Health Care Concerns Related to Lifting: An Inside Look at Intervention Strategies

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As members of injury prevention and injury management teams, physical therapists and occupational therapists have the opportunity to evaluate back stress associated with patient-lifting activities. In this study, three mathematical formulas are presented that can be used to objectively assess health care workers’ maximum safe lifting capacity for moving patients. Recommendations to reduce the rate of back injury in health care workers include the use of lifting machines for moving patients, mandatory in-service education on body mechanics, and employee assistance programs that improve job satisfaction and worker morale.

Costs associated with back injuries have skyrocketed over the past decade. In 1989 an estimated 45 million days (approximately 40% of all work days missed) were missed because of back pain. The estimated cost to corporate America was $14 billion (Peterson, 1990).

According to the National Institute for Occupational Safety and Health (NIOSH), among the workers most adversely affected by back problems are nursing aides and, to a lesser extent, licensed practical nurses and registered nurses (Jensen, 1990). Although nurses have been shown to take fewer sick leave absences than do the general population, they have about 30% more absences per year due to back pain. (Pheasant & Stubbs, 1992). According to Pheasant and Stubbs, 36% of all episodes of back pain in nurses were associated with patient-handling procedures. General consensus throughout the literature is that the major reason for the high prevalence and incidence rates of lower back pain in nurses is biomechanical stress developed during the lifting and transferring of patients. Of additional concern are the asymmetrical trunk positions and unpredictable velocities that accompany patient-moving activities (Marras & Mirka, 1989).

In this article we describe how a tertiary care hospital in Vermont has dealt with both the rising workers’ compensation costs associated with back pain and with the increasing number of missed days resulting from injuries. We review the causes of employee back injuries believed to be associated with lifting and moving patients in the health care setting, as well as the subsequent dilemmas faced in ergonomic evaluations. We also highlight the roles that physical therapists and occupational therapists can play in the prevention and management of lower back injuries in hospital settings. This article focuses on the various methods for calculating safe lifting loads for health care workers.

Incidence of Work-Related Back Injuries

The struggle of nurses dealing with lower back pain as an occupational hazard is well established in the literature. Klein, Jensen, and Sanderson (1984) reported that nurses are ranked fifth among all U.S. workers filing compensation claims for back injuries. Owen (1989) found that only one third of those nurses who said they had episodes of occupationally related back problems (63 of 189) actually filed an incident report. Most nurses accepted back pain as part of their job and used employee sick days accordingly (Owen, 1989). Stubbs, Buckle, Hudson, Rivers, and Baty (1986) found that 3.5% of a sample of nurses who left their jobs cited back pain as a main cause or contributory factor. Furthermore, of those who intended to leave the nursing profession, 12% cited back pain as a main cause or contributory factor, and half of these cited back pain as the sole reason for their decision. A 5-year study by Heap

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(1987) found that 12% of those nurses who suffered acute back injuries at work (severe enough to keep them out of work for 3 days or more) eventually had their employment terminated on medical grounds (Pheasant & Stubbs, 1992).

The Medical Center Hospital of Vermont (MCHV) is a tertiary care, 550-bed facility that employs approximately 2,000 workers. The hospital’s workers’ compensation insurance rose from $656,786 in October 1990 to $1,200,000 in October 1991. Of the 109 workers’ compensation incidents reported during this period, 49 (45%) involved patient transfers or patient-handling tasks. Of those 49, 84% were females and 75% were nurses; 42% of the orderly staff members experienced injuries. Twenty-five of the 49 (51%) missed time from work due to the injuries. In 1990, the hospital’s insurance company paid $254,352 in incurred costs, medical treatment, and lost wages. Of the 49 incidents—a major reason for the increase in the hospital’s premium rate the following year (Laflin et al., 1993). These costs provided the impetus for hospital administration to take a serious look at the causes of the injuries and create a plan for injury prevention and management.

Retrospective accident investigation surveys were sent to all 49 employees injured between 1990 and 1991 and concurrent survey forms were sent to employees injured between 1991 and 1992. Many factors were found to have contributed to the injuries. These included:

- **Staff member factors:** lifts done alone; cumulative stress from lifting and moving patients all day and repetitive bending at the waist; overestimation of the patients’ abilities to help, as reflected in comments such as “it just happened”; and weights of lifts exceeding the static strength of the 50th percentile of the female population at elbow height (about 42 lb)(U.S. Department of Health and Human Services, 1981).

- **Patient factors:** unexpected physical collapse; uncooperativeness or combative behavior; weakness; and unexpected incidents.

- **Equipment factors:** brakes not working on wheelchairs, stretchers, and beds; and sheets tearing.

- **Environmental factors:** rooms too small and cluttered with equipment.

These findings were consistent with injury factors cited in articles by Jensen (1990), Hollenbeck, Ilgen, and Crampton (1992), and Garg and Owen (1991).

**Intervention**

As a result of the rising costs associated with back injuries, MCHV administration made the decision to become self-insured. Hospital staff members from physical therapy, occupational therapy, employee health services, the employee assistance program, human resources, and psychiatry services were selected to meet regularly and design and implement a strategic plan for managing injuries. The plan focused on early treatment and referral of injured staff members to physical therapists and occupational therapists within the hospital, who were familiar with the management and physical parameters of staff members’ jobs. In addition, innovative return-to-work programs that included light duty and flexible work scheduling were designed. Although the multidisciplinary team reviewed all hospital staff members’ injuries, this article focuses on lower back injuries in MCHV’s nursing staff members.

Return-to-work programs appear to be popular in settings other than hospitals. In a survey of 1,050 employees, 78% said their organizations have therapy programs with a return-to-work focus, and 85% listed such programs as effective cost-control techniques for returning injured workers to the workplace (Towers Perrin, 1993). Hollenbeck, Ilgen, and Crampton (1992) reported that among the most critical factors affecting the recovery of injured employees are the skills of human resource personnel who assist employees in the return-to-work process, the employee’s decision to seek treatment, and the employee’s choice of treatment providers. In a review of the literature, Frymoyer and Cats-Baril (1987) found that low job satisfaction and low employee morale were also correlated to an increase in injuries. Therefore, all employees at MCHV who were injured after the implementation of the self-insured hospital program were called by an in-house employee assistance program staff member and were offered optional counseling sessions.

Because the MCHV staff member rehabilitation caseloads reflected a large number of nurses (who were primarily in the 35- to 45-year-old age group), we began to confront the complex issues surrounding the physical demands placed on nurses during patient-moving tasks. Our task force came up with the following questions:

1. What were reasonable lifting capacities for employees to achieve in therapy before returning to work?
2. What was the premorbid strength of the employee?
3. How much patient weight should any health care professional be required to lift alone?

**Lifting Requirements**

In the Dictionary of Occupational Titles (1991), the nursing profession is listed as having medium physical demands. This classification means that job expectations may include the infrequent lifting of objects weighing 50 lb or less and the frequent lifting of objects weighing 25 lb or less. According to Snook and Ciriello (1991), the safe lifting weight for women at the 50th percentile is 36.4 lb. NIOSH guidelines have recommended that organizations...
that require employees to lift weights heavier than 50 lb should impose engineering or administrative controls (Waters, Putz-Anderson, Garg, & Fine, 1993). Many physical therapy and occupational therapy clinics run physical screening programs for employees before placing them in demanding jobs. One of the program requirements is that nurses who are returning to work have the capacity to lift and carry 50 lb. The physical therapy and occupational therapy staff members at MCHV abandoned this lifting requirement because it did not translate well to the types of jobs nurses perform (i.e., a nurse’s capacity to lift a 50-lb box with handles differs from the nurse’s capacity to roll a bed containing a patient or pull a patient up in bed). Because we recognize that factors such as age, gender, body weight, and spinal compression play critical roles in the injury rate, we searched for alternative ways to measure the risk of lower back injury to nursing staff members.

Compressive Strength

Spinal compression tolerance limits have been widely used by ergonomists in setting work tolerance limits for manual materials handling operations. Genaidy, Walz, Khalil, and Higalgo (1993) found that factors including age, gender, body weight, and spinal component explained between 42% and 74% of the variation in compressive strength of the lumbar spine. Women, on average, demonstrated 67% of the compressive strength demonstrated by men. The compressive strength of the spine was found to decrease by 10% to 20% with each decade of life beyond 29 years. Compressive strength was also found to increase with an increase in body weight.

Weight Limits

It is widely accepted that injuries occur when the physical demands of a job exceed a worker’s strength (Anderson, 1985). Nurses who work with adults lift and move patients who range in weight from approximately 90 lb to more than 500 lb. Frequency and intensity of patient handling have been found to be factors in the incidence and prevalence of back pain in nurses (Pheasant & Stubbs, 1992). Biomechanical stress developed during repeated lifting and transferring of patients is also believed to be a major contributing factor to back pain (Jensen, 1990). Of daily lifting task tallies from four different hospital units at MCHV, the average patient weight was 180 lb. Opinions on the maximum safe weight to be handled by workers vary. A few examples of weight-limit guidelines are:

- At elbow height: static strength for women at the 50th percentile was 42.2 lb (U.S. Department of Health and Human Services, 1981)
- At knuckle height: maximum acceptable weight lifted (in which a compact load box width = 14 in.) for women at the 50th percentile was 36.4 lb; maximum acceptable weight lifted for men at the 50th percentile was 63.8 lb (Snook & Cirillo, 1991)
- At knuckle height (with horizontal load 18 in. from the center of gravity): recommended weight limit for women at the 50th percentile is 30.8 lb; recommended weight limit for men at the 50th percentile is 52.8 lb (Chaffin & Anderson, 1984)
- For frequent lifting in ideal versus difficult patient-handling tasks, safe weights for men aged 21 years through 44 years was 55 lb (ideal) versus 35 lb (difficult); safe weights for women aged 21 years through 44 years was 26 lb (ideal) versus 22 lb (difficult) (Zuidema & Van Akkerveeken, 1983)

Assessing Spinal Compression

With an extensive body of research at hand, the MCHV physical therapy and occupational therapy departments sought to assess the spinal stresses for nurses and orderlies who performed patient-moving tasks. Three assessment tools were chosen from the literature: the NIOSH lift formula (Waters et al., 1993), Bloswick’s (1993) measure of compressive forces, and the Genaidy et al. (1993) formula for calculating compressive strength. Some might question the application of the NIOSH lift formula for patient-moving tasks because these tasks fall outside the general criteria for which the formula was meant to be applied. The formula was initially selected because it was the only formula widely available to physical therapists and occupational therapists for objective work-site evaluations. Although seemingly complicated in its mathematics, the NIOSH formula draws on principles basic to physical therapy and occupational therapy task analysis. Spinal compression measurement has been thought to be outside the realm of expertise for physical therapists and occupational therapists. However, the formulas measuring spinal compression offered by Bloswick and by Genaidy et al. offer more possibilities for physical therapists and occupational therapists who assess the physical demands of workers’ duties.

For the purpose of comparison, the three formulas will be applied to the same lifting scenario. This scenario, which involves transferring a patient from a recliner to a bed, was chosen for analysis because it is a typical task...
performed in a hospital setting and because it is perceived by staff members to be one of the most difficult types of transfer.

The patient, who weighs 180 lb, needs to be moved from a recliner to a bed located next to the recliner. Two male orderlies, each of whom is 6 ft 2 in. in height and weighs 200 lb, perform the transfer with a sheet placed under the patient (see Figure 1). The orderly on the right (bedside) stands opposite from where the recliner is located. The orderly on the left (recliner side) carries the lift with the sheet. The patient is unable to assist with the transfer, and each orderly is assumed to be lifting half the weight of the patient (i.e., 90 lb).

The NIOSH Lift Formula

The NIOSH lift formula was originally published in 1981 and was revised in 1991. Both the original and revised equations were based on three criteria derived from scientific literature and from the work of experts in the fields of biomechanics, psychophysics, and work physiology. Information from each of the three fields was used to devise the final lifting equation:

1. The biomechanical model was used to examine the maximum disc compression force before risk of injury increases, with the cut-off value at 770 lb (Chaffin & Anderson, 1984).
2. The physiological model was used to assess maximum energy expenditure with maximum values of 2.2 to 4.7 kcal/min, depending on the vertical height of the object being lifted and the duration of continuous lifting (Rodgers, Yates, & Garg, 1991).
3. The psychophysical model was used to calculate an acceptable weight tolerated by 75% of female workers and for 99% of male workers based on lower back compression forces (Ayoub & Mital, 1989).

As defined by NIOSH, the criteria for use of this tool for risk assessment are:

1. Manual handling activities other than lifting are minimal and do not require substantial energy expenditure, especially when repetitive lifting tasks are performed (Ayoub, Selan, & Liles, 1983).
2. The equation does not include task factors to account for unpredictable conditions, such as unexpected heavy loads, slips, or falls.
3. The equation does not assess tasks involving one-handed lifting, lifting while seated or kneeling, lifting in a constrained work space; lifting persons; lifting extremely hot, cold, or contaminated objects; lifting of wheel barrels; shoveling; or high-speed lifting.
4. Worker/floor surface coupling (traction) provides at least a 0.4 coefficient of static friction between the shoe sole and working surface.

Figure 1. Lifting scenario used in task analysis. Two orderlies transfer patient from a recliner to a bed.
5. Lifting and lowering tasks have the same level of risk for lower back injuries (Waters et al., 1993).

The 1991 NIOSH lifting equation for calculating the recommended weight limit (RWL) is based on a multiplicative model that provides weightings for each task variable (see Table 1):

\[ RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \]

The weightings are expressed as coefficients that are used in the model to decrease the recommended load constant (i.e., maximum weight to be lifted).

The variables should be calculated in the following manner:

- \( H \) = Horizontal location of hands from midpoint between the ankles. Measure at the origin and destination of the lift (cm or in.).
- \( V \) = Vertical location of the hands from the floor. Measure at the origin and destination of the lift (cm or in.).
- \( D \) = Vertical travel distance between the origin and the destination of the lift (cm or in.).
- \( A \) = Angle of asymmetry. Angular displacement of the load from the sagittal plane. Measure at the origin and destination of the lift (degrees).
- \( FM \) = Frequency Multiplier
- \( CM \) = Coupling Multiplier

Specific information regarding how to evaluate the coupling and frequency multiplier is not described in this paper. Interested readers should consult Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks (Waters et al., 1993).

Once the RWL is calculated, the evaluator may want to simplify the numerical information with the Lifting Index (LI) which provides a simple estimate of a worker’s hazard of overexertion injury for a manual lifting job.

\[ LI = \frac{RWL}{L} \]

where

- \( L \) = the weight of the object being lifted

For our scenario, the calculations of the variables for the orderly on the recliner side at the beginning of the lift were:

- \( H = 15 \)
- \( V = 37 \)
- \( D = 2 \)
- \( FM = 1.0 \)
- \( AM = 0 \)
- \( CM = .9 \)

These calculations were applied to the formula to determine the recommended weight limit:

\[ RWL = \frac{51 \times 10 \times H}{4 \times (1 - (0.0075 \times V - 30)) \times (.82 + (1.8/D)) \times (1 - (0.032A)) \times FM \times CM}{51 \times 10 \times 15 \times (1 - (0.0075 \times 37 - 30)) \times (.82 + (1.8/2)) \times (1 - (0.032 \times 0)) \times 1 \times .9}{51 \times .67 \times .95 \times 1.72 \times 1 \times 1 \times .9} = 50 \text{ lb} \]

The recommended weight limit to be handled for the orderly on the recliner side is 50 lb. Although the patient weighs 180 lb, each orderly was assumed to be lifting half the weight (i.e., 90 lb each). The LI was also calculated:

\[ LI = \frac{L}{RWL} \]

\[ LI = \frac{90}{50} \]

\[ LI = 1.8 \]

The orderly on the recliner side thus lifted 1.8 times more weight than the weight NIOSH recommended as safe for 99% of male workers.

Applying the same formula for the orderly on the bed side shows that the recommended weight limit was 27 lb. This resulted in a lifting index of 3.3. This orderly was thus at more than twice the risk as the orderly on the recliner side.

**The Bluswick Measure of Compressive Forces**

Bluswick (1993) devised a formula that can be used to estimate the spinal compressive forces of lifting and lowering tasks. As with the NIOSH lift formula, the task variables must be broken down into component parts and can be used to determine task redesign priorities. Bluswick has recommended the use of the NIOSH limit of 770 lb or 3,400 Newtons (N) as the maximum allowable compressive force for healthy, young workers. Injured workers or older workers may have difficulty working at tasks that require 770 lb of compressive force.

The Bluswick measure states that:

\[ F_{\text{comp}} = A + B + C \]

\[ F_{\text{comp}} = 3((BW) \cos(\theta)) + 5(L \times HB) \]

\[ + 0.8[(BW)/2 + L] \]

where

- \( A = 3((BW) \cos(\theta)) \) = Back force resulting from upper body weight. (To reduce this number, the upper body angle should be made more vertical.)
- \( B = 5(L \times HB) \) = Forces resulting from the amount of weight lifted and the distance it is being held away from the body
- \( C = 0.8[(BW)/2 + L] \) = Contribution of upper body weight and load being lifted that directly compresses the lower back.

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**Table 1**

<table>
<thead>
<tr>
<th>Multipliers</th>
<th>Metric</th>
<th>U.S. Customs</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC = Load constant</td>
<td>23 k</td>
<td>51 lb</td>
</tr>
<tr>
<td>HM = Horizontal Multiplier</td>
<td>25/H</td>
<td>H</td>
</tr>
<tr>
<td>VM = Vertical Multiplier</td>
<td>(1 - (0.0075 \times V - 30)) \times (.82 + (1.8/D))</td>
<td>(1 - (0.0075 \times 30)) \times (.82 + (1.8/2))</td>
</tr>
<tr>
<td>DM = Distance Multiplier</td>
<td>(1 - (0.032A)) \times FM \times CM</td>
<td>(1 - (0.032 \times 0)) \times 1 \times .9</td>
</tr>
<tr>
<td>AM = Asymmetric Multiplier</td>
<td>From a table</td>
<td>From a table</td>
</tr>
<tr>
<td>CM = Coupling Multiplier</td>
<td>From a table</td>
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</tbody>
</table>

*Note: NIOSH = National Institute for Occupational Safety and Health. RWL = recommended weight limit.*

The following measurements are used to calculate the equation:

- BW = Body weight of the lifter.
- L = Weight of the load being lifted.
- HB = Horizontal distance of the load being lifted, measured in inches from the hands to the lower back.
- \( \cos \theta \) = Cosine of torso angle with horizontal (see Figure 2):
  - If torso is vertical, use \( \cos(\theta) = 0 \)
  - If torso is bent \( \frac{1}{4} \) use \( \cos(\theta) = .38 \)
  - If torso is bent \( \frac{1}{2} \) use \( \cos(\theta) = .71 \)
  - If torso is bent \( \frac{3}{4} \) use \( \cos(\theta) = .92 \)
  - If torso is horizontal, use \( \cos(\theta) = 1.0 \)

Applying the Bloswick formula to our lifting scenario revealed the following spinal compression force:

- BW = 200 lb
- L = 90 lb

As in the NIOSH example, the calculation of weight for the orderly on the recliner side, who is initiating the lift, will be considered to be half the load of 180 lb, or 90 lb. However, this is a conservative estimate and may be greater because the orderly on the bed side is in a poor position to assume a major part of the load. In our scenario:

\[
F_{\text{comp}} = 3(BW \cos(\theta)) + 0.5(L \times HB) + 0.8(0.5(BW)/2 + L)
\]

\[
= 3(200 \times 0) + 0.5(90 \times 15) + 0.8(200/2 + 90)
\]

\[
= 0 + 675 + 152
\]

\[
= 827 \text{ lb.}
\]

Translated to newtons, 827 lb = 3678 N.

The compression force calculated (827 lb) is just slightly more than the maximum force of 770 lb recommended by NIOSH. These calculations revealed that the low horizontal distance of the load and the moderate load weight places the worker at only slight risk. When the same formula is applied for the orderly on the bed side, the compressive force is 1838 lb, or 8160 N. This weight is approximately 2.4 times the recommended limit of 770 lb. In this lifting scenario, the large horizontal reach is the primary factor causing biomechanical stress.

The Genaidy et al. Formula

Genaidy et al. (1993) reviewed the literature on spinal compression tolerance limits (SCTL) and reported their findings in a way they hoped would be easily accessed by ergonomists, researchers, and practitioners. They defined spinal compression tolerance limit (SCTL), also known as compressive strength, as the maximum compressive load imposed upon the spine before the compression leads to the failure of one or more of its parts (e.g., vertebral bodies, intervertebral discs, end-plates). The lumbar spine has the highest spinal compression values, followed by the thoracic spine and the cervical spine. Sonoda (1962) suggested that the compressive strengths of vertebral bodies are much lower than those of intervertebral discs. These findings are consistent with the studies of Farfan (1975), Marras and Mirka (1989), Hickey and Hulkins (1980), and NIOSH (Waters et al., 1993), which found that complex loading such as bending and twisting result in much lower SCTL values.

The following formula for calculation of SCTL for the lumbar motion segments takes into account the weakest link in the structure (the vertebrae), whereas the NIOSH formula assesses compressive force on the L5/S1 disc, a stronger link in the structure. The Genaidy et al. formula may be more protective to workers than the NIOSH formula because it is used to calculate the load at which microtrauma occurs. The NIOSH formula, on the other hand, is used to calculate the load at which failure may occur. The Genaidy et al. formula was designed to be used as an adjunct to biomechanical approaches such as that proposed by Chaffin and Anderson (1984) and Blos-
wick (1993) in calculating compressive forces of a given lumbar segment, the following formula is used:

\[ CS = -13331.2 - (73.7 \times Age) - (562.6 \times Gender) + (405.0 \times LMS) + (79.8 \times BW), \]  

where

- \( CS \) = Compressive strength (N)
- \( Age \) = Age (in years)
- \( Gender \) = Gender (male = 1, female = 2)
- \( LMS \) = Lumbar motion segment (L1–L2 = 44)
- \( L2–3 = 45, L3–4 = 46, L4–5 = 47, L5–S1 = 48)\)
- \( BW \) = Body weight (kg)

\[ R^2 = .4828 \] (R\(^2\) is the multiple correlation coefficient)

If compressive strength for a given percentage of the working population is needed, the following regression equation may be used:

\[ CS = 7222.41 - (1047.71 \times Age) - (1279.18 \times Gender) + (56.73 \times PP), \]  

where

- \( PP \) = Population percentile

\[ R^2 = 0.649 \]

From either of these calculations, the damage load (DL) can be found. The DL is defined by Eie (1966) as the weight that causes the first gross signs of damage, such as tissue fluid, blood, and bone tissue to be squeezed out from the surface of the narrowest part of the vertebra. An average value of 60% of compressive strength is used as the criterion for serious damage:

\[ DL = -805.18 + (0.74554 \times CS) \]

\[ R^2 = 0.649 \]

The result of this calculation was used to obtain the ratio of job demands and biomechanical tolerance limits on the basis of the compressive strength capacities of a given population versus the predicted compressive forces from biomechanical analysis such as that obtained with the Bloswick (1993) formula outlined in the previous section.

Given our scenario, the compressive force according to the Bloswick formula for the orderly on the recliner side is 3678 N. With the Genaidy et al. formula for population percentile of the 38-year-old male worker, for 1% of the working population (which protects 99% of workers), the compressive strength is

\[ CS = 7222.41 - (1047.71 \times 2 \text{ [age constant]}) - (1279.18 \times 1 \text{ [gender constant]}) + (56.73 \times 1 \text{ [population percentile]}) = 3904.54 N \]

\[ CS = 3904.54 \]

\[ DL = -805.18 + (0.74554 \times 3904.54) = 2105.4 N \] (The maximum compressive force tolerated per NIOSH is 3432 N.)

Actual compressive force based on biomechanical analysis (Bloswick, 1993) = 3678 N.

The ratio of job demand to biomechanical tolerance limit is actual/predicted = 3678 N/2105.4 N = 1.7

This ratio was greater than 1, revealing that the task of moving patients from recliner to bed places 99% of 38-year-old male workers performing this task from the recliner side at 1.7 times NIOSH’s recommended compressive stress limit on the lumbar spine. The stress to the orderly on the bed side is 8160 N/2105.4 N, or 3.9 times the recommended compressive stress limit on the lumbar spine. The same example calculated for 1% of the 38-year-old female population results in a maximum compressive stress of 2625 N. The damage load is 1152.13 N, and the ratio of job demand to biomechanical tolerance is 3678 N/1152.13 N = 3.2. Thus, compressive stress on the lumbar spine of 38-year-old female lifters on the recliner side performing the lift is 3.2 times the recommended force. For the female lifters on the bed side, the job demand to biomechanical tolerance is 8160 N/1152.13 N, or 7 times the recommended compressive stress on the lumbar spine.

Genaidy et al. have recommended that the following algorithm be employed to restructure job tasks on the basis of the ratio of job demands to biomechanical tolerance limits:

1. If the ratio is greater than 1, apply engineering and administrative controls ergonomically. (An example of an engineering control is the alteration of a task variable, such as weight, distance, and frequency of handling or use of a mechanical aide. An example of an administrative control is the use of a greater number of staff members to lift a patient.)
2. If the ratio is less than 1, it may be possible to increase job demands in order to match the demands with employee capability, thereby improving work efficiency.
3. If job demands are within the biomechanical tolerance limits, no correction is needed.
4. The algorithm can be used to test whether step 3 does in fact result in minimal risk of musculoskeletal injury by prospective epidemiological studies. If a correction needs to be made, revise the value of 1 to the new value that will result in minimal risk of injury and go through steps 1–3 again.

Research by Yoganandan, Ray, Pintar, Myklebust, and Sances (1989) has supported the concept of damage load. In their study, the average loads at the initiation of trauma were found to be 9 kiloNewton (kN) for normal and 4.4 kN for degenerated spine motion segments. The maximum compressive strength was 11 kN for normal and 5.3 kN for degenerated spine motion segments. The threshold of injury was reached at 82% of compressive strength for normal spine motion segments and at 83% of compressive strength for degenerated spine motion seg-
ments. According to NIOSH, persons should not compress forces greater than 3.4 kN during lifting tasks.

Results of MCHV Intervention Strategy

Ergonomic analysis of lifts done at MCHV revealed factors identified in the literature as stressful, including large horizontal or vertical heights, heavy loads exceeding worker capacity, forward flexed positions of the trunk, static loading, and asymmetrical lifting positions. Four of the most difficult transfers, including the lifting scenario described in this article, were analyzed with the three formulas described in this paper (see Table 2).

Regardless of which formula we used, it was apparent that all the lifts analyzed exceeded various recommended compressive force guidelines and put health care workers at high risk for back injury. In such situations, administrative controls should be employed to reduce the biomechanical risk of back injury. For example, additional orderlies could assist in the lift, or the hospital could mandate the use of lifting machines for this type of lift. Another solution is to use recliners that lie flat and could be elevated to bed height for a patient transfer. This scenario would change the physical demands on the order from lifting to pulling and thus be less stressful to the order.

In addition to biomechanical risk factors, understaffing, lack of peer support, and stress were identified as contributors to lifting injuries. These findings, coupled with the work of Owen and Garg (1993), who identified pulling to be less stressful than pushing or lifting during patient moving tasks, provided MCHV’s multidisciplinary injury prevention and management team with the impetus to initiate changes in lifting techniques used by personnel. A proposal to implement a three-part program was presented to the hospital’s administration; recommendations included

1. Purchase of more lifting machines for the hospital
2. Mandatory video in-service sessions on safe transfer techniques to be provided during the employee’s orientation to MCHV
3. Hands-on in-service training in lifting techniques on a yearly basis for all nurses.

The new program, coupled with the use of a special interest prevention group, also offered the following to injured workers:

4. Early referral to the employee assistance program for issues of job satisfaction and employee/supervisor relations
5. The option for employees to perform light duty work (reduced hours or reduced physical demands) to maintain work habits and employee contact with the institution
6. Work site evaluations and ergonomic solutions
7. Individual and group educational sessions
8. Gradual return-to-work accommodations.

The program was implemented in January 1993 and is ongoing. Machines were purchased to be used for lifting patients from the floor, from recliner to bed, and from wheelchair to bed. Machines were also purchased for the use of pulling patients up in bed in cases where a patient’s weight or a shortage of staff members would result in undue risk. Compliance with machine use at MCHV has been slow, and this trend is consistent with studies by Owen and Garg (1993), who cited time constraints and staff members’ perception of difficulty with use as barriers to utilization of machines. MCHV nurses have reported that they are reluctant to locate lifting machines when they are rushed. Further in-service sessions and administrative direction are needed to break down these barriers and increase the use of machines.

Mechanical assist devices, such as gait belts and slide boards, are slowly being integrated into MCHV’s nursing repertoire of transfer aids. Owen and Garg’s (1993) finding that gait belt use lowers spinal compressive forces reinforces our commitment to encourage staff members to use this lifting aid. During their therapy sessions, all

### Table 2

**Analysis of Patient Transfers**

<table>
<thead>
<tr>
<th>Transfer Type</th>
<th>NIOSH Lift Formula</th>
<th>Lifting Index</th>
<th>Blowswick Measure</th>
<th>Genauzy et al. Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed to recliner lift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedside lifter</td>
<td>50 lb</td>
<td>1.8</td>
<td>827 N</td>
<td>1.7</td>
</tr>
<tr>
<td>Recliner side lifter</td>
<td>20 lb</td>
<td>4.5</td>
<td>1926 N</td>
<td>17</td>
</tr>
<tr>
<td>Bed to bed lift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedside lifter</td>
<td>27 lb</td>
<td>3.3</td>
<td>1858 N</td>
<td>3.9</td>
</tr>
<tr>
<td>Recliner side lifter</td>
<td>50 lb</td>
<td>1.8</td>
<td>822 N</td>
<td>17</td>
</tr>
<tr>
<td>Bed to bed, lifters on the same side using sheet lift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifter at head</td>
<td>20 lb</td>
<td>4.5</td>
<td>1505 N</td>
<td>5.2</td>
</tr>
<tr>
<td>Lifter at feet</td>
<td>20 lb</td>
<td>4.5</td>
<td>1322 N</td>
<td>2.8</td>
</tr>
<tr>
<td>Wheelchair to bed, using crossed arm technique</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifter at head</td>
<td>18 lb</td>
<td>5</td>
<td>1412 lb</td>
<td>3.0</td>
</tr>
<tr>
<td>Lifter at feet</td>
<td>22 lb</td>
<td>4.1</td>
<td>1322 N</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*Note: N = newtons.*

injured workers are instructed in proper use of gait belts and are given their own personal belt for use once they return to work. Although workers' acceptance and use continues to increase, we are currently tracking long-term compliance with and percentage of injuries involved in the use of gait belts for lifting tasks.

Small and large slide boards have been made available on nursing floors. However, employees need more education to enhance their compliance and creativity with these devices in order to change a lifting task that induces biomechanical stresses to a less stressful pushing or pulling task. After the first year of program intervention, the percentages of patient-related lifting injuries to total injuries was reduced by 49%, from 45% in fiscal year 1991 to 23% in fiscal year 1993.

The best success story occurred in the orderly department. The orderly supervisor, who remains current in patient-handling techniques, has provided a good example for his staff members in his commitment to the prevention of injuries and ergonomic philosophy. He has been a key person in supporting the purchase of lifting machines in the hospital and for his department, despite fear among his employees that these purchases could result in job losses. The orderly supervisor encouraged his staff members to practice and review lifting principles, and he worked with the departments of physical and occupational therapy to develop sound transfer techniques on the basis of ergonomic analysis. As a result, orderlies refused to perform unsafe lifts, and they increased their use of machine lifts. The orderly department continues to play an active role in educating and encouraging nurses to increase their use of lifting machines and to decrease their reliance on the orderlies for manual lifting techniques. The orderlies have had no injuries during the first year of the self-insured hospital program, whereas they had had an injury rate of 42% in the previous 2 years.

Conclusion

Ergonomic analysis of transfers in a health care setting place safe lifting limits ranging from 20 to 50 lb upon staff members. These limits may reduce the risk of injury in 75% of the female population and 99% of the male population. Although we have made strides at MCHV in the treatment and prevention of lifting-related injuries to workers, questions remain.

What is a reasonable lifting capacity that injured health care professionals need to achieve in therapy before returning to work? We contend that the answer is dependent on the injured worker's age and type of injury, premorbid strength, and period of rehabilitation, as well as accommodations that can be made on the job. Returning an injured nurse to work duties that specify a maximum lifting capacity of 30 lb to 35 lb may be more acceptable than the standard of 50 lb that many institutions use.

Educating workers on both their individual maximum lifting capacity and the recommended maximum based on ergonomic analysis allows workers to better know when to ask for additional staff member assistance or when they need to use a lifting machine.

Questions also remain regarding the premorbid strength of the nursing population. Results of further descriptive research studies would empower health care institutions to enforce safe lifting policies. This research would also help assess realistic staffing patterns, job expectations, injury risks, reasonable accommodations, and acceptable weight-lifting goals for injured workers.

How much patient weight should any nurse be required to lift alone? As noted in the task analysis, this answer depends on variables such as horizontal distance and may vary from 20 lb to 50 lb or more. There needs to be more emphasis on educating nurses as to the principles of ergonomics so they can play a more proactive role in deciding which stresses are safe for their bodies and how they are going to affect changes in any given situation. This emphasis may improve staff members' compliance with proper lifting techniques, as there is some question in the literature as to whether employees continue to comply over time with body mechanics training in the health care setting (St-Vincent, Tellier, & Lortie, 1989). Management must support injury prevention principles and encourage the use of mechanical lifting aids to reduce workers' biomechanical stress and risk of injury. Managers may need to use firm corrective action principles as an adjunct to enhance their employees' compliance.

Back pain continues to plague our society. Some of the stresses of lifting tasks in health care, especially the transferring of heavy patients, result in biomechanical stresses on the back that exceed spinal compression tolerance limits and are unsafe for health care workers. Ergonomic analysis is a useful tool in determining which types of lifts place workers at the most risk and in planning modifications that enhance safety and decrease repetitive trauma to the spine. As more and more organizations proactively plan to control escalating workers' compensation costs, physical therapists and occupational therapists will continue to have an important role to play in injury prevention and management.

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