A Guide to Manual Materials Handling and Back Safety

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Acknowledgment

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For more information concerning OSHA in North Carolina or **To obtain additional copies of this book, or if you have questions about N.C. occupational safety and health standards or rules, please contact:**

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Additional sources of information are listed on the inside back cover of this book.

The projected cost of the OSHNC program for federal fiscal year 2002–2003 is $13,130,589. Federal funding provides approximately 37 percent ($4,920,000) of this total.

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Foreword

"Am I ready for this lift?" It is a question millions of workers ask themselves daily. Warehouse employees may ask it 30 times a shift as they move heavy boxes to the loading dock. An office manager may only ask it once in that same time as she prepares to move a computer terminal to a new desk. Whether you manually lift and handle loads all day or only once in while, the same worries are there. Will you hurt your back? Will it be too heavy? Can you carry that valuable equipment without dropping it?

A Guide to Manual Materials Handling and Back Safety explains the many risk factors involved in lifting and handling materials. It discusses ways to move materials more safely and examines hazard control from a workplace design viewpoint. Finally, this guide explains many ways to keep our backs and muscle groups healthy and safe while we perform our varied on-the-job duties.

In this state, North Carolina Department of Labor consultants and inspectors administer the federal OSHA laws through a plan approved by the U.S. Department of Labor. All current OSHA standards are enforced. Many educational programs, publications (including this guide), and other services are also offered to help inform people about their rights and responsibilities regarding OSHA.

As you look through this guide, please remember that OSHA's mission is greater than just enforcement. An equally important goal is to help citizens find ways to create safe and healthy workplaces. Everyone profits from working together for safety. Reading and using the information in *A Guide to Manual Materials Handling and Back Safety* will help you form sound occupational safety and health practices in your workplace.

Cherie K. Berry
Commissioner of Labor

Note

This completely new version of the North Carolina Department of Labor's Industry Guide 26 combines the essential information from two earlier industry guides into one easy to use booklet. The original Industry Guide 26 (*A Guide to the Safe Handling of Materials*) and the original Industry Guide 24 (*A Guide to Minimizing the Risk of Lifting Related Back Injuries*) contained information that overlapped and caused many readers to need both booklets.

We hope that this new publication, *A Guide to Manual Materials Handling and Back Safety*, will give readers the relevant information they need on these closely related topics in a single guide.

Finally, this guide is intended to be consistent with federal and state OSHA standards. However, if an area is considered by the reader to be inconsistent with a standard, then the standard should be followed.

1

Introduction

Manual materials handling (MMH) is a component of many jobs and activities undertaken in life. Typically it involves lifting, lowering, pushing, pulling, and carrying objects by hand. Loading and unloading trucks, carts, boxes, or crates; moving parts or assemblies from one place to another; loading paper to the copier or picking binders from an overhead shelf; lifting patients from a bed or transporting them in a wheelchair are typical MMH activities found in work settings. Likewise, carrying groceries to the kitchen or garbage cans to the curb, picking up sticks in the yard or mowing the lawn, or simply holding a child in your arms are forms of MMH we encounter at home. This is by no means an all-inclusive list of MMH tasks. Manual materials handling permeates all aspects of life on and off the job. Even with all the technology available today, manual materials handling will always be with us.

The one thing all these tasks have in common is the potential to result in some adverse health effect, from simple cuts, bruises, and sore muscles to more serious conditions related to low back pain (LBP). Based on available statistics, almost half of all low back injuries are related to lifting, about another 10 percent are associated with pushing and pulling activities and another 6 percent occur while holding, wielding, throwing, or carrying materials.[1]

The introduction to the *Applications Manual for the 1991 Revised NIOSH Lifting Equation* says that low back pain and injuries attributed to manual lifting activities are among the leading occupational health and safety issues facing preventative medicine. The September 26, 1989, issue of *The Wall Street Journal*, in a front-page article on low back pain, said that LBP accounts for about one-quarter of all lost workdays in the United States and costs $15 billion to $20 billion annually in medical expenses and lost earnings. When you consider that roughly 80 percent of all people, at some point in their lives, are afflicted with low back pain, it is easy to see that this is a significant problem that concerns us all.

Guide Purpose

Very often the specific cause of an individual's chronic low back pain is unknown. Much more often than not, it is a result of wear and tear on the back that occurs over time, as opposed to an acute, or one-time, strenuous activity resulting in an episode of LBP. There are recognized risk factors that can contribute to, or exacerbate, chronic low back pain; likewise, there are ways and means of reducing exposure to those risk factors so we can avoid the toll of LBP. About one-third of the U.S. workforce is presently required to exert significant strength as part of their job, and overexertion was listed as the cause of low back pain by 60 percent of the people who suffer from it.[2] The purpose of this industry guide is to provide employers and employees with useful information to help them reduce the frequency and severity of low back musculoskeletal disorders.

Introduction to MMH Analysis

While there is little understanding of the specific causes for low back pain in each particular case, there is some understanding of how the body responds in general to physical stressors. And there is relative agreement on the mechanisms which can injure the lower back. If extremely heavy weights must be handled, the forces we have to exert on those objects may result in direct damage to the spine, and to the intervertebral discs in particular. So, it would be helpful to know that the weights we handle and postures we assume will not put us in a position to do mechanical damage to our back (i.e., herniate or rupture an intervertebral disc).

If a lifting task is repetitive in nature and takes place over an extended period of time, it will probably require sustained strength and endurance from us. The body responds to this demand by increasing the heart rate and by breathing more heavily to take in more oxygen. In this instance too, we would like to be sure that the manual materials handling task does not overly tax us from a physiological standpoint (i.e., strained muscles or worse).

There are four fundamental approaches to the analysis of MMH tasks. To better understand the issues of concern related to MMH and chronic low back pain, it is necessary to first understand a little about each of those approaches.

Biomechanical approach: Biomechanics relates the principles of physics to the human body to determine the mechanical stresses that affect it and the resultant muscular forces needed to counteract the stresses.[3] Mathematical models have been developed to help determine the forces and torques acting on various systems of the body, such as the back, arms, or legs. The design goal of biomechanics is to ensure that loads and strength demands are reasonable. The post-injury analysis aspect of biomechanics is to determine the levels of demand that were placed on an injured worker. Biomechanics is especially useful in analyzing forces and torques acting on the L5/S1 disc. This is the low back spinal disc most frequently injured in the performance of materials handling tasks. Application of the biomechanical approach has generally been limited to the analysis of infrequent high force lifting, lowering, pushing, and pulling tasks.

Physiological approach: The physiological approach is concerned with energy consumption and the stresses acting on the cardiovascular system.[4] As we perform a repetitive lifting task, our oxygen consumption increases, our heart beats faster, and muscles become fatigued. This is the physiological cost associated with the activities we perform. While the biomechanical approach is most useful in analyzing infrequent lifting tasks, the physiological approach is most applicable to repetitive lifting tasks. In this kind of job the individual's physiological response is the limiting factor with respect to the work.

Psychophysical approach: The underlying premise of the psychophysical approach is that when people perform a lifting task, they intuitively combine both biomechanical and physiological stresses in their subjective perception of the demands placed on them. In other words, people adjust their workload to the maximum amount they feel they can sustain without undue strain or discomfort, and without becoming unusually tired, weakened, overheated, or out of breath.[5]

Epidemiological approach: Epidemiology studies groups of people and analyzes information and data to determine the root causes of (in the case of manual materials handling) back injuries. A better understanding of what has happened in the past can be used to help prevent injuries in the future.

Each of the four approaches used in the design and analysis of MMH tasks is appropriate under different circumstances and conditions. Authors of the *1991 Revised NIOSH Lifting Equation* used three of the four approaches (biomechanics, physiological, and psychophysical) in developing the equation. The Suggested Reading List at the back of this guide includes texts and other materials that expand on each of the approaches presented above.

2

Manual Materials Handling Risk Factors

Risk factors (also known as “ergonomic hazards”) are conditions that may adversely affect a person’s well-being and could influence an individual’s ability to safely perform an MMH task. As with most musculoskeletal disorders, chronic low back pain usually results from some combination of risk factors acting together over time. It should be noted, though, that there is no established dose/response relationship. In other words, it is impossible to say how many times, or over what period of time, an activity, posture, force, or other risk factor can be performed before resulting in a low back musculoskeletal disorder.

It should be safe to say, however, that in the case of LBP there is a mismatch between the task and the person’s ability to safely perform the task that results in injury. The mismatch may originate from personal characteristics inherent to the worker or may stem from environmental, workstation, psychosocial, or job task factors. Additionally, LBP may well be associated with activities performed both on and off the job.

Nonoccupational or Personal Risk Factors

A variety of personal qualities and traits, which the worker may bring to a manual materials handling job, have been identified as potential risk factors in the development of low back pain. These include a prior history of back injury, poor personal fitness levels, second jobs, recreational activities, hobbies, smoking, the aging process, gender, obesity, physical stature, and psychosocial issues (including family, financial or other personal difficulties, job or management dissatisfaction, a lack of job control, and work-related stress among other factors).

A prior history of back injury is one of the few personal risk factors that probably has some positive correlation as a predictor of future LBP. Persons who have had an injury are more prone to reinjure that body part. With regard to personal fitness levels, the better condition we are in the better we are able to tolerate and recuperate from the stressors we place on our body. Second jobs, recreational activities, and hobbies, especially those which closely mimic the physical demands of our work, can add to the wear and tear on the systems being taxed on the job. As important, they reduce our opportunity for rest and recuperation, which we must have if we are to protect our health and well-being.

No universal conclusions can be drawn about smoking, aging, gender, obesity or stature. In a general sense though, smoking adversely affects the cardiorespiratory system and endurance. When considering gender differences, men are, on average, bigger and stronger than women; however, there is considerable overlap between men and women with regard to size and strength, and without a doubt, some women are bigger and/or stronger than some men. Employers must be careful not to discriminate against people who can perform MMH tasks without undue risk. One additional gender consideration: It is generally accepted that heavy lifting and physically strenuous exertion carries an increased risk of miscarriage, or spontaneous abortion, during early pregnancy (the first trimester). Additionally, the pregnant woman's exercise tolerance will diminish rapidly as physical work becomes more arduous during the last trimester.[6]

In lifting tasks we not only lift the load but the weight of our upper body as well; obesity works against the materials handler because of this. People who are overweight tend to "have a great deal of difficulty in repetitive load handling, and can get exhausted quickly, particularly when the load is located on the floor."[7] As pertains to stature, a number of studies have also shown that "tall people are relatively weaker in lifting strength and are more susceptible to back pain as they have to lean and reach further to pick up or set down a load."[8] Our body changes considerably over time, especially after 40 years of age. "Aging leads to reductions in physical work capacity, range of lumbar spinal motion, muscle strength, muscle contraction speed, shock absorbing characteristics of the lumbar discs, intra-abdominal pressure, load supporting capacity of the spine, and aerobic capacity."[9]

Environmental Risk Factors

Confined or limited workspaces may be considered a risk factor for low back pain. Work in spaces that constrain an individual's posture should be eliminated where possible, especially when it affects headroom or horizontal reaches. Reaching over obstacles and into containers at a distance from the torso places undue strain on the back. Work areas should be unobstructed and allow the handler freedom of choice as to how the object is appraised, approached, and handled. Foot and legroom should be sufficient to allow the handler to bend the legs and knees when getting close to the object. Good housekeeping practices cannot be overemphasized. Floors should be free of debris or materials that might pose a slip, trip, or fall hazard.

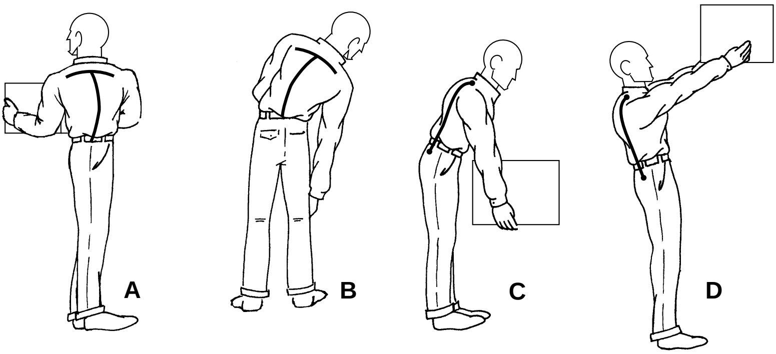
Many materials handling jobs are performed while standing. It is generally agreed that there is a correlation between standing for extended periods of time (four hours or more) and LBP. As a rule of thumb, the harder the flooring (with concrete being the worst offender), the more discomfort and fatigue are likely. Flooring properties, surface treatments, and shoe sole materials need to provide ample friction between the shoes and floor, especially when the job requires heavy lifting or when materials are to be pushed or pulled. Adequate floor/foot friction should be provided to improve effort efficiencies and reduce the chance of slipping. Because of the complex dynamics between flooring materials, surface treatments, and the handler's shoes, the designation of a "safe" flooring coefficient of friction is not possible with any degree of precision.[10] It is safe to say, however, that slick or slippery surfaces pose a significant health and safety concern, and manual materials handling tasks are riskier when performed on slick floors.

Workplace Risk Factors

The workplace risk factors typically associated with low back pain include handling heavy loads, task repetitiveness, extreme postures of the back (twisting, bending, stretching, and reaching), static postures, whole body vibration, prolonged sitting, direct trauma to the back (striking or being struck by an object), slips, trips and falls, and work-related stress. (See figure 1.)

Figure 1

Extreme postures of the back which are of particular concern. A) Twisting the back without moving the feet. B) Lateral bending. C) Back flexion; associated with picking up objects below knuckle height. D) Back extension; associated with reaching above the heart.

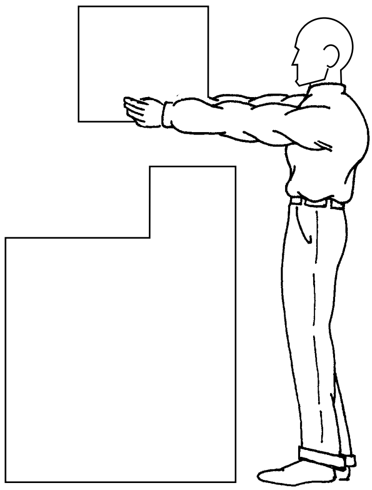


People performing heavy work, working near their personal strength and endurance limits, are more likely to develop back problems than those who need to use only a small fraction of their strength capacity.[11] Therefore, the more an object weighs, the greater the chance of musculoskeletal injury. A high level of MMH task repetitiveness increases LBP risk, especially if combined with other risk factors such as extreme postures of the back. For example, lifting frequently from floor level is more demanding physiologically and biomechanically than lifting infrequently from knuckle height. The pace at which we work carries some physiological cost, but there is a personal work rate at which each of us can safely work without deleterious physical effects. This is most often the case when work is "self-paced"—when the individual establishes a personally comfortable work rate; however, work rates are often established by machines and equipment, standards, management, or co-workers. Increasing the work rate, or task frequency, increases the body's physiological response.

The postures we assume while working may be self- or workplace-imposed. A person may (inappropriately) choose an extreme posture on his or her own to perform a task. Workpiece positioning, equipment orientation, and workstation layout may also compel the use of extreme postures. (See figure 2.) Use of extreme postures will adversely impact energy expenditure and the strength we can bring to bear to accomplish a task. Awkward or extreme postures are less efficient than postures that keep joints near the center of their range-of-motion. A person working from an extreme posture will have to use more force to accomplish the same amount of work when compared to using a neutral posture. Bending, twisting, kneeling, reaching, and stretching in particular are stressors on the low back and influence how we feel after finishing a taxing task.

Figure 2

An obstruction at the workstation forces the handler's back into flexion, moves the object away from the spine and increases the load on the spine.



3

Education and Training

The primary means of reducing the risk of musculoskeletal disorders among materials handlers is to provide engineering solutions to workplace risk factors. Providing education and training is an important complement to engineering intervention, but is not a replacement for it. A comprehensive low back pain prevention initiative will include a multitiered education and training program.

Employees need to understand the risks associated with LBP in order to actively participate in protecting their own well-being. Employee "back schools" typically include information on back anatomy, ways to improve body mechanics for materials handling and general work tasks, the safe and effective use of MMH devices found in the workplace, and ways to increase back muscle strength. Employees must also know about early reporting of pain, how to assist with an ergonomic workplace analysis, and the subsequent development of potential solutions to identified concerns. Employee participation can be invaluable to the engineer in the creation of safer, more user-friendly work systems. Training should be reinforced on a periodic basis, and management should display active support for safe MMH training efforts.

It is management's role and responsibility to control low back disability, especially as pertains to incidence and severity. How management responds to pain can serve to accelerate recovery or make matters worse. As with most musculoskeletal disorders, there are no outward signs or symptoms associated with LBP; this might lead some people to believe that the employee is simply disgruntled or malingering. Poor management practices, such as assuming malingering or not making workplace modifications to eliminate or significantly reduce the ergonomic stressors that prompted the injury, can only make matters worse. To compound the situation, there is often little or no communication with the injured employee to show concern and promote an early return to work. Management and supervisory training should include positive acceptance of employee reports of low back pain, promoting the early reporting of pain, follow-up and communication, and early return to work.[12]

Management must understand the scope of the employer's LBP problem and the need for engineering-based ergonomic intervention and prevention. This understanding translates into providing management with information on back injury incidence and severity, the costs associated with the problem, where the problems are occurring, and the potential consequences of not intervening or preventing LBP. This should be followed with a request to management for access to the resources (people, time, and money) necessary to address the problem adequately.

Other employees will also need specific training in ergonomics as it relates to their area of expertise. These include engineers, space planners, health care providers, human resources, and purchasing, for example. Their training should provide them with the tools necessary to be more effective in pain prevention and personal accommodation as it relates to their field and sphere of influence.

It is not uncommon, after completion of education and training, to see an increase in the reporting of LBP in the short run. Often this is attributed to people coming forward with conditions that already existed. Incidence and severity rates will significantly improve in the long run through an integrated, comprehensive approach to preventing chronic LBP, with education and training as one of the key elements of this approach.

Safe Lifting Technique

Experts do not often agree as to what constitutes a truly safe lifting method, and in reality there is no single correct way to lift. The method espoused for the past several decades (bend the knees and not the back) has not been particularly effective in reducing the incidence or severity of low back injury by itself. Lifting, in practice, is highly dependent on the particulars of the task at hand.

Expert opinions differ as to which lifting methodology poses the least physical threat to the handler. The biomechanical approach indicates that a squat lift (knees and hips bent with the back more or less straight) places the least stress on the back. Proponents of the physiological approach to lifting argue that the stoop lift (legs straight with the back bent) is less physiologically stressful than the squat lift. And the psychophysical approach to lifting indicates that a freestyle lift is least taxing.[13] A freestyle lift is described as a semi-squat posture, which allows the handler to rest the load on the thigh(s) during the lift.

However, there is general agreement on some fundamental principles that should help protect materials handlers when lifting under most circumstances. Typically, when lifting the handler should:

1. Test the weight of the load, its weight distribution and stability within the container. This minimizes the chance of being surprised by an unexpectedly heavy weight or having to contend with a shifting load.

2. Get help from someone or use a mechanical assist device whenever very heavy or awkward loads must be handled. When lifting with a partner, the team should communicate and coordinate the task (when lifting, moving, and lowering the object).

3. Know where the load is going. Make sure the path is free from obstructions or hazards, and ensure that space is available at the destination to set the object down.
4. Be positioned close to the load, with the feet flat and stable. Keep the load as close to the body as possible so that the center of gravity is as close to the spine as possible. Moving the load away from the torso (horizontally and/or vertically) greatly increases the load to the back, shoulders, and arms, and, therefore, increases the risk of injury.
5. Grasp the object with the whole hand using a power grip whenever possible. Avoid pinching with the fingertips to hold an object. Ideally, the handler should be able to use both hands on handles or handholds to pick up the load.
6. Move with natural, smooth, continuous, and balanced motions while avoiding rapid, jerky, or unbalanced lifts. Move the feet to avoid twisting the torso and to maintain balance and stability during the lift, if necessary.
7. Minimize twisting, bending, stretching, and reaching with the trunk during the lift. These movements greatly increase the risk of developing LBP.

These principles should make it clear that we need to lift with our head before we lift with our back. Taking a couple of seconds to help ensure our safety and health is time well spent.

4

The 1991 Revised NIOSH Lifting Equation

The purpose of the 1991 Revised NIOSH Lifting Equation is to provide a means of quantifying the relative risk or acceptability of a specific lifting task, to subsequently be able to identify specific task deficiencies, and then plan for their elimination.

There is no single “magic number” for a weight that can be safely lifted under any set of circumstances. The biomechanical load to the back and the physiological cost of the lift are related to a number of criteria. The revised equation takes into account six variables that are associated with every lift. The variables are translated into equation multipliers. The variables, or multipliers, are the Horizontal Multiplier (HM), the Vertical Multiplier (VM), the Distance Multiplier (DM), the Frequency Multiplier (FM), the Asymmetry Multiplier (AM), and the Coupling Multiplier (CM).

Specifically, they examine:

- ➢ The horizontal distance of the load from the body (HM): the greater the horizontal distance, the greater the load to the spine.
- ➢ The vertical distance of the load from the floor at the start of the lift (VM): lifting from the floor and reaching above shoulder height are of particular concern.
- ➢ The vertical distance the load is lifted (DM): studies have shown that the greater the vertical distance of a lift, the greater the toll.
- ➢ The frequency and duration of the task (FM): endurance suffers with increasing frequency.

- ➢ Asymmetry associated with the lift (AM): twisting the back without moving the feet adversely affects strength and stability while improperly loading intervertebral discs.
- ➢ Coupling with the load (CM): handles or handholds provide a better interface, allow use of a power grip, allow for increased weights to be handled, and reduce the chances of dropping the load.

All of these factors play a role in determining the weight of a load that can be safely handled by most people. Applying the revised equation to a task results in a Recommended Weight Limit (RWL), which has been defined as the weight that nearly all healthy workers could lift over a substantial period of time (up to eight hours) without an increased risk of developing lift-related low back pain.[14] Again, there is no "magic number" that is safe for most people to lift under any set of circumstances, but rather, all of the factors listed above influence the acceptability of a lifting task.

The algebraic expression of the 1991 Revised NIOSH Lifting Equation is:

- ➢ $RWL = LC \times (HM) \times (VM) \times (DM) \times (FM) \times (AM) \times (CM)$

where:

- RWL is the Recommended Weight Limit.
- LC is the Load Constant and is always equal to 51 pounds.
    - The Load Constant is the weight a person should be able to lift once under ideal conditions at minimal risk.
- The other six multipliers (HM, VM, DM, FM, AM, and CM) reduce this weight based on the actual conditions of the lift being examined.

Additionally:

- Lift Index (LI) = actual weight of the load, divided by the RWL. The Lift Index is the ratio of the load being lifted to the Recommended Weight Limit.

The Lift Index is intended to provide a means of comparing lifting tasks. A Lift Index greater than 1.0 is likely to pose an increased risk of low back pain for some fraction of the exposed workforce and may, therefore, be used to identify potentially hazardous lifting jobs.[15] The higher the Lift Index, the greater the risk to the persons performing the task. The goal should be for all lifting tasks to have a Lift Index less than 1.0.

The revised NIOSH equation can assist in the elimination or reduction of explicit task variables of concern. The individual multipliers can identify specific aspects of the lift that are problematic and require addressing in order to make the lift more acceptable. As the task is applied to the equation, each of the multipliers will be assigned a value between zero and 1.0 (except for the coupling multiplier, whose value will range between 0.9 to 1.0) depending on its level of acceptability. The lower a multiplier's value, the less acceptable it is. Those multipliers farthest from 1.0 are the task variables that should be addressed first to make the lifting task more acceptable.

The revised equation does not apply to all lifting situations. For example, it is not applicable to one-handed lifts, extremely hot or cold objects, very heavy or unstable loads (such as people), slips or falls, lifts from a kneeling or seated position, and other nonlifting components of job tasks. The equation assumes, however, that other manual materials handling tasks are minimal and do not require significant levels of energy expenditure, that there is adequate foot/floor friction, and that lifting and lowering tasks have the same level of risk.[16]

Detailed guidance on the application and interpretation of the revised equation is beyond the scope of this industry guide. The applications manual for the 1991 Revised NIOSH Lifting Equation is available through the National Technical Information Service for $12 plus shipping and handling. Ask for publication PB94-176930, entitled *Applications Manual for the Revised NIOSH Lifting Equation*, when calling 800-553-NTIS.

5

Hazard Identification

Records Review

Probably the easiest and most effective record from which to gather summary information pertaining to low back injuries is the OSHA 200 Log, which is the employer's record of work-related injuries and illnesses. This informational record provides the analyst with the department in which the injured employee works, the date on which the injury occurred, a description of the injury, and any lost and/or restricted time resulting from the injury. Work-related illness data on the OSHA 200 log reveal similar information. Other sources of information pertaining to back-related injuries are on- and off-site medical records, workers' compensation records, and personal medical insurance records. Patient confidentiality must be maintained through the records review, data collection, data analysis, and reporting process.

It is important to review this information on a periodic basis to identify where and to what extent back injuries are occurring. One of the primary reasons for this exercise is so resources may be efficiently and effectively brought to bear in addressing the problem of low back pain and to measure program effectiveness in the long run.

Incidence and Severity Rates

The OSHA 200 log is often used to generate incidence and severity rates associated with low back injuries. These rates are important indicators of the scope and depth of the LBP problem and for measuring remediation effectiveness (or lack thereof) over time. Resources should be directed toward jobs with a high incidence or severity rate of low back disorders. Incidence and severity rates can be generated for an entire building's population, individual departments, specific jobs, or period of time. In order to generate incidence and severity rates, all back-related injuries and the lost time associated with those injuries must be identified (usually from the OSHA 200 log, as described above).

The incidence rate (IR) is equivalent to the number of new cases per 100 workers per year. The severity rate (SR) is equivalent to the number of lost workdays per 100 workers per year.

$$\text{Incidence Rate} = \frac{\text{number of new cases during the period} \times 200{,}000 \text{ hours}}{\text{hours worked during the period}}$$

$$\text{Severity Rate} = \frac{\text{number of lost workdays during the period} \times 200{,}000 \text{ hours}}{\text{hours worked during the period}}$$

200,000 hours represents 100 employees working 40 hours per week, 50 weeks per year (or, $100 \times 40 \times 50 = 200{,}000$). Hours worked should not include non-work time, such as vacation, sick leave, holidays, and the like.

Worksite and Task Analysis

After identifying where low back injuries are occurring (through review of OSHA 200 logs, and so forth), steps should be taken to identify ergonomic risk factors and deficiencies in the workplace that may lead or contribute to the problem. This is often accomplished through the use of questionnaires, surveys, and audits, which are standard analytical tools of the occupational ergonomist. The risk factors should be examined in terms of the duration of handler exposure to them. In general, the greater the duration of exposure to the risk factors, the greater the likelihood of pain development.

Performing lift, lower, push, pull, and carry analysis can help tremendously in identifying whether or not a task is acceptable and with finding where deficiencies are in the task. Lift and lower analysis was discussed in chapter 4 of this guide. One source for quantitative push, pull, and carry analyses is *A Guide to Manual Materials Handling.* Information on this text is contained in the Suggested Reading List at the back of this guide.

Videotaping the worker, workplace, and processes is often used in manual materials handling analysis. The analyst will shoot video tape and review it with an eye toward identification of ergonomic risk factors. He or she may use the fast forward, slow motion, or still features on the playback unit to observe specific motions or postures of concern more closely, or to identify methods or processes used.

The advent of mini- and microcomputers and components has advanced several state-of-the-art analytical systems in recent years. Sophisticated computer-based video analysis systems can perform motion and posture analysis and assess biomechanical and physiological risks associated with a job. Other systems allow the materials handler to perform his or her job normally while wearing a data collection appliance. These units collect motion and posture information during the work day, which is later downloaded to a computer for analysis. These systems quantify activities performed during work for the purpose of identifying the physical demands of the job that might place the worker at risk.

Participation in the analysis process should not be limited to ergonomists, engineers, or space planners. Employees, supervisors, managers, health care providers, human resource specialists, and others possess a wealth of knowledge and experience related to the job, work environment, tools and methods that are used, as well as the loads that are handled. Employees in particular should be actively engaged in the workplace analysis and improvement process. Including workers in the hazard identification and abatement process helps to reduce surprises, can help ensure the adequacy of change, and improves the likelihood of change acceptance.

6

Pushing, Pulling, Carrying, and Transporting Loads

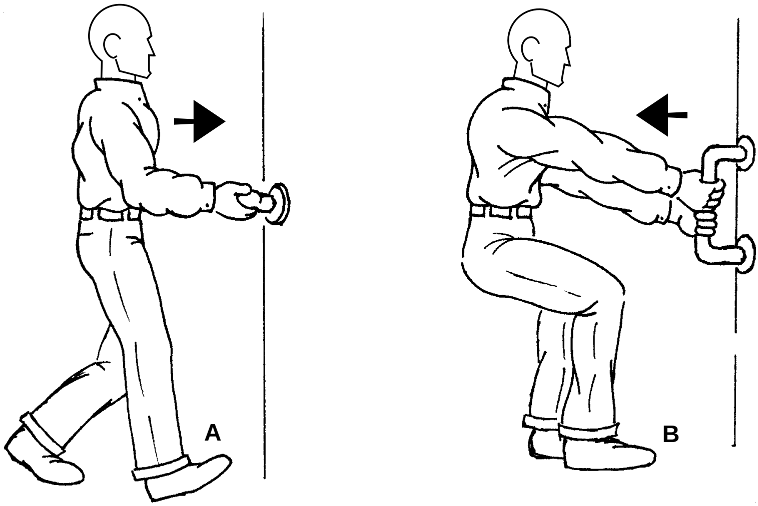
Pushing, Pulling, and Carrying Loads

Generally speaking, lowering is preferable to lifting and pushing is preferable to pulling; however, all these activities have the potential to be stressful to the arms, shoulders, back, and legs. Factors that influence the ease or difficulty of pushing and pulling are the initial (or breaking) and sustaining forces necessary to move the device, steering, and controlling the unit while in motion, the frequency with which the push/pull task is performed, and the terrain and distance over which the task takes place.

In pushing and pulling tasks it is harder to start a body moving (the initial forces) than it is to keep the body in motion (the sustaining forces). When pushing or pulling, the handler should use his or her own weight to advantage. When pushing the person should lean into the push and when pulling should lean in the direction of travel. All push/pull tasks require adequate friction between the floor and the operator's shoes to provide adequate traction and avoid slipping.[17] When pushing, arms should be flexed at the elbow, extended to about half their length, thereby allowing the operator to regulate effort as necessary by flexing and extending the arms. When pulling, arms should be extended, then effort to move the load is transferred to the lower extremities. (See figure 3.)

Figure 3

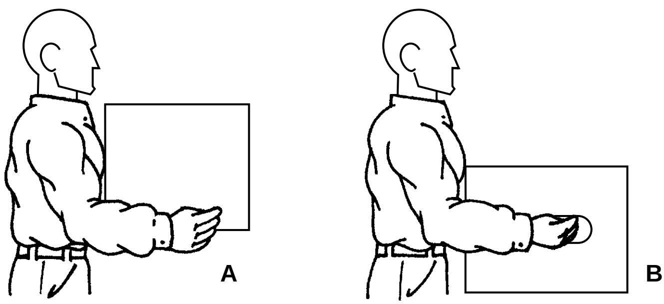
Materials handlers should use their weight to advantage when A) pushing or B) pulling an object. Note: In the pushing task the arms are flexed and in the pulling task the arms are extended.



Carrying tasks have the potential to stress the arms, shoulders, and back in particular. To help minimize these stressors, keep the weight of the load acceptable; keep the load as close to the body as possible; and use both hands in a power grip (rather than a pinch grip) to hold the load. Other factors that influence the ease of a carrying task are the width (side-to-side) and height of the load, the frequency with which the task takes place, and the distance over which the load is carried. Ideally, the width of the load should be about as wide as the person's torso. The height of the load should allow the handler a clear view of the travel path. Carrying distances should be minimized. "The easiest way of carrying a load like a crate or a box is holding it by the front corners, with the arms straight, at hip height, so that it does not interfere with the movements of the lower limbs."[18] (See figure 4.) Loads to be carried to the side of the body (suitcases, grocery bags, brief cases, etc.) should be equipped with suitable top mounted handles, “should be as slim as possible and should clear the ground when the carriers’ arm hangs by their side.”[19]

Figure 4

Carrying boxes; A) with, and B) without hand-holds. Note: Subject uses a power grip with both type boxes, his arms are extended, and the load is held close to the body.



MMH Assistive Technologies

The person who specifies a materials handling device should understand and clearly define usage expectations and desired outcomes.

This includes, but is not limited to, identifying:

- What will be carried (assessing size, weight, and other pertinent parameters)
- Overall weight and size capacity demands (using worst case load weight and size estimates)
- The terrain and anticipated travel path (identifying the presence of ramps, severe floor irregularities, steps, or other obstacles)
- Pertinent environmental conditions (extremes in temperature, water, or chemical exposures, etc.)

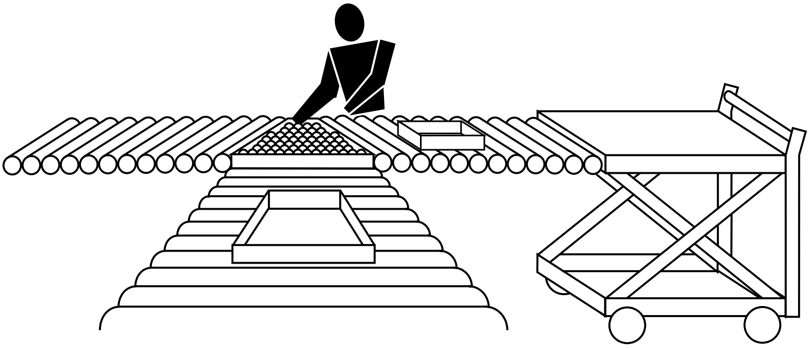
- How frequently the unit will be used (infrequently to constantly)
- Information pertaining to the people who will use the device (user population characteristics versus load and device characteristics), as necessary and appropriate

Such detailed information will help ensure that the specified device will fit the task requirements, reduce ergonomic risk factors, and reduce the human burden. Improperly designed or specified MMH aids have the potential to slow down work, lead the user to abandon the unit, or, worse, result in injury to the handler and perhaps to others. Choosing the right equipment can make work less physically taxing, reduce MMH risk factors, and make performing the task more acceptable to a wider range of people.

There is a host of MMH assistive technologies available, including cranes, hoists, and monorails for lifting, lowering, and transporting; manipulators for picking and orienting; and work positioners and lift tables for lifting, lowering, and rotating objects. Carts, dollies, and trucks are used for transporting loads, and a wide variety of tools and equipment, intended to reduce physical stressors associated with manual handling tasks, are available. Examples include conveyors, totes, flow racks, and ball transfers. Often teaming a combination of handling devices to work in concert as a system is desirable and should be considered. An example of this would be the use of a lift table used in conjunction with a conveyor and ball transfer to move materials from a receiving department through an incoming inspection process area. (See figure 5.)

Figure 5

An integration of technologies intended to reduce the manual handling of materials. This system combines a scissors-lift dolly, conveyor, and ball-transfer to move materials or boxes.



Two- and Four-Wheeled Transport Device Design Considerations

Handles—Horizontally oriented handles should be positioned at about hip height (in the range of about 33"–39"), and should run the width of the device. Vertically oriented, handles should start at about 35" from the floor and extend to about 47" from the floor. Handles should be free from sharp edges (specify them with an elliptical or rounded cross-section) and should provide a comfortable, nonslip grip surface.

Wheel or caster type—The larger the wheel or caster diameter the easier it will be to start and keep the device rolling and to negotiate flooring imperfections.

Steering in tight quarters, however, will be relatively harder with large casters or wheels. The unit will steer easier if swivel casters are installed at the end from which the operator pushes or pulls, and directionally fixed casters are provided at the opposite end. If the handling device will be left unattended and has the potential to roll, it should be equipped with one or more locking or braking casters. Wheel or caster composition selection is typically a function of the type flooring the unit will traverse, the worst case load capacity, noise, and environmental considerations.

Limit the load capacity so as not to overtax the handler—Typical initial and sustaining forces should be kept in a range that will not be too strenuous for the people using the device. Consider the use of powered units when loads are excessive, when long distances must be traveled, or when ramps or severe flooring irregularities are encountered.

Ease of loading and unloading—Use of open type shelves is desirable for this purpose. The fewer lips or raised edges shelves have, the less lifting and lowering will be performed. The ideal workrange is from the knuckles to the heart; keeping materials in this workrange will make items convenient and easily accessible. This workrange also raises the unit's center of gravity, which should be kept as low as possible for stability.

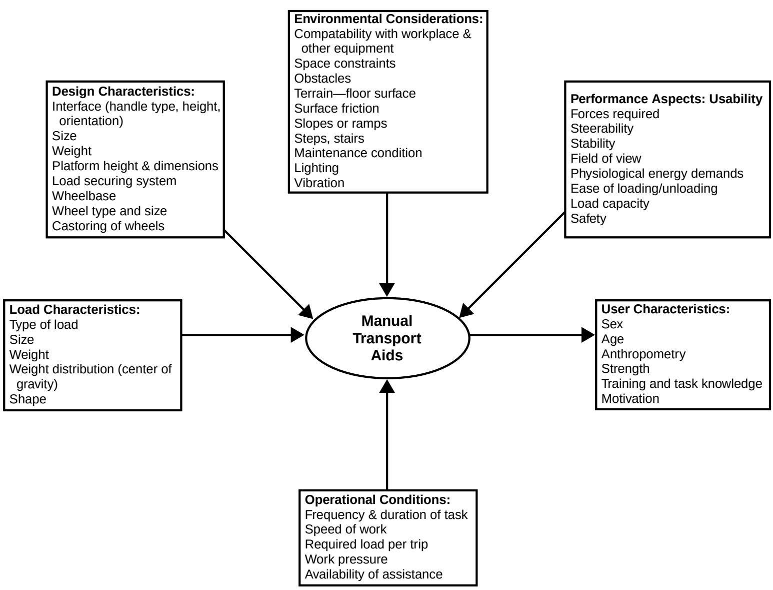
Load and unit stability—The unit (including its anticipated load) should have a low center of gravity and a wide enough wheelbase to prevent it from tipping. Likewise, materials should be prevented from shifting during transport (as a result of sudden starts, stops, or changes of direction) to keep the unit from tipping or spilling its load.

Good visibility—Handlers should have clear visibility above and/or around the unit and its load. Consider the use of open, rigid wire shelving for tall units with materials that otherwise would hinder operator visibility.

The cost of materials handling equipment can often be justified through an increase in productivity (cost improvement) and/or a reduction in injuries (cost avoidance). Designing ergonomics into a work system often results in both of these important benefits. End-user feedback is particularly meaningful during the design specification and prototype trial stages of device selection. Typical handler concerns with device design may include difficulties in starting and stopping the unit, ease of steering, the operator interface (handles too high, too low, or nonexistent), contending with a limited field of vision, and overloading of the unit (decreasing load stability and necessitating the use of greater force). (See figure 6.)

Figure 6

Factors which are important to the specification of MMH aids



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Employees who will use materials handling devices must be trained to help ensure personal safety and proper utilization of the unit. Instituting a preventive maintenance program for materials handling equipment often helps with significantly reducing injury risk exposure and with keeping the device operating as intended.

7

Hazard Control and Prevention

To be most effective, hazard control and prevention has to be a sustained, consistently applied, long-term initiative. Long-term results can be most impressive. Reductions in the incidence and severity of back injuries and the associated medical costs, workers' compensation, and lost and restricted activity time are the norm. Improvements in productivity and quality are added advantages usually derived over time.

Instituting ergonomic design principles in the workplace brings a number of important advantages. Use of the ergonomic approach is meant to ensure that worker capabilities and limitations are taken into account, and ergonomic risk factors are minimized. This means the job and work environment are more acceptable to a wider range of people. Additionally, the choices some employers might explore, as alternatives to engineering solutions, become less attractive. These alternatives typically involve worker selection (with a potential for discrimination), life-style modification, or attempts at changing behavioral patterns of workers.[20]

Prevention of chronic low back pain is a continuous improvement process. An integrated approach, based on the concept of continuous improvement, holds the greatest chance for success. A systems approach to the ergonomic design of the load, job, and workplace, in conjunction with employee and management training, worker selection (where necessary), and medical management, holds the greatest potential for successfully preventing low back musculoskeletal disorders.

The first option in hazard control and prevention is always to see if the manual materials handling task can be abolished. This approach directly addresses the cause of LBP and is the most effective means of eliminating the source of it. The best manual materials handling task is the one that has been done away with.

Load Guidance

Small is better than big. Generally speaking, when it comes to the manual handling of loads, small is better than big. Large, awkward loads present the handler with a variety of potential problems including added stress and strain to the upper extremities and the back. Containers should not be so tall that they obstruct vision or, conversely, bump annoyingly against the legs as they are carried. Loads that will be lifted should be packaged in containers narrow enough to fit between the knees during a squat lift (knees and hips bent, and the back more or less straight). This design will allow the load to be positioned close to the spine, thereby reducing the load's compressive forces on the spine.[21]

Loads should not be too light. Loads that are too light may encourage the handler to lift a number of units at a time, creating an unstable load that is more likely to fall. Conversely, loads should sometimes be made so heavy that people will not attempt to lift the load without the help of another person or will get mechanical assistance. Whenever possible, packages should be labeled with the content's weight so people who handle them will immediately know how heavy a load they are dealing with.

Containers should be designed to prevent their contents from shifting. Loads that shift in their containers may move the center of gravity away from the handler, suddenly and traumatically increasing the load on the lower back. Likewise, loads that are unevenly distributed in their container (a nonsymmetric center of gravity) place torsion on the spine. Therefore, it is recommended that packaging "capture" the contained items, to prevent movement within the container and hold the items in as symmetric an orientation as possible. For nonsymmetric loads, the heavier portion of the container should be closest to the handler in order to keep the center of gravity as close to the spine as possible.

Boxes, totes, and containers should have handles. Handles or hand cutouts provide the best coupling between the handler and the object. According to the 1991 Revised NIOSH Lifting Equation, the ideal handle design is 0.75"–1.5" in diameter, at least 4.5" long, and features a 2.0" hand clearance. Handlers should be of a cylindrical shape with a smooth, nonslip surface. The optimal handhold cutout has a 1.5" or greater height, a length of at least 4.5", a semioval shape, and a 2.0" hand clearance, a smooth nonslip surface, and at least a 0.25" wall thickness. Handholds near the bottom of the container allow the handler to carry the load near knuckle height and minimize static muscle loading of the upper extremities. The edges of the container should be rounded, not sharp. Sharp edges create opportunities for contact stress between the box and the hand, arm and body.

Workplace Design

Engineering controls are preferred over other intervention measures because they are intended to address the workplace sources of ergonomic hazards. Their goals are to lessen the physical exertion or stamina requirements of the job by providing a work system (equipment, tools, furniture, processes, methods, work flow, and environment) that allows people to safely and effectively perform their jobs. Engineering controls often use “assistive technologies” to this end. The alternatives to engineering controls are the use of administrative controls, personal protective equipment, or personnel selection. These are likely to be less effective than eliminating or significantly reducing the root cause of the hazard.

Engineering based design or redesign of the workplace should seek to eliminate the risk factors associated with chronic and acute LBP. This would entail minimizing manual materials handling tasks and personal exposure to excessive loads, bending, twisting, reaching, vibration, and prolonged sitting or standing.

General Workplace Design Guidance

The workplace should be adequately sized. Workplace dimensions need to meet the demands of the job, its related tools and equipment, and the people who will work there. Provide employees with ample physical space to perform their duties. A person who has to handle materials should be provided enough space to freely choose the "best" posture for the task at hand. Materials handling devices to be pushed or pulled require added space for the extended postures a person may assume to start a device rolling and control directional movement. Practicing good housekeeping habits is of primary importance. Ensure floors and work surfaces are free from debris and materials that could hinder the operator or pose a slip, trip, or fall hazard.

Lighting quantity and quality must be considered. Adequate lighting needs to be specified relative to the tasks being performed and the materials being handled. The Illuminating Engineering Society (IES) of North America publishes standards and guidance materials pertaining to lighting. See the Suggested Reading List for an American National Standards Institute (ANSI)/IES publication that can provide lighting recommendations for most work environments and conditions.

Materials should not be staged on the floor. By definition, this increases the vertical workrange and imposes a greater risk of LBP. Lifting materials from the floor will require greater strength and endurance while perhaps prompting the use of postures and movements that have been identified as increasing the odds of developing LBP. Ideally, the lift/lower workrange should be between the knuckles and the heart to minimize flexion and extension of the back.

Conserve momentum wherever possible and let gravity work to your advantage. Movements and motions should generally flow in one direction and not be constantly changing direction. Gravity-fed conveyors, flow racks, and other similar equipment typically reduce the amount of work that would otherwise have to be manually performed.

Environmental considerations should include the type of flooring and floor finishes to be used. Flooring must provide adequate traction and minimize the chance for slips and falls. For people who stand in a specific work zone on hard flooring, consideration should be given to reducing this source of fatigue and discomfort to the legs and back. Extremely stiff or thin mats, usually used for slip resistance, do not seem to reduce fatigue or discomfort. Mats with some cushioning or resilience are preferred, but mats that are extremely soft and thick are not desirable (akin to running in sand). In addition to cushioned mats, antifatigue shoe inserts appear to be beneficial as well.[22]

Where engineering controls are not feasible, the use of administrative controls, personal protective equipment (PPE), or job redesign should be used to limit personal exposure to identified risk factors. In exceptional cases postoffer, pre-placement personnel selection may be necessary.

Administrative Controls

The purpose of administrative controls is to limit the duration of personal exposure to the risk factors associated with MMH tasks. Administrative controls can take many forms, among them are:

- Job rotation (rotating the exposed population into less physically demanding jobs, or jobs that do not tax the same muscle groups as the job of concern)
- Job enlargement or enrichment (providing added task variety, adding less taxing aspects to the job, and sharing tasks among several muscle groups)
- Increasing the number of people performing the job (thereby spreading the exposure to a wider population, but reducing individual exposure duration)
- Training in safe handling techniques
- Worker selection and placement

Job Design

As MMH job demands increase, so does the risk of developing chronic low back pain. It is estimated that two-thirds of all back injuries associated with MMH activities can be prevented if the job is designed to fit at least 75 percent of the workforce.[23] Jobs should be well-rounded, providing task variety as another means of reducing exposure to the risk factors associated with the manual handling of materials. Jobs should be designed to avoid overtaxing the worker physiologically. Heavy work should be alternated with light work. Wherever possible, work pace should be governed by the person performing the job, rather than by the supervisor, other employees, or equipment demands. Self-pacing of a job is almost always preferable to having a work pace imposed on the worker.

In physically demanding jobs, rest breaks become all the more important. Sometimes short work periods with short rest periods result in better physiological recovery and lower stress levels than long work periods with long rest periods. This is a good general principle for scheduling work and rest to maximize recovery and minimize stress in jobs that require physical stamina.[24]

Odds are, a variety of people will perform any given job over time. Job designers need to remember that male or female, young or old, fit or unfit will probably perform the job at some point in time. Generally speaking, jobs should be designed so the widest variety of people can do them safely. This implies that the task mix should tax workers well below their maximum physiological limits.

Worker Selection/Characteristics

One purpose of worker selection is to prevent people with a history of low back musculoskeletal disorders from being placed in what, for them, would be a high-risk job. A second purpose is to make sure that people who are assigned to a strenuous job have the physical attributes of strength or endurance necessary to safely perform it.[25] There is general agreement that the most reliable predictor for future low back injury is having experienced a previous back injury. The old injury provides a "weak link" that is susceptible to reinjury. People who have injured their backs should not be placed in a job that will significantly expose them to further trauma. There is considerable evidence that the better a person's physical fitness and conditioning are, the less apt that person is to experience a low back musculoskeletal disorder.[26]

Preplacement job screening is often used to assess an employee's capacity to perform the tasks of a job. Once a person's capacity has been established, the employer has the ability to place the worker in a job that will not exceed his or her capabilities and limitations. Great care must be taken in designing and implementing a screening program. Preplacement screening must reflect the specific requirements of the job for which the employee is being tested. Screening examinations must be uniformly applied, be safe to apply, should yield quantitative (as opposed to qualitative) results, and should predict the job candidate's risk of injury in the future. This type of testing can require a tremendous amount of time and effort to perform and maintain. To date, their results have not been up to expectations in reducing musculoskeletal disorders of the low back.

Using gender as a criterion for hiring in jobs that require heavy physical exertions, such as lifting, discriminates against the many women who are capable and endangers many men who are not. Strength testing to identify those suited to performing the job, whether male or female, is a far more equitable basis for screening new hires.[27] Personnel selection testing may play a vital role in jobs with potentially high physical demands and work settings that the employer cannot control, such as fire fighters, police, and EMS personnel.

Personal Protective Equipment

Personal protective equipment (PPE) is safety equipment designed to be worn or attached to the body. Its purpose is to provide protection that engineering and administrative controls cannot offer.[28] Desirable qualities of PPE are that they perform the function for which they are intended, should fit, should not require the user to exert greater force than is otherwise necessary, or make the user assume extreme postures as a result of their use. PPE should be provided in a variety of sizes in order to fit different users. Typical MMH personal protective equipment includes safety shoes, gloves, eye protection, hard hats, etc. Employees issued PPE should be trained in its purpose, when and how it should be used, its limitations, care, useful life, and proper disposal. The Occupational Safety and Health Standards for General Industry, sections 1910.132 through 1910.137, provides additional guidance on PPE.

Back Belts

In 1992 NIOSH formed a working group to review the scientific literature related to the effectiveness of back belts in reducing work-related back injuries in healthy, previously uninjured workers. The working group concluded that the effectiveness of using back belts to reduce the risk of back injury remains unproved. It does not recommend the use of back belts to prevent injuries among uninjured workers and does not consider back belts to be PPE. The work group recommends that the most effective means of minimizing the likelihood of back injury is to develop and implement a comprehensive ergonomics program.[29] Federal OSHA does not recognize the use of back belts as a “control measure” for the prevention of back injury. Their use is neither forbidden or endorsed. The North Carolina Department of Labor supports the philosophy of workplace ergonomic intervention and, likewise, does not consider back belts to be personal protective equipment.

Medical Management

According to the federal Occupational Safety and Health Administration (OSHA), the goals of a medical management program are to reduce the duration and severity of symptoms and conditions associated with musculoskeletal disorders. Further, its purpose is to prevent, eliminate, or significantly reduce the duration and severity of functional impairment and disability associated with these symptoms or conditions.

In order to have an effective medical management program, employers must provide employees who experience pain on the job with prompt access to a health care provider for medical assessment and treatment. To help minimize the impact of LBP, the employer must facilitate the early reporting of pain. The earlier in the pain cycle intervention takes place, the more effective conservative treatment can usually be. The employer should establish a contact person to work with the health care provider. The contact person should be familiar with the jobs, work environment, and risk factors in the workplace in order to expedite appropriate job placement during the employee's recovery period. The contact person should also furnish the health care provider with a completed risk factor checklist, a job description, and graphic descriptions (layouts, photographs, etc.) pertaining to the injured employee's job. It is always advisable for the health care provider to conduct periodic walk-throughs of the workplace. This helps the health care provider become familiar with the tasks being performed and the equipment being used and helps identify opportunities for restricted work activities and a safe return to work by the injured worker.

Typically, the first and most important information a health care provider uses in making a diagnosis is the patient's description of what bothers him or her, how the problem started, how it has progressed, and what makes it better or worse.[30] The patient's medical history, including any prior injuries, must be obtained. A physical examination followed by a diagnosis usually occurs next. The health care provider, as a part of gathering information on the patient's history and background, should determine whether off-the-job activities (such as hobbies, recreation, and sports participation) could be contributing to or aggravating the back injury, and recommend limiting those activities during the recovery period.

The employer needs to have a written plan for medical treatment and return to work. The plan should include conservative medical treatment, physical and/or occupational therapy, and a return to work plan (including any subsequent work restrictions and job modifications). Likewise, the plan needs to include a means to identify and remediate exposure to workplace risk factors (engineering intervention, administrative controls, or personal protective equipment). This is done to safely return the person to work while minimizing the chance for injury recurrence. The health care provider should monitor the patient over time to determine medical improvement (or lack thereof). Most musculoskeletal disorders improve under a conservative medical management plan, such as the one outlined above.

8

Stretching, Strengthening, and Wellness

As stated earlier, the heavier the work the greater its physiological toll. The American Red Cross has said that "weak, under-exercised muscles rob the back of its support. Poor muscle tone also makes the muscles more likely to be injured when they are stressed."[31] It is widely believed that one of the prime contributors to chronic low back pain is weak back muscles. Conversely, the better physical shape we are in, the better we are able to perform heavy work without undue fatigue or stress. With strength and endurance, injury risk is reduced; and should injury occur, recovery tends to be quicker.

Strengthening and flexibility exercises are often prescribed as a treatment modality for low back pain patients. Stretching and exercise "prescriptions" should be made an integral part of a pain intervention strategy as described above. Such prescriptions should be made by, and under the supervision of, a health care provider, physical therapist, or other qualified individuals so that prescribed stretches do not compound health problems. It should be noted that a back strengthening program is not a substitute for, but rather is a complement to, ergonomic risk factor intervention.

Before starting any strenuous, physically demanding activity (on or off the job), it makes sense to perform warm-up stretching exercises first. Simple flexibility and range-of-motion stretching helps limber tight muscles and may help avoid injury. Stretches should target the muscle groups that will be involved in the activity. Stretching warms the muscles and increases blood flow through them, making them better prepared for the work they will perform. All it takes is a couple of minutes before the start of work to get the body ready for what is in store for it.

Exercise should be performed regularly, several times a week, in order to develop or maintain strong, flexible muscles. It is suggested that a more comprehensive strengthening exercise routine start with a warm-up period, which gently stretches the muscles and slowly improves flexibility and range-of-motion. Exercises should be performed with slow, steady, controlled movements, avoiding rapid, jerky motions. A cool-down period after exercise is also recommended.

As important as it is to exercise, it is perhaps even more critical to identify satisfying recreational activities that can be pursued for life. Pastimes that are consistent with a person's lifestyle, needs, and desires are much more likely to succeed and become a routine part of our whole life activities. Be it walking, bike riding, tennis, swimming, aerobics, or some other fitness regimen, the goal is to make exercise a regular, naturally occurring part of life.

Glossary Terms

Acute Injury: An injury caused by a single instantaneous event or which rapidly develops.

Administrative Controls: Any procedure that significantly limits daily exposure to ergonomic hazards or risk factors by controlling or manipulating the work schedule or manner in which work is performed. Administrative controls include, but are not limited to, job rotation, use of rest breaks, providing alternative tasks, enlarging job content to increase task variability, redesign of work methods, and adjustment of the work pace or number of repetitions in a task. *(Adapted from federal OSHA)*

Awkward or Extreme Posture: A deviation from the neutral position of adjacent bones about any particular joint. *(Adapted from federal OSHA)*

Back: The trunk of the body from below the neck (cervical spine) to the tailbone (sacrum). The back includes the upper and lower back. *(Adapted from federal OSHA)* Supporting the back are usually 24 bony vertebrae; 7 cervical, 12 thoracic, and 5 lumbar.

Center of Gravity: The point in or near an object or body that acts as a focal point of the mass for that object and determines its symmetry, balance, and ease of handling. *(Adapted from federal OSHA)*

Chronic Injury or Illness: Symptoms that recur and usually increase in severity over time. Symptoms are the result of wear and tear or prolonged misuse, as opposed to a single, instantaneous (acute) event which results in an injury or illness.

Contact Stress: When hard, sharp-edged objects make forceful contact with the body (hands, wrists, forearms, elbows, and other sites), the forces are transmitted to the soft tissues under the skin (primarily nerves, tendons, and muscles) with the potential for direct trauma to those tissues. Mechanical stress is defined as force divided by the area over which it is exerted. The greater the force and the smaller the area, the greater the stress. Conversely, reducing the force or increasing the area over which forces are applied will reduce contact stress.

Cycle Time: The time to complete one sequence of successive task elements needed to achieve a specific unit of work. The time it takes to move through a sequence of task elements from start to start.

Engineering Controls: Physical changes to work-stations, equipment, tools, materials, production facilities, product design, or any other relevant aspect of the work environment with the potential to reduce or prevent exposure to ergonomic hazards or risk factors. *(Adapted from federal OSHA)*

Environment: "The circumstances, conditions, and influences that affect the behavior and performance of people in the workplace. Physical factors such as noise, vibration, lighting, temperature, humidity, and air flow are important environmental factors in job design."[32]

Ergonomics: The word is derived from Greek: *ergos*, meaning work; *nomos*, meaning natural laws. Ergonomics is the application of scientific information concerning human beings to the design of objects, systems, and environments for human use (man-machine systems). Ergonomics seeks to optimize worker efficiency, health and safety, comfort, and provide ease of use.[33]

Extension: Movement that increases the angle between adjacent bones about a joint. With respect to the back, this is described as leaning backward 10° or more.[34]

Fatigue: With regard to manual materials handling, it is the generalized state of bodily exhaustion that results from prolonged heavy work, the consequence of a depletion of the body's energy reserves.[35]

Flexion: Movement that decreases the angle between adjacent bones about a joint.[36]

Health Care Provider: A physician who specializes in occupational medicine, registered nurse specializing in occupational health, or other health personnel (such as emergency medical technicians) working under the supervision of a physician or registered nurse.[37]

Job: A series of tasks performed to reach a goal or defined end product. *(Adapted from federal OSHA)*

Job Design, Ergonomic: The design of jobs such that a wide variety of people, with varying capabilities and limitations, can perform the tasks with minimal exposure to ergonomic risk factors.

Lateral: Movement side-to-side, away from the centerline of the body. *(Adapted from federal OSHA)*

Low Back Pain (LBP): Pain that affects the area between the lower rib cage and gluteal folds (the lumbar region of the back), which often radiates into the thighs.[38]

Manual Materials Handling (MMH): The movement or transport of parts, raw supplies, chemicals, sub-assemblies, humans, animals, finished products, or other objects. The movement may be done by hand, as in lifting objects or pushing hand trucks and carts, or with assistance from mechanical equipment or aids, as in using forklift trucks, storage and retrieval systems, or conveyors. *(Adapted from federal OSHA)*

Methods: The physical activities and motions used to perform job tasks, such as reaching, gripping, using tools and equipment, or picking and setting aside objects.

Musculoskeletal Disorders, Work-related (MSDs): Those diseases, illnesses, and injuries affecting the musculoskeletal, peripheral nervous, and neurovascular systems that are caused or aggravated by occupational exposure to ergonomic hazards or risk factors. They include damage to tendons, tendon sheaths, synovial lubrication of tendon sheaths, bones, muscles, nerves, and ligaments of the upper extremities, back, and lower extremities. These disorders are also known as repetitive strain injuries (RSIs), repetitive motion injuries (RMIs), cumulative trauma disorders (CTDs), and ergonomic disorders, among other descriptive titles.[39]

Personal Protective Equipment (PPE): A device or item used by the worker as protection from recognized hazards, such as heat, cold, vibration, or other physical hazard(s). Examples of PPE are safety glasses, steel-toed shoes, hearing protection, and gloves.[40]

Power Grip: Uses the whole hand to grasp an object; the four fingers grip the object from one direction and the thumb is used to oppose the fingers and pull the object into the palm of the hand. A power grip is typically used when holding a hammer.

Precision or Pinch Grip: Several hand postures fall into this category of gripping, all of which feature using the thumb opposing one or more finger tip pads or the sides of the fingers. A precision grip is used to hold a pencil or pair of tweezers.

Psychosocial Factors: On-the-job stress resulting from personal limitations and/or job deficiencies that create an imbalance or misfit between personal capabilities or needs of the individual and the demands or provisions of the job. Pronounced or unrelenting stress takes a toll in terms of our physical and mental well-being. These stress problems are termed “strains,” and strains can lead to injury or illness.[41]

Redesign: Changes to an existing workplace or to production equipment to make it suitable for more employees through the elimination or significant reduction of MSD risk factors and incorporation of sound ergonomic principles. Redesign is very often more expensive than incorporating ergonomic principles in the initial design of a job or work environment. Workplace redesign is often used for personal accommodation of persons with a musculoskeletal disorder. *(Adapted from federal OSHA)*

Repetition: A task or series of motions performed over and over with little variation. In terms of manual materials handling, repetition is usually quantified in terms of the number of lifts, twists, bends, etc., per minute.

Risk Factors/Ergonomic Hazards: The physical stressors and workplace conditions that present some level of risk of injury or illness to the musculoskeletal system of the worker. They include, but are not limited to, repetitive and/or forceful motions, heavy lifting, pushing, pulling or carrying heavy objects, vibration, temperature extremes, awkward postures that arise from improperly designed workstations, tools and equipment, and improper work methods. They may also arise from improperly designed jobs, psychosocial or work organization factors.[42]

Static Muscle Loading: A condition in which the muscles are exerting force (they are in a state of contraction) but are not moving. This results in reduced blood flow through the muscle and an oxygen and sugar deficiency in the muscle. Another important consequence of static muscle loading is an accumulation of waste products in the muscle (lactic acid), which the person feels as acute muscular fatigue or pain. Carrying an object is an example of static muscle loading of the arms (the affected muscles are working to hold the load, but are not contracting and expanding in a dynamic fashion).

Systems Approach: With regard to ergonomics, this means a comprehensive program by the employer to address the workplace, jobs, processes, operations, and conditions as interdependent systems; in order to identify and eliminate or significantly reduce all types of hazards to employees. Typically, complex ergonomics problems require a combination of solutions.[43]

Work-related: Describes when the work environment and the performance of work contribute to, but perhaps as one of a number of factors, the causation of a musculoskeletal disorder.[44]

Suggested Reading List

A Guide to Manual Materials Handling, By A. Mital, A. S. Nicholson, and M. M. Ayoub, Taylor and Francis, London, 1993.

American National Standard Practice for Industrial Lighting, American National Standards Institute/Illuminating Engineering Society-RP-7-1991, Illuminating Engineering Society of North America, New York, 1991.

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Ergonomics for Beginners, By J. Dul and B. Weerdmeester, Taylor and Francis, London, 1993.

Ergonomic Design for People at Work, Volume 2, By Eastman Kodak Company, Ergonomics Group, Van Nostrand Reinhold, New York, 1986.

Ergonomics, Work and Health, By Stephen Pheasant, An Aspen Publication, Gaithersburg, MD, 1991.

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The following industry guides are available from the N.C. Department of Labor's Division of Occupational Safety and Health:

#1. *A Guide to Safety in Confined Spaces*
#2. *A Guide to Procedures of the Safety and Health Review Board of North Carolina*
#3. *A Guide to Machine Safeguarding*
#4. *A Guide to OSHA in North Carolina*
#5. *A Guide for Persons Employed in Cotton Dust Environments*
#6. *A Guide to Lead Exposure in the Construction Industry*
#7. *A Guide to Bloodborne Pathogens in the Workplace*
#8. *A Guide to Voluntary Training and Training Requirements in OSHA Standards*
#9. *A Guide to Ergonomics*
#10. *A Guide to Farm Safety and Health*
#11. *A Guide to Radio Frequency Hazards With Electric Detonators*
#12. *A Guide to Forklift Operator Training*
#13. *A Guide to the Safe Storage of Explosive Materials*
#14. *A Guide to the OSHA Excavations Standard*
#15. *A Guide to Developing and Maintaining an Effective Hearing Conservation Program*
#17. *A Guide to Asbestos for Industry*
#18. *A Guide to Electrical Safety*
#19. *A Guide to Occupational Exposure to Wood and Wood Dust*
#20. *A Guide to Crane Safety*
#21. *A Guide to School Safety and Health*
#23. *A Guide to Working With Electricity*
#25. *A Guide to Personal Protective Equipment*
#26. *A Guide to Manual Materials Handling and Back Safety*
#27. *A Guide to the Control of Hazardous Energy (Lockout/Tagout)*
#28. *A Guide to Eye Wash and Safety Shower Facilities*
#29. *A Guide to Safety and Health in Feed and Grain Mills*
#30. *A Guide to Working With Corrosive Substances*
#31. *A Guide to Formaldehyde*
#32. *A Guide to Fall Prevention in Industry*
#33. *A Guide to Office Safety and Health*
#34. *A Guide to Safety and Health in the Poultry Industry*
#35. *A Guide to Preventing Heat Stress*
#36. *A Guide to the Safe Use of Escalators and Elevators*
#37. *A Guide to Boilers and Pressure Vessels*
#38. *A Guide to Safe Scaffolding*
#39. *A Guide to Safety in the Textile Industry*
#40. *A Guide to Emergency Action Planning*
#41. *A Guide to OSHA for Small Businesses in North Carolina*

Occupational Safety and Health (OSH)
Sources of Information

You may call 1-800-NC-LABOR to reach any division of the N.C. Department of Labor; or visit the NCDOL home page on the World Wide Web, Internet Web site address: http://www.nclabor.com.

N.C. Division of Occupational Safety and Health

Mailing Address: 4 W. Edenton St., Raleigh, NC 27601-1092
Physical Location: 111 Hillsborough St. (Old Revenue Building, 3rd Floor)
Local Telephone: (919) 807-2900 Fax: (919) 807-2856

For information concerning education, training and interpretations of occupational safety and health standards contact:

Bureau of Education, Training and Technical Assistance

Mailing Address: 4 W. Edenton St., Raleigh, NC 27601-1092
Physical Location: 111 Hillsborough St. (Old Revenue Building, 4th Floor)
Telephone: (919) 807-2875 Fax: (919) 807-2876

For information concerning occupational safety and health consultative services and safety awards programs contact:

Bureau of Consultative Services

Mailing Address: 4 W. Edenton St., Raleigh, NC 27601-1092
Physical Location: 111 Hillsborough St. (Old Revenue Building, 3rd Floor)
Telephone: (919) 807-2899 Fax: (919) 807-2902

For information concerning migrant housing inspections and other related activities contact:

Agricultural Safety and Health Bureau

Mailing Address: 4 W. Edenton St., Raleigh, NC 27601-1092
Physical Location: 111 Hillsborough St. (Old Revenue Building, 2nd Floor)
Telephone: (919) 807-2923 Fax: (919) 807-2924

For information concerning occupational safety and health compliance contact:

Safety and Health Compliance District Offices

Raleigh District Office
Telephone: Safety (919) 662-4597 Fax: (919) 662-4709
Health (919) 662-4711

Charlotte District Office
(901 Blairhill Road, Suite 200, Charlotte, NC 28217-1578)
Telephone: Safety (704) 342-6163 Fax: (704) 342-5919

Winston-Salem District Office
(901 Peters Creek Parkway, Winston-Salem, NC 27103-4551)
Telephone: Safety (336) 761-2700 Fax: (336) 761-2326
Health (336) 761-2700 Fax: (336) 761-2130

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(1200 N. 23rd St., Suite 205, Wilmington, NC 28405-1824)
Telephone: (910) 251-2678 Fax: (910) 251-2654

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For statistical information concerning program activities contact:

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Mailing Address: 4 W. Edenton St., Raleigh, NC 27601-1092
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For information about books, periodicals, vertical files, videos, films, audio/slide sets and computer databases contact:

N.C. Department of Labor Library

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