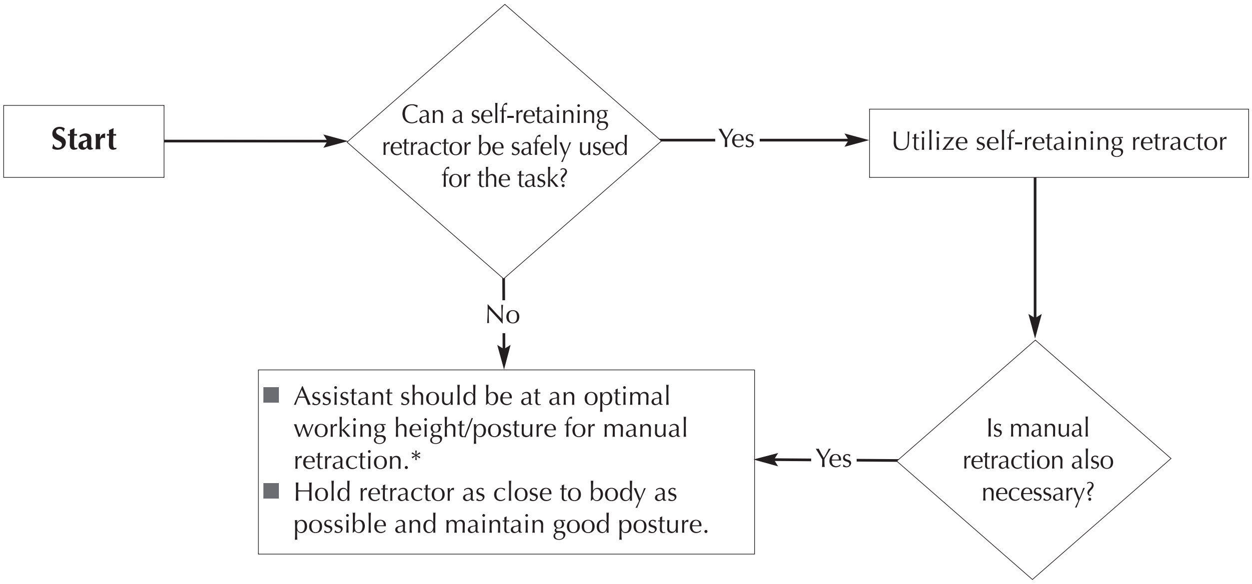
Ergonomic Tool #6: Lifting and Carrying Supplies and Equipment

Members of the perioperative team may need to lift and carry many different types of unsterile and sterile supplies, instrument trays, and equipment. This tool is intended to assist caregivers in evaluating these tasks and taking measures to protect themselves. Information from Association for the Advancement of Medical Instrumentation, the organization that sets standards for safety and efficacy of medical instrumentation, recommends that instrument trays weigh a maximum of 25 lbs.[48]

Manual lifting and carrying of objects is physically demanding and may place the worker at substantial risk of low back pain. The NIOSH has developed an equation for calculating the recommended weight

Ergonomic Tool #5

RETRACTION



- Arm rests should be utilized as possible and be large enough to allow repositioning of the arms.
- Under optimal working height and posture, an assistive device should be used to lift or hold more than 35 lbs.
- Further research is needed to determine time limits for exposure. Since this is a high-risk task, caregivers should take rest breaks or reposition when possible.
- Avoid using the hands as an approach to retraction; it is very high-risk for musculoskeletal or sharps injuries.

* Optimal working height is defined as area between the chest and the waist height to operative field. Optimal posture is defined as perpendicular/straight-on to the operative field; asymmetrical posture may be acceptable, depending on load and duration; torso twisting should be avoided at all times.

limit and lifting index for assessing the physical demands of manual lifting tasks.[49,50] A description of the NIOSH lifting equation is presented in the section entitled "Other background materials."

Typical lifting tasks performed by perioperative nurses were identified and evaluated for potential risk of low back pain due to manual lifting using the Revised NIOSH Lifting Equation (RNLE). **Ergonomic Tool #6** lists the lifting index values for these tasks. According to NIOSH, tasks with a lifting index value greater than 1.0 place some workers at risk of low back pain and a lifting index value greater than 3.0 places many workers at risk of low back pain. In a subsequent study that examined the effects of the NIOSH lifting index as a predictor, the risk of back pain increases when the lifting index exceeds 2.0.[51] As can be seen in the table, tasks with a lifting index value less than 1.0 can easily be performed manually. For those tasks with a lifting index value greater than 1.0, however, caution should be used. Alternate handling procedures may help reduce risk of low back pain due to lifting these objects. The list is not all inclusive; the NIOSH equation can be used to calculate a lifting index value for other two-handed manual lifting tasks not on the list.[50]

***Note:** Assistive devices include adjustable-height lift tables, rolling carts, two-wheeled carts, dollies, or mechanical transport devices.*

Rationale and Calculations for Ergonomics Tool #6

A series of typical operating room lifting tasks were identified and evaluated with the NIOSH Lifting Equation (NLE) for potential risk of low back pain due to manual lifting of objects in support of patient care (see **Table 1**). The NLE is a tool for assessing manual lifting of objects that allows the user to calculate the recommended weight limit for a specified two-handed manual lifting task. In addition, the lifting index for the task can be calculated by dividing the actual weight of the load lifted by the recommended weight limit (for details, see "Other background material").

Ergonomic Tool #6

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.

Table 1

DATA USED TO CALCULATE THE NIOSH LIFTING INDEX VALUES FOR TYPICAL ITEMS LIFTED IN THE OR						
Lifting Task	Weight (lbs.)	Horizontal Distance (inches)	Vertical Location-Origin (inches)	Vertical Location-Destination (inches)	Distance Carried (feet)	Lifting Index
3000 cc IV bags irrigation fluids	2.5 lbs	6 in	42 in	30 in	49–118 ft	< 0.2
Sand bags	10.5 lbs	12 in	30 in	32 in	20 ft	0.3
Linen bags	15 lbs	6 in Set = 10 in	Floor Set = 0 in	42 in	140–251 ft	0.4
Lead aprons	16 lbs	13 in	36 in	36 in	N/A on cart	0.4
Custom sterile packs (heart or spine)	12.4 lbs	18 in	23 in	32 in		0.5
Garbage bags (full)	23.6 lbs	6 in Set = 10 in	Floor Set = 0 in	42 in	140–251 ft	0.7
Positioning devices off shelf or rack (stirrups)	17 lbs each (2 stirrups would be 34 lbs)	18 in	36 in	36 in		0.7
Positioning devices off shelf or rack (gel pads)	8–25 Set to 25 lbs	18 in	36 in	36 in	5–10 ft	0.9
Hand table (49″ x 28″); largest hand table, used infrequently	15–27 lbs Set to 27 lbs	20 in	43 in	32 in	49–118 ft	1.2
Fluoroscopy board (49″ x 21″)	26 lbs	20 in	43 in	32 in	49–118 ft	1.2
Stirrups (2, one in each hand)	34 lbs	18 in	36 in	36 in		1.4
Wilson frame	27 lbs	32 in	31.5 in	32 in	49–118 ft	1.4
Irrigation containers for lithotripsy (12,000 mL)	0–50 lbs Set to 50 lbs	6 in Set = 10	63 in (top shelf)	N/A Housekeeping places in bags Set to 33 in	49–118 ft	1.5
Instrument pans	3–38 lbs Set to 38 lbs	19 in	6–50 in Set to 6 in	Varies Set to 34 in	5–10 ft	2.0

Ergonomic Tool #7: Pushing, Pulling, and Moving Equipment on Wheels

Introduction

Case preparation is a combination of many activities. The movement of patients, supplies, and equipment in and out of the OR contributes to physical stress and should be performed based on scientific evidence. The recommendations in **Ergonomic Tool #7** are a result of research done by task force members and include some, but not all, of the necessary activities undertaken to prepare for a case.

Pushing forces were measured for equipment listed in the following table. Maximum pushing distances were determined based on Liberty Mutual's psychophysical limits. All results are presented in both US and metric units.

Based on these results, it is clear that pushing an occupied standard hospital bed or standard or specialty OR beds, whether occupied or not, presents a moderate to high risk of injury to the caregiver. For these situations it is strongly recommended that a minimum of two caregivers participate in the transport task, or ideally, that a powered transport device is used.

Recommendations

The recommendations in **Ergonomic Tool #7** are based on Liberty Mutual's psychophysical limits for push forces, where hands are positioned at a middle push point of 3 ft (0.92 m) from the floor or above and task is performed no more frequently than once every 30 minutes.[34]

- Pushing tasks are ergonomically preferred over pulling tasks.[34]
- Ensure that handles are at a correct push height of approximately 3 ft (0.92 m) from the floor.[34]

Ergonomics Tool #7

RECOMMENDATIONS FOR PUSHING, PULLING, AND MOVING EQUIPMENT ON WHEELS					
OR Equipment	Pushing		Max Push Distance ft/(m)		Ergonomic Recommendation
Electrosurgery unit	8.4 lbF	(3.8 kgF)	>200 ft	(60 m)	
Ultrasound	12.4 lbF	(5.6 kgF)	>200 ft	(60 m)	
X-ray equipment portable	12.9 lbF	(5.9 kgF)	>200 ft	(60 m)	
Video towers	14.1 lbF	(6.4 kgF)	>200 ft	(60 m)	
Linen cart	16.3 lbF	(7.4 kgF)	>200 ft	(60 m)	
X-ray equipment, C-arm	19.6 lbF	(8.9 kgF)	>200 ft	(60 m)	
Case carts, empty	24.2 lbF	(11.0 kgF)	>200 ft	(60 m)	
OR stretcher, unoccupied	25.1 lbF	(11.4 kgF)	>200 ft	(60 m)	
Case carts, full	26.6 lbF	(12.1 kgF)	>200 ft	(60 m)	
Microscopes	27.5 lbF	(12.5 kgF)	>200 ft	(60 m)	
Hospital bed, unoccupied	29.8 lbF	(13.5 kgF)	>200 ft	(60 m)	
Specialty equipment carts	39.3 lbF	(17.9 kgF)	>200 ft	(60 m)	
OR stretcher, occupied, 300 lbs	43.8 lbF	(19.9 kgF)	>200 ft	(60 m)	
Bed, occupied, 300 lbs	50.0 lbF	(22.7 kgF)	<200 ft	(30 m)	**Min two caregivers required**
Specialty OR beds, unoccupied	69.7 lbF	(31.7 kgF)	<100 ft	(30 m)	
OR bed, unoccupied	61.3 lbF	(27.9 kgF)	<25 ft	(7.5 m)	Recommend powered transport device
OR bed, occupied, 300 lbs	112.4 lbF	(51.1 kgF)	<25 ft	(7.5 m)	
Specialty OR beds, occupied, 300 lbs	124.2 lbF	(56.5 kgF)	<25 ft	(7.5 m)	

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.

- For tasks where the push point is lower than 3 ft (0.92 m), maximum and sustained push forces will be decreased by approximately 15%.[34]
- For tasks performed more frequently than once every 30 minutes, maximum and sustained push forces will be decreased by approximately 6%.[34]
- If push force limits are exceeded it will be necessary to reduce the weight of the load, use two or more caregivers to complete the task together, or use a powered transport device.
- Equipment casters need to be properly maintained to assist in moving equipment more easily.
- For OR equipment not listed above, compare physical effort to that required to push an unoccupied standard hospital bed. If greater effort is required, then additional caregivers and/or use of powered transport device is recommended.

Rationale/Calculations Used for Ergonomic Tool #7

Push forces were measured in Newtons (N) for each item of equipment listed in **Table 2**. Initial forces were measured as the peak force to initially propel the item. Sustained force was measured as the minimum force required to maintain equipment propulsion. Initial-wheels turned were measured as the peak initial force where the wheels on the equipment

Table 2

MEASURED PUSH FORCES FOR OPERATING ROOM EQUIPMENT

Equipment	Type of Force	Trial1 (N)	Trial2 (N)	Trial3 (N)	Trial4 (N)	Trial5 (N)	Mean (N)	Mean (lbF)	Max Push Distance (ft)
Electrosurgical unit	initial force	30	35	35	30	30	32.0	7.2	>200
	sustained force	10	10	10	10	10	10.0	2.2	>200
	initial-wheels turned	40	35				37.5	8.4	>200
OR stretcher, unoccupied	initial force	62	70	65	75		68.0	15.3	>200
	sustained force	20	20	25	25	25	23.0	5.2	>200
	initial-wheels turned	113	110				111.5	25.1	>200
OR stretcher, occupied, 300 lbs	initial force	120	120	120	115	120	119.0	26.8	>200
	sustained force	30	35	30	40	40	35.0	7.9	>200
	initial-wheels turned	210	180				195.0	43.8	<50
Bed, unoccupied	initial force	115	120	125	110	105	115.0	25.9	>200
	sustained force	30	25	30	25		27.5	6.2	>200
	initial-wheels turned	130	135				132.5	29.8	>200
Bed, occupied, 300 lbs	initial force	170	160	167	135	155	157.4	35.4	>200
	sustained force	40	50	50	40	60	48.0	10.8	>200
	initial-wheels turned	230	215				222.5	50.0	<25
OR bed, unoccupied	initial force	218	275	245	280	270	257.6	57.9	<25
	sustained force	120	125	120	100	120	117.0	26.3	<25
	initial-wheels turned	270	275				272.5	61.3	<25
OR bed, occupied, 300 lbs	initial force	425	432	445	405	325	406.4	91.4	<25
	sustained force	180	180	180			180.0	40.5	<25
	initial-wheels turned	485	515				500.0	112.4	<25

Table 2, *continued*

MEASURED PUSH FORCES FOR OPERATING ROOM EQUIPMENT									
Equipment	**Type of Force**	**Trial1 (N)**	**Trial2 (N)**	**Trial3 (N)**	**Trial4 (N)**	**Trial5 (N)**	**Mean (N)**	**Mean (lbF)**	**Max Push Distance (ft)**
Specialty OR beds, unoccupied	initial force	175	182	190	260	200	201.4	45.3	<25
	sustained force	100	100	100			100.0	22.5	<100
	initial-wheels turned	305	315				310.0	69.7	<25
Specialty OR beds, 300-lb patient	initial force	365	290	320	305	305	317.0	71.3	<25
	sustained force	140	160	140	115	115	134.0	30.1	<25
	initial-wheels turned	560	545				552.5	124.2	<25
Microscopes	initial force	62	75	80	75	75	73.4	16.5	>200
	sustained force	20	25	20	25	25	23.0	5.2	>200
	initial-wheels turned	125	120				122.5	27.5	<50
Case cart, full	initial force	62	108	75	108		88.3	19.8	>200
	sustained force	30	40	40	40		37.5	8.4	>200
	initial-wheels turned	122	115				118.5	26.6	>200
Case cart, empty	initial force	60	65	65	62	65	63.4	14.3	>200
	sustained force	40	30	35	40	35	36.0	8.1	>200
	initial-wheels turned	120	95				107.5	24.2	>200
X-ray equipment, C-arm	initial force	100	75	100	75	85	87.0	19.6	>200
	sustained force	20	25	25	25	25	24.0	5.4	>200
	initial-wheels turned	n/a	n/a				n/a	n/a	n/a
X-ray equipment, portable	initial force	60	55	55	60	58	57.6	12.9	>200
	sustained force	25	30	30	30	30	29.0	6.5	>200
	initial-wheels turned	n/a	n/a				n/a	n/a	n/a
Video towers	initial force	35	40	40	35	35	37.0	8.3	>200
	sustained force	15	20	20	15	20	18.0	4.0	>200
	initial-wheels turned	60	65				62.5	14.1	>200
Ultrasound	initial force	35	40	45	45	40	41.0	9.2	>200
	sustained force	20	20	25	20	20	21.0	4.7	>200
	initial-wheels turned	55	55				55.0	12.4	>200
Specialty equipment carts	initial force	105	90	120	125	145	117.0	26.3	>200
	sustained force	25	30	30	25	25	27.0	6.1	>200
	initial-wheels turned	165	185				175.0	39.3	<200
Linen cart	initial force	50	70	55	55	65	59.0	13.3	>200
	sustained force	20	25	20	25	20	22.0	4.9	>200
	initial-wheels turned	75	70				72.5	16.3	>200

were turned perpendicular to the desired direction of travel. The average force measured across five repeated trials for each condition and equipment item was computed and converted into US units.

Maximum pushing distances were determined and reported in **Table 2**, based on Liberty Mutual's push force limits.[34] The shortest acceptable push distance, considering both initial and sustained forces, was accepted (see **Table 3**). These values are based on the operator with his or her hands positioned at a middle push point of 3 ft (0.92 m) from the floor or above and performing a task no more frequently than once every 30 minutes.

Measuring Pushing/Pulling Forces

To measure OR equipment not listed in **Table 2**, a measuring device can be applied to measure applicable pushing/pulling forces. Commercially available measuring instruments can be used to measure push/pull forces (eg, strain gage, force meters, precision springs). A simple low-cost method for measuring the required forces for pushing or pulling objects, such as beds, carts, and transfer equipment, is shown in **Figure 1**. As illustrated, a broom handle or other lightweight cylindrical object can be taped to a bathroom scale and used to measure push forces. Required pull forces would be identical to the required pushing force. The scale is placed against the object to be pushed and a force is then slowly applied to the handle until the object moves. The maximum required pushing force is read off the weight scale. The scale should provide a continuous readout of applied force to obtain the maximum value. To obtain the best estimate of the actual maximum force, the measurement should be repeated several times and the average value should be used for assessment. This force can then be compared to the maximum recommended push force values shown in **Table 3**. For example, assume that the force required to push a cart was measured to be 60 lbs. According to **Table 3**, this task would not be acceptable for one caregiver for any distance, but would be acceptable for two caregivers (assuming each pushed 26 lbs) for a distance of up to 25 feet. A powered transport device would be recommended if one caregiver is performing the task.

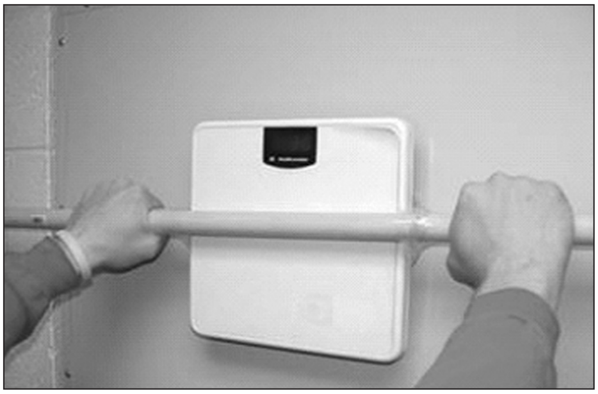


Figure 1. *Simple device for measuring required push force. Photo by Tom Waters, PhD, CPE.*

Table 3

PUSH FORCE LIMITS					
Push/Pull Forces Based on 75% Acceptable for Women Design Goal					
Distance (ft)	25	50	100	150	200
Initial (lbs)	51	44	42	42	37
Sustained (lbs)	30	25	22	22	15

Adapted from Manual Materials Handling Guidelines, http://libertymmhtables.libertymutual.com/CM_LMTablesWeb/pdf/LibertyMutualTables.pdf. *Reprinted with permission from the Liberty Mutual Research Institute for Safety.*

Other Background Materials

The Revised NIOSH Lifting Equation

The Revised NIOSH Lifting Equation (RNLE) provides a mathematical equation for determining the recommended weight limit (RWL) and lifting index (LI) for selected two-handed manual lifting tasks. The RWL is the principal product of the RNLE and is defined for a specific set of task conditions and represents 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," NIOSH means workers who are free of adverse health conditions that would increase their risk of musculoskeletal injury.

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 pounds or 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 lbs that is reduced by six factors related to task geometry (ie, location of the load relative to the worker at the initial liftoff and set-down points), task frequency and duration, and type of handhold on the object. Assessment of patient handling tasks was specifically excluded as a restriction for use of the RNLE due to limitations in the data used to derive the equation. For some patient handling tasks, however, where the person being lifted is noncombative or where there is little or no movement of the patient during the lifting task, the RNLE may be applicable, and it should be possible to determine whether the lift exceeds the RWL for those tasks. For example, the RNLE was used to derive the 35-lb weight limit for patient lifting in the VA and AORN ergonomic tools.[52] The precise formulation of the revised lifting equation for calculating the recommended weight limit is based on a multiplicative model that provides a weighting (ie, multiplier) for each of six task variables, which include the

- 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 recommended weight limit for that task would be reduced from the ideal starting weight (see **Table 4**).

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 following list briefly describes the measurements required to use the RNLE. Details for each of the variables are presented later in this chapter (see section entitled "Obtaining and using the data").

H = Horizontal location of hands from midpoint between the inner ankle bones. This is measured in centimeters or inches at the origin and the destination of the lift.

V = Vertical location of the hands from the floor. This is measured in centimeters or inches at the origin and destination of the lift.

D = Vertical travel distance in centimeters or inches between the origin and the destination of the lift.

A = Angle of asymmetry; 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/min. Duration is defined as follows: short-duration (< 1 hour); moderate-duration (> 1 but < 2 hours); or long-duration (> 2 but < 8 hours), assuming appropriate recovery allowances (see **Table 5**).

Table 4

RECOMMENDED WEIGHT LIMIT

The recommended weight limit is defined as follows:

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

Where:

Variable		Metric	US Customary
LC =	Load Constant =	23 kg	51 lbs
HM =	Horizontal Multiplier =	(25/H)	(10/H)
VM =	Vertical Multiplier =	$1-(.003\lvert V-75\rvert)$	$1-(.0075\lvert V-30\rvert)$
DM =	Distance Multiplier =	.82 + (4.5/D)	.82 + (1.8/D)
AM =	Asymmetric Multiplier =	1-(.0032A)	1-(.0032A)
FM =	Frequency Multiplier =	From Table 5	From Table 5
CM =	Coupling Multiplier =	From Table 6	From Table 6

C =Quality of hand-to-object coupling (quality of interface between the worker and the load being lifted). The quality of the coupling is categorized as good, fair, or poor, depending upon the type and location of the coupling, the physical characteristics of load, and the vertical height of the lift (see **Table 6**).

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 RWL.

The LI is defined by the following equation:

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

Where Load weight (L) = Weight of the object lifted (lbs or kg).

According to NIOSH, the lifting index 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 a lifting index > 1.0 pose an increased risk for lifting-related low back pain for some fraction of the work force.[49] Lifting jobs should be designed to achieve a lifting index 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 a lifting index of 1.0) without significantly increasing their risk of work-related injury above the baseline level.[49,50] Those who endorse the use of selection criteria believe that the criteria must be based on research studies, empirical observations, or theoretical considerations that include job-related strength testing and/or aerobic capacity testing.

Even these experts agree, however, that many workers will be at a significant risk of a work-related injury when performing highly stressful lifting tasks (ie, lifting tasks that would exceed a lifting index of 3.0). "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 a lifting index of 1.0, at least in theory, without substantially increasing their risk of low back injuries above the baseline rate of injury.

To gain a better understanding of the rationale for the development of the recommended weight limits and lifting index, the *Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks* provides a discussion of the criteria underlying the lifting equation and of the individual multipliers.[49] This article also identifies both the assumptions and uncertainties in the scientific studies that associate manual lifting and low back injuries. For more detailed information about how to use the RNLE, the reader should consult the *Applications Manual for the Revised NIOSH Lifting Equation.*[50]

Table 5

FREQUENCY MULTIPLIERS						
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

Table 6

COUPLING MULTIPLIER		
	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

Glossary

Air-assisted lateral transfer device: A mattress that is inflated with air by a portable air supply, thus facilitating a smoother lateral transfer.

Anti-fatigue mats: A special mat designed with friction-reduction properties, used for workers who stand for long periods of time.

Anti-fatigue technique: Any technique that will reduce fatigue experienced by the worker.

Assistive devices/technology: Equipment that can be used to take all or a portion of a load such as the weight of a body part, off of the person performing a high risk task.

Clinical tools: A standardized process or set of rules by which a provider makes decisions about a complex process (eg, which equipment and techniques to use when performing high-risk patient handling and movement tasks).

Compressive force: Mechanical force directed along the Y (ie, vertical) axis, brought about by the combined effect of internal and external load bearing.

Ergonomics: Applied science of designing and arranging things for people to use efficiently and safely; matching job tasks to workers' capabilities.

Ergonomist: A practitioner in the field of ergonomics.

Friction-reducing devices: Low-friction (slippery) material assistive aids for lateral transfer of patients.

Lateral position: Side-lying.

Lateral transfer: Movement of a patient in a supine position on a horizontal plane, such as transferring a patient from a bed to a stretcher.

Lateral transfer device: A device that is used to move a patient from one surface to another while in a supine position.

lbF: A unit of force equal to the mass of 1 pound with an acceleration equal to 1 gravitational constant (32 ft/s^2) Acceleration due to gravity (g) equals 9.8 meters per second squared (9.8 m/s^2) or 32 feet per second squared (32 ft/s^2).

Lifting index: Relative estimate of physical stress associated with one specific task. It is equal to the load of the object/recommended weight limit.

Lithotomy position: Supine position with the hips and knees flexed and the thighs abducted and rotated externally.

Manual retraction: When a member of the perioperative sterile team (ie, scrubbed team) provides exposure of underlying anatomical parts during surgery with his or her hand or by physically holding and/or pulling with a sterile device designed to hold back the edges of tissue and organs.

Maximum sustained force: Force needed to pull or lift for a period of time.

Mechanical lateral transfer device: A powered device that moves a patient horizontally from one surface to another while in a supine position.

Mechanical lift device: Patient transfer device that uses a sling and mechanical lift to transfer patients and/or lift body parts (includes ceiling-mounted and floor-based lifts as well as sit-to-stand lifts).

Musculoskeletal: Relating to or involving the muscles and the skeleton.

Newton (N): A metric unit of measure for forces. (1 Newton = 0.2248 lbs)

Newton meter (Nm): A metric unit of measure for moments (ie, force x length). One Newton meter = .738 ft·lb.

Optimal posture: Perpendicular/straight on to the operative field.

Optimal working height: Area between the chest and waist height to the operative field.

Prone: With the front (or ventral) surface of the body positioned face downward.

Recommended weight limit: Recommended weight limit is the principal product of the revised NIOSH lifting equation defined for a specific set of task conditions as the weight of the load that 75% of the population could perform safely.

Revised NIOSH Lifting Equation: Mathematical equation for determining the recommended weight limit and lifting index for selected two-handed manual lifting tasks.

Self-retaining retractor: A sterile device designed to mechanically hold back the edges of tissue and organs to provide exposure to underlying anatomical structures during a surgical procedure.

Semi-Fowler position: The upper half of the body raised to an incline of 30 to 45 degrees; also called the beach-chair position.

Sit-stand stool: A stool that allows the worker to sit or stand while working without changing levels.

Spinal compression: Forces acting along the length of the spine.

Spine loading: Overall mechanical force acting on the spine calculated as root-mean-square value of compressive, lateral, and anterior-posterior components.

Static posture: Postures requiring a sustained position for a long period of time (eg, standing in one position during surgery).

Supine: With the back or dorsal surface of the body positioned downward (ie, lying face up).

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