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Patient Care Ergonomics: Biomechanical Drivers for Patient Handling Technology and Design

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Introduction

Manual patient handling is the primary reason for musculoskeletal injuries in patient care providers, and the understanding of the impact of patient handling on the body leads to a clear understanding why this is so. When the biomechanical capabilities of the body are exceeded, injury occurs. To set industry recommendations that decrease the risk of injury to caregivers from manual patient handling and moving, a patient lifting weight limit was determined, algorithms and guidelines for patient handling tasks were developed, and guidelines for the introduction of patient care ergonomics in design and construction were instituted.

Ramifications of Exceeding the Body's Biomechanical Limits

Providing Patient Care is High Risk

In 2007, nursing aides, orderlies, and attendants suffered 24,340 musculoskeletal disorders (MSDs) requiring days away from work, the second highest number in the country while registered nurses experienced 8,580 MSDs, the seventh highest number of MSDs. The rate of injuries for nursing aides, orderlies, and attendants as a group (252 MSDs per 10,000 workers) was the highest rate of MSDs for any occupation, more than seven times the national MSD average.[i] However, a large number of patient handling injuries are not reported[ii], so these numbers may be misleading and not tell the true story of injuries to caregivers. Some estimate that caregiver injuries are underreported by at least 50 percent.[iii]

The 2003 Occupational Safety and Health Association (OSHA) Ergonomic Guidelines for Nursing Homes directly related manual patient handling to the high rate of injuries in healthcare providers.[iv] And, manual patient handling has become even more problematic over the years as patient acuity levels and weights have increased. With the recognition of the importance of patient mobilization in the healing process, these increasingly dependent and larger patients are moved and handled more often.

Unfortunately, for more than 30 years, caregivers were trained in body mechanics and "proper" lifting techniques to decrease injuries related to manual patient handling. However, for those thirty plus years, injuries from manual patient handling continued to increase.[v] Today, evidence demonstrates that no amount of training in proper body mechanics and lifting techniques will ever overcome the effects on the body when the biomechanical limits are exceeded, and lifting patients has been found to exceed caregivers' biomechanical limits.[vi, vii, viii, ix, x, xi]

Why and How Caregivers are Injured

When manual patient handling or any other activity that exceeds a person's biomechanical capabilities is performed, the musculoskeletal system is damaged.[xii] Any part of the musculoskeletal system can be affected - muscles, bones, tendons, ligaments, joints, etc. The majority of patient handling injuries are located in the lower back, but injuries also occur in the middle and upper back, shoulders, neck, arms, wrists, and even the hands and knees.

Most musculoskeletal injuries in caregivers are cumulative trauma ones, though the majority are recorded as and considered (incorrectly) acute injuries. In acute injuries, one event results in damage. For instance, an acute injury may occur when a caregiver is providing ambulation rehabilitation for a large patient. If the patient loses his balance and falls, and the caregiver attempts to prevent the fall, a muscle may be torn or a shoulder dislocated.

Nearly all patient handing injuries, though, are cumulative trauma. A cumulative trauma injury results from the accumulation of micro-injuries over time. These micro-tears in the muscles or micro-fractures to the end plates of spinal vertebrae often progress until severe damage occurs.[xiii] Micro-tears to the muscles result from muscle fatigue when the muscle is no longer able to produce energy for contraction. Over-exertion for an extended period of time or too often without adequate recovery will result in muscle fatigue. Muscle fibers can also be damaged when exposed to excessive loading or repetitive actions without sufficient recovery periods.[xiv]

Excessive spinal loading is a consequence of lifting heavy loads and even light loads for a long period of time and/or twisting, bending and other similar actions. Lifting results in compressive forces on the spine. Twisting, reaching, bending, pulling, and such motions produce shear forces on the spine. Together or separately, these result in spinal loading.[xv] When spinal forces exceed the spinal loading capacity, micro-fractures occur in the vertebral endplates and scar tissue is formed. This impacts the flow of nutrients into the intervertebral discs of the spine. In most tissues, the body's blood supply brings nutrients to the tissues; however, intervertebral discs receive nutrients only by diffusion through the vertebral endplate. Nutrients will easily diffuse through a healthy vertebral endplate into the adjacent disc, but endplate scar tissue impedes this flow. Without adequate nutrients, a disc degenerates, and without a nerve supply to the discs as well as a blood supply, disc degeneration continues unnoticed until nerve impingement results in pain and decreased work capacity.[xvi]

Guidelines and Algorithms to Decrease Risk of Injury from Patient Handling

Patent Lifting Weight Limit

In order to have a quantitative value for understanding risk from activities that exceed the safe load on the musculoskeletal system, Thomas Waters, PhD, CPE, adapted the Revised National Institute for Occupational Safety and Health (NIOSH) Lifting Equation (RNLE) for patient handling tasks. His calculations led to a maximum lifting limit of 35 pounds for caregivers lifting patients under the best of circumstances and under ideal conditions. The 'best of circumstances' includes no tubes, lines, contractures, combative behavior, etc.,[xvii] not often found in our hospitals and nursing homes with high acuity patients. Ideal conditions preclude lifting with arms extended, lifting from near the floor, lifting while twisting, or lifting from the side of the body.

The RNLE is an ergonomic assessment tool that is used to determine safe lifting weight limits for two-handed manual lifting tasks. Through inclusion of quantitative values for specific task variables, the RNLE calculates a recommended weight limit (RWL). The RWL is defined for a specific set of task conditions in which the weight of the load could be lifted by nearly all healthy workers for up to eight (8) hours without an increased risk of developing low back pain. These criteria include the load of the object, horizontal distance of the load from the worker, vertical height of the lift, vertical displacement during the lift, frequency, duration, hand-to-object coupling characteristics, and angle of asymmetry.[xviii] However, the RNLE specifically excluded patient lifting.[xix] Reasons included the unpredictability of patients, leading to unexpectedly heavy loads when a patient has a muscle spasm, is combative, or resists care, as well as the common occurrence of patient movement that increases forces due to acceleration of the load beyond what it would be when performing a slow, smooth lift of a stable object. Additionally, estimating the weight being lifted is quite difficult, especially when more than one caregiver is lifting a patient or when a patient has partial weight-bearing and/or assistance capabilities. However, Waters determined that the RNLE could be used to determine the RWL for patient lifting during some tasks, such as those when the patient is cooperative and can follow directions, the amount of weight to lift can be estimated, the body and hand positions in relation to the object being lifted do not change, the weight being lifted does not change, and the patient is not likely to make sudden movements during the lift.[xx]

To modify the RNLE in order to calculate an RWL for lifting patients, criteria used in the RNLE were evaluated for how and if they pertained to patient handling and assumptions were made. One critical assumption was that, most likely, when lifting patients, a caregiver is not able to get as close to the patient as they would to a box – the standard NIOSH test item. Lifting patients often involves reaching out for, as well as lowering a load (e.g., lowering a patient into a chair or onto a bed), so the horizontal distance variable would be greater in patient lifting activities. In the RNLE, the minimum horizontal reach for the RWL is set at 10 inches,[xxi] however, for patient lifting, Waters determined a more appropriate distance of 14.5 inches. Using this modified horizontal distance, the recommended weight limit would then be 35 pounds, for an ideal patient lift.

Guidelines and Algorithms for Safe Patient Handling

Research has been conducted in various patient care environments[xxii, xxiii, xxiv, xxv, xxvi] to identify manual patient handling tasks that put caregivers at risk for injury, and findings confirm that these high risk patient handling tasks place excessive biomechanical and postural stress on the musculoskeletal system of caregivers.[xxvii] In order to give caregivers information to make ergonomically safe patient handling and movement decisions, algorithms and guidelines were developed. After identifying ergonomic hazards in specific clinical environments, clinicians and

ergonomists collaborated to develop ergonomic guidelines and algorithms. Most algorithms and guidelines reflect control measures for high risk patient handling tasks such as patient lifts and transfers, but some focus on other high risk activities found in clinical environments such as pushing/pulling beds/equipment. The Veterans Health Administration (VHA), American Perioperative Registered Nurses Association (AORN) and the National Association of Orthopaedic Nurses (NAON), the American Nurses Association (ANA) and NIOSH were in the forefront in the development of such guidelines.

The first algorithms for safe patient handling developed by the VHA and the Department of Defense (DoD) were released in 2001. These algorithms were developed by a national team of clinicians who trialed them in all clinical settings prior to release. These algorithms, for the first time in the United States, standardized care in relation to completion of high risk patient handling and movement tasks, however it is important to understand that the algorithms provide general direction. Caregivers must use their professional judgment in applying algorithms.[xxviii]

As a first step in using these algorithms, a patient assessment is completed that provides information on a patient's level of assistance, weight-bearing capability, upper body strength, level of cooperation and comprehension, weight, height, and any medical or physical factors affecting moving and handling. The information from the assessment is then used to answer questions found in the algorithms. Answering the algorithm questions leads a caregiver to find out the number of caregivers and patient handling equipment needed for a particular high risk task based on the unique characteristics of the patient assessed. The original algorithms were developed for these high risk tasks.[xxix]

- Transfer To and From: Bed to Chair, Chair to Toilet, Chair to Chair, or Car to Chair
- Lateral Transfer To and From: Bed to Stretcher, Trolley
- Transfer To and From: Chair to Stretcher, Chair to Chair, or Chair to Exam Table
- Reposition in Bed: Side to Side, Up in Bed
- Reposition in Chair: Wheelchair or Dependency Chair
- Transfer a Patient Up from the Floor

Later, the need for algorithms for bariatric patient care was determined. These algorithms provide guidance for the following high risk tasks involving bariatric patients. [xxx]

- Transfer To and From: Bed to Chair, Chair to Toilet, Chair to Chair, or Car to Chair
- Lateral Transfer To and From: Bed to Stretcher, Trolley
- Reposition in Bed: Side to Side, Up in Bed
- Reposition in Chair: Wheelchair or Dependency Chair
- Tasks Requiring Sustained Holding of Limb/s or Access to Body Parts
- Transporting (stretcher, wheelchair, walker)
- Toileting
- Transfer Patient Up from Floor

Soon after release of these algorithms, clinicians from specific clinical settings recognized the need for guidance specific to the high risk tasks performed as a result of their special patient populations. The AORN was the first group to develop such individualized guidelines. The ergonomically high risk tasks in the perioperative environment include both patient handling and non-patient care ergonomic guideline.[xxxi]

- Lateral Transfer from Stretcher to OR bed

- Positioning/Repositioning the Patient on the OR bed to and From the Supine Position
- Lifting and Holding Legs, Arms and Heads for Prepping
- Prolonged Standing
- Retraction
- Pushing, Pulling and Moving Equipment on Wheels

NAON then developed guidelines specific to the orthopaedic clinical environment. The high risk tasks found in this clinical setting include the following.[xxxii]

- Turning patient in bed (side to side)
- Vertical transfer of a post-operative total hip replacement patient
- Vertical transfer of a patient with an extremity cast/splint
- Ambulation
- Lifting or holding legs or arms in an orthopaedic setting

Patient Care Ergonomic Guidelines in the Design and Construction of Healthcare Facilities

Patient care ergonomics, including basic ergonomic assessment methodologies, institution of resultant technology control measures, and incorporation of such technology into the design of new and existing buildings has been found to decrease the incidence of caregiver injuries, lost time, and modified duty days, while demonstrating a cost/benefit for an organization. As well, patient benefits are seen. For these reasons, a Patient Handling and Movement Assessment (PHAMA) was incorporated into the 2010 Guidelines for the Design and Construction of Health Care Facilities[xxxiii] and a comprehensive white paper was written to further explain and provide additional information for designers and organizations.[xxxiv]

The main purpose of the white paper, *Patient Handling and Movement Assessments: A White Paper*, is to relay information to assist in ensuring appropriate patient handling equipment is introduced and other conditions and building attributes support safe patient handling and movement. However, further information needed to be relayed to designers, building owners, administrators, and others. In addition to supplying in-depth information related to the PHAMA, the White Paper includes chapters on the rationale for and background of patient care ergonomics, developing a business case, Safe Patient Handling Program implementation, and resources. [xxxv]

The PHAMA has two distinct yet interdependent phases. The first phase includes a patient handling needs assessment to identify appropriate patient handling and patient movement equipment for each clinical area in which patient handling and movement occurs. The second phase includes definition of space requirements and structural and other design considerations to accommodate incorporation of such patient handling and movement equipment. Phase 2 include the following design considerations.

- Structural
- Electrical & Mechanical
- Provision of adequate space
- Destination Points
- Door Openings – sizes & types
- Floor Finishes, Surfaces, Transitions

- Installation Coordination
- Storage Space
- Impact on Environment of Care
- Impact of Aesthetics
- Infection Control Risk Mitigation

In Summary

Solid science supports the need for biomechanical control measures, a weight limit for patient lifts, use of clinical guidelines and algorithms, and the institution of a systematic assessment to ensure building design promotes safe patient handling and movement. Together and separately, these provide critical guidance to ensure safe patient handling and movement and the ergonomic safety of our caregivers.

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[i] Facilities Guidelines Institute (FGI). 2010. *Patient Handling and Movement Assessments: A White Paper* (retrieved February 28, 2011) (http://www.fgiguidelines.org/interim_pubs.html).

[ii] K. Siddharthan, M. Hodgson, D. Rosenberg, D. Haiduven & A. Nelson, "Under-reporting of work-related musculoskeletal disorders in the Veterans Administration." *International Journal of Health Care Quality Assurance Incorporating Leadership in Health Services* 19, nos. 6–7, 2006: 463–76.

[iii] K. Siddharthan, M. Hodgson, D. Rosenberg, D. Haiduven & A. Nelson, "Under-reporting of work-related musculoskeletal disorders in the Veterans Administration." *International Journal of Health Care Quality Assurance Incorporating Leadership in Health Services* 19, nos. 6–7, 2006: 463–76.

[iv] U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). 2003. *Ergonomic Guidelines for Nursing Homes* (retrieved February 28, 2011) (http://www.osha.gov/ergonomics/guidelines/nursinghome/final_nh_guidelines.html).

[v] U.S. Department of Labor, Bureau of Labor Statistics (BLS). 2001. *Survey of occupational inquiries and illnesses.* (Bureau of Labor Statistics: Washington, DC, December 19, 2002).

[vi] Owen, B. D. "Preventing injuries using an ergonomic approach." *Association of periOperative Registered Nurses Journal.* 72, no. 6, 2000: 1031–36.

[vii] Owen, B. D. & Garg, A. "Reducing back stress through an ergonomic approach: Weighing a patient," *International Journal of Nursing Studies.* 31, no. 6, 1994: 511–19.

[viii] A. Garg & B. Owen., "Prevention of back injuries in healthcare workers," *International Journal of Industrial Ergonomics.* 14, 1994: 315–31.

[ix] Rice, M. S., Woolley, S. M. & Waters, T. R. "Comparison of required operating forces between floor-based and overhead-mounted patient lifting devices." *Ergonomics* 52, no. 1, 2009: 112–20.

[x] Marras, W. S., Knapik, G. G. & Ferguson, S. "Lumbar spine forces during manoeuvring of ceiling-based and floor-based patient transfer devices." *Ergonomics* 52, no. 3, 2009: 384–97.

[xi] Nelson, A. L., Lloyd J., Menzel, N. & Gross, C. "Preventing nursing back injuries: Redesigning patient handling tasks." *AAOHN Journal* 51, no. 3, 2003: 126–34.

[xii] Waters, T. R. "When is it safe to manually lift a patient?" *American Journal of Nursing.* 107, no. 6, 2007: 40–45.

[xiii] W. S. Marras, "Occupational low back disorder causation and control," *Ergonomics* 43, no. 7 (2000): 880–902.

[xiv] Waters, T. R. "Science to support specific limits on lifting, pushing, and pulling and static postures." (Presentation at the 8th Annual Safe Patient Handling Conference, Lake Buena Vista, Florida, March 2008).

[xv] Waters, T. R. "Science to support specific limits on lifting, pushing, and pulling and static postures." (Presentation at the 8th Annual Safe Patient Handling Conference, Lake Buena Vista, Florida, March 2008).

[xvi] Waters, T. R. "Science to support specific limits on lifting, pushing, and pulling and static postures." (Presentation at the 8th Annual Safe Patient Handling Conference, Lake Buena Vista, Florida, March 2008).

[xvii] Waters, T. R. "When is it safe to manually lift a patient?" *American Journal of Nursing.* 107, no. 6, 2007: 40–45.

[xviii] National Institute for Occupational Safety and Health (NIOSH). 1994. *Applications Manual for the Revised NIOSH Lifting Equation*. (retrieved March 1, 2011) (http://www.cdc.gov/niosh/docs/94-110/)

[xix] Waters, T.R., Putz-Anderson, V., Garg, A., & Fine, L.J. "Revised NIOSH equation for the design and evaluation of manual lifting tasks." *Ergonomics*. 36 (7), 1993: 749-776.

[xx] Waters, T. R. "When is it safe to manually lift a patient?" *American Journal of Nursing.* 107, no. 6, 2007: 40–45.

[xxi] Waters, T.R., Putz-Anderson, V., Garg, A., & Fine, L.J. "Revised NIOSH equation for the design and evaluation of manual lifting tasks." *Ergonomics*. 36 (7), 1993: 749-776.

[xxii] Nelson, A. "unpublished research data from pilot study" (James A. Haley VA Medical Center, Tampa, FL, 1996).

[xxiii] Nelson, A. L. & Fragala, G. "Equipment for safe patient handling and movement." in *Back Injury among Healthcare Workers*, eds. W. Charney & A. Hudson (Washington, DC: Lewis Publishers, 2004), 121–35.

[xxiv] Owen, B. & Garg A. "Assistive devices for use with patient handling tasks." in *Advances in Industrial Ergonomics and Safety,* ed. B. Das (Philadelphia, PA: Taylor & Frances, 1990).

[xxv] Sedlak, C. A., Doheny, M. O., Nelson, A. & Waters, T. R. "Development of the National Association of Orthopaedic Nurses guidance statement on safe patient handling and movement in the orthopaedic setting." *Orthopaedic Nursing*, Supplement to 28, no. 25, 2009: 2–8.

[xxvi] AORN Workplace Safety Taskforce. *Safe Patient Handling and Movement in the Perioperative Setting.* (Denver, CO: Association of periOperative Registered Nurses [AORN], 2007).

[xxvii] Nelson, A; Lloyd, J; Menzel, N; and Gross, C. 2003. *Preventing nursing back injuries*. (retrieved March 1, 2011) (http://www.aaohnjournal.com/SHOWABST.asp?thing=34518).

[xxviii] Nelson, A. (Ed.). 2001. *Patient Care Ergonomics Resource Guide: Safe Patient Handling and Movement.* Tampa, FL: Veterans Administration Patient Safety Center of Inquiry. (retrieved March 1, 2011) (http://www.visn8.va.gov/visn8/patientsafetycenter/resguide/ErgoGuidePtOne.pdf).

[xxix] Nelson, A. L., Owen, B., Lloyd, J., Fragala, G., Matz, M., Amato, M., Bowers, J., Moss-Cureton, S., Ramsey, G., & Lentz, K. "Safe patient handling & movement." *American Journal of Nursing, 103*(3), 2003: 32-43.

[xxx] Nelson, A. (Ed.). 2001. *Patient Care Ergonomics Resource Guide: Safe Patient Handling and Movement*. Tampa, FL: Veterans Administration Patient Safety Center of Inquiry. (retrieved March 1, 2011) (http://www.visn8.va.gov/visn8/patientsafetycenter/resguide/ErgoGuidePtOne.pdf).

[xxxi] Association of periOperative Registered Nurses (AORN) Workplace Safety Taskforce. *Safe Patient Handling and Movement in the Perioperative Setting.* (Denver, CO: Association of periOperative Registered Nurses [AORN], 2007).

[xxxii] Sedlak, C. A., Doheny, M. O., Nelson, A. & Waters, T. R. "Development of the National Association of Orthopaedic Nurses guidance statement on safe patient handling and movement in the orthopaedic setting." *Orthopaedic Nursing*, Supplement to 28, no. 25, 2009: 2–8.

[xxxiii] Facility Guidelines Institute. *Guidelines for Design and Construction of Health Care Facilities.* American Society for Healthcare Engineering, 2010.

[xxxiv] Facilities Guidelines Institute (FGI). 2010. *Patient Handling and Movement Assessments: A White Paper* (retrieved February 28, 2011) (http://www.fgiguidelines.org/interim_pubs.html).

[xxxv] Facilities Guidelines Institute (FGI). 2010. *Patient Handling and Movement Assessments: A White Paper* (retrieved February 28, 2011) (http://www.fgiguidelines.org/interim_pubs.html).