Strain and Sprain Injury Prevention

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Introduction:

Overexertion injuries are a priority source of reports of workplace injury and loss through Workers' Compensation. Liberty Mutual's Workplace Safety Index for 2002 suggests overexertion injuries account for $10.3 Billion of the $40.1 Billion total cost of Workers' Compensation to American businesses. That is 25.5% of the total loss develops from strain and sprain injury. For developing the Index, "Overexertion" included strain and sprain injuries from lifting, pushing, pulling, holding, carrying or throwing of an object. We generically refer to these activities as manual material handling.

Strain and Sprain Injuries:

This chart shows the nature of the overexertion injuries that occur in the workplace by the part of body impacted by the injury. Liberty Mutual completed this study in 1997 based on 1994 claims.

Body Part	Nature of Injury	% of MMH Claims	Mean	Median	% of Cost
Lower back area (1)	Strain	(27.2)	$4,475	$303	(37.9)
Upper arm (2)	Strain	(6.1)	$4,048	$249	(7.7)
Wrist	Strain	(2.5)	$2,285	$206	(1.8)
Pelvis	Strain	(1.8)	$1,806	$124	(1.0)
Upper (thoracic) back area	Strain	(1.7)	$3,097	$232	(1.7)
Lower back area (1)	Sprain	(1.4)	$4,750	$367	(2.0)
Knee	Strain	(1.3)	$5,593	$311	(2.3)
Chest (3)	Strain	(1.3)	$915	$151	(0.4)
Multiple trunk	Strain	(1.2)	$3,019	$228	(1.1)
Lower arm	Strain	(1.1)	$2,368	$184	(0.8)
Wrist	Sprain	(1.1)	$2,168	$217	(0.7)
Elbow	Strain	(1.0)	$2,981	$231	(0.9)

1. Includes lumbar and lumbo-sacral spine
2. Includes clavicle and scapula
3. Includes ribs, sternum, and soft tissue

The analysis of nature of injury categories most frequently reported indicates that strains are the most common type of claim associated with MMH. Strains and sprains account for 57% of the claims, indicating that the majority of claims associated with MMH are related to overexertion.

The table presented shows the body part and nature of injury combinations accounting for the largest percentage of claims from manual handling. Strains of the lower back area (27.2%) accounted for over four times the number of claims as the next highest category (strain of the upper arm).

Ruptures are the second leading source of claims costs (7.2%), while representing only 0.4% of the claims. The primary contributor to the costs of ruptures is intervertebral disc claims. The costs of intervertebral disc claims for the trunk and neck: $39,698 and $35,965 respectively are high when compared to the more typical strain or sprain injury. These injuries and their cost are not included in the chart.

Strain Injury Risk Evaluation and Assessment:

A key step in the control of strain and sprain injuries from manual handling is the measurement and evaluation of physical loading on the musculoskeletal system. As part of a systemic approach to the control of WMSDs, measurement and evaluation of physical loading provides valuable information for job design and redesign decisions. However, it is important to view measurement and evaluation from the perspective of broader efforts to control work-related injuries and illnesses.

The WMSD loss prevention process, which is usually ongoing, should include the following:

Surveillance - Active and passive surveillance activities are useful for identifying potential problems and existing problems, respectively. Active surveillance includes worker surveys to solicit information on discomfort, pain, or symptoms related to the work tasks. Passive surveillance (also called loss source analysis) involves analyzing previous injuries and illnesses to determine the job, department, task, etc., associated with losses. See Kuorinka and Forcier (1995) for examples of active and passive surveillance techniques.

Measurement and Evaluation of Physical Loading - A key step in the loss prevention process is evaluating those aspects of tasks, machines, equipment, and work organization that may lead to losses. This step is discussed in more detail later.

Alternative Solutions Development - Once the problems are identified, it is generally beneficial to develop several alternative solutions. The selection of the solution will depend on, among other factors, technical and economic constraints. Similarly, the evaluation method used to analyze the job can provide relative estimates of the efficacy of the solution. For example, when a biomechanical approach is used, the analyst can express the percentage reduction in spinal compression that the different solutions will offer.

Solution Implementation - Once a solution is selected, the next step is to implement the solution in the workplace. This may be a discrete implementation or a continuous improvement effort carried out over time.

Continued Surveillance - Following implementation, Step 1 should be continued to determine if further redesign is required (and Steps 2-5 if problem continues).

Selection of Measurement and Evaluation Methods

A challenging aspect of workplace assessment is the selection of the particular method that will be used. This can range from self reports by workers, direct observation, to direct measurement. Direct measurement often involves instrumentation attached to workers' bodies (such as electromyography electrodes to measure muscle activity and electrogoniometers to measure joint motion), whereas direct observation involves measurements taken by the analyst. The types of measurements include dimensions, load weights, etc. Self reports are surveys, etc., performed by workers. Progressing from self report to direct measurement, the cost, time, and expertise required usually increases, but often the amount and quality of information increase. The discussions to follow will focus more strongly on direct observation.

Measurement and Evaluation of Physical Loading on the Low-Back

Physical loading on the back is often assessed using different criteria such as spinal compression (biomechanics) (e.g., Chaffin and Page, 1994), oxygen consumption (physiology) (e.g., Garg et al., 1978), and the percentage of the population that finds a task acceptable with respect to fatigue and stress (psychophysics) (e.g., Snook and Ciriello, 1991). Although these criteria are assumed to prevent low-back disorders, epidemiological evidence is sparse. However, these criteria have substantial application to job design, which is rarely differentiated from risk assessment.

Major Assessment Methods

Manual handling criteria are applied through direct observation of the tasks. The analyst first separates a job into distinct tasks, and then measures the parameters of the tasks. The methods discussed focus on those that can be accomplished through the use of a tape measure, protractor and watch. The parameters measured include joint angles, task frequency, lift distance, and object weight.

Psychophysical tables are among the easiest methods to use and cover the broadest range of tasks (see Snook and Ciriello (1991) or Mital et al. (1997) for tables, or Liberty Mutual's CompuTask™ for a computerized version). Some argue that these data ignore high physiological and biomechanical demands. Energy expenditure models are helpful for assessing the fatigue potential of high frequency tasks, but most other models are based on rather limited samples of college students.

The use of a biomechanical model usually requires purchasing a model. These models are applicable to tasks requiring high forces or handling heavy loads, and provide a *relative* assessment of different job components (e.g., task 3 causes the highest spinal compression). However, these static models ignore the effects of motion and should be used by those with knowledge of statics and dynamics. For this reason, VidliTeC™ (Video-based Lifting Technique Coding System) was developed by Liberty Mutual. The VidliTeC™ system analyzes the dynamic features of a lifting task by using an on-screen video coding system combined with four lifting events identified from video. These four lifting events are the initial position, the closest-to-body position, the highest position and the final position. Research has shown this simple biomechanical analysis system produces results that are as accurate as those produced by more complex and less field friendly biomechanical analysis systems that use comparable motion analysis/motion tracking technology. In effect, the primary shortcomings of static analyses are avoided without the extensive equipment required to perform a traditional dynamic analysis.

The Lumbar Motion Monitor is an electrogoniometer for measuring lateral flexion, flexion/extension, and twisting of the low-back. The device is worn by workers, and the data are downloaded to a portable unit worn by the worker or sent to a computer via telemetry. Such a device does require considerable technical expertise to operate, but has the advantage of direct measurement. The output can be used to estimate low-back disorder risk (Marras et al., 1993).

Finally, the revised NIOSH equation assesses two-handed lifting or lowering tasks. The usability of the equation is fairly limited, but it does consider biomechanics, physiology and psychophysics. The equation has been used by OSHA inspectors (under the General Duty Clause).

Here is a strategy you can use for choosing among biomechanical, psychophysical, and physiological approaches. A biomechanical approach implies that high loads or forces are involved. According to Mital et al. (1997), lifting or lowering 60 lbs. or more will violate biomechanical limits. The physiological approach implies that high frequencies are involved, and typically lower loads. A frequency of between 4.3 and 6 lifts per minute is where psychophysical data begin to violate physiological limits (Ayoub and Dempsey, 1999). This frequency range can be used as a rough guide as to when physiological demands become important, noting that this is not a rule. The psychophysical approach has been judged to be best for intermediate frequencies (Dempsey, 1998). A rough guide to "intermediate frequencies" is between 1 and 6 lifts per minute. Tasks with frequencies below and above this range may be candidates for biomechanical or physiological analyses, respectively.

In some cases, it may be necessary to examine tasks/jobs from several perspectives. For instance, a psychophysical assessment of a job may indicate which elements are problematic. Biomechanical analyses can provide additional justification as to why a particular component needs to be redesigned. Similarly, a psychophysical assessment may indicate that population percentages are reasonable, but the accompanying physiological assessment may indicate that energy expenditure requirements may be too high. Although it is very possible to over-analyze a job, many cases justify looking at a job from more than one perspective.

Risk Assessment versus Compliance Assessment

Risk assessment is a process comprised of several components. The National Research Council (1983) has defined these components as: (a) hazard identification, (b) dose-response assessment, (c) exposure assessment, and (d) risk characterization. As the National Research Council (NRC) pointed out, not every risk assessment will consist of all components.

A true risk assessment is rarely possible when MMH criteria are used, as there are few, if any, dose-response relationships between criterion values and injury cost or severity. The dose-response relationship is typically replaced by predictions of the acute responses of the cardiovascular and musculoskeletal systems to a particular task design. These responses are assumed to approximate risk; however, there is not strong epidemiological support for this assumption (e.g., Dempsey, 1998).

However, ergonomic evaluations do provide information helpful to those persons using relatively simple risk assessment models. Many models are based on ratings of the probability of an incident and the severity of injury or damage you would expect. Liberty Mutual has recently developed Residual Risk Reduction™. R3™ is a group process that includes a risk assessment model. The model rates the Frequency at which the potentially hazardous task is completed, the Likelihood of injurious contact with the hazard, and the plausible Severity of the resulting injury or damage. Each characteristic is rated on a five point scale and the ratings multipled to produce a relative risk index.

- Ergonomic evaluations typically collect information that would define the Frequency. This fact is required to complete a psychophysical evaluation, a physiological evaluation and to use the NIOSH Lifting Equation.

- The epidemiological, biomechanical, psychophysical or physiological evaluations completed may well answer the Likelihood rating. The writer has developed tables to be used for this purpose. To help groups remove the subjectivity from the rating.

- The data on page one tends to define the Severity rating. The plausible outcome will be some lost time with full recovery. There may be extenuating circumstances in the hazard to cause the Severity rating to be based on permanent disability.

The term "compliance assessment" denotes the process of analyzing MMH tasks when dose-response relationships are replaced by comparisons of observed criterion values to a specific MMH criterion. Within the context of industrial hygiene, Claycamp (1996) defined compliance assessment as "compar[ing] predicted/measured exposures with relevant standards or occupational exposure limits." Analyses using MMH criteria can be considered compliance assessments rather than risk assessments (Dempsey, 1999b).

The difference between considering results to be a compliance assessment rather than a risk assessment has implications for the manner in which the results are expressed to management. The results of a true risk assessment can be expressed as more of an objective assessment of whether or not a job or task poses a risk level beyond what is deemed acceptable. On the other hand, the results of a compliance assessment are better presented within the context of a more systematic perspective. Passive surveillance (or loss source analysis) should provide an indication of how much risk a job poses to the worker population. The results of the quantitative job assessment can then be used to support the changes that are being recommended to address losses. Thus, the focus of using quantitative assessments of MMH exposures is to support recommendations for change, not necessarily for categorizing jobs into redesign needed or redesign not needed.

Measurement Error

A study was conducted to evaluate the accuracy of users' measurements of lifting and lowering task parameters when using the revised NIOSH equation (Dempsey et al., 2000a). The NIOSH equation (NIOSH, 1981) and the revised equation (Waters et al., 1993) have long been assumed to be easy to use by a wide range of practitioners; however, usability has not been investigated. The accuracy study was undertaken to examine the most fundamental usability issue of measuring parameters. The following conclusions were made:

1. Users of the NIOSH equation should receive formal training.
2. The length of training and/or the complexity of the tasks measured can affect users' ability to measure parameters.
3. Due to the sensitivity of the lifting index (LI) to errors in frequency and horizontal location measurements, these parameters should receive priority when providing training. Additionally, these parameters are rather difficult to measure compared to the vertical locations (and hence distance traveled). For instance, a sensitivity analysis demonstrated that errors in frequency could result in an LI between less than 1.0 to over 6.0. In practice, this indicates that the results of the analysis could lead to incorrect decisions regarding whether or not a task needs to be redesigned.

Based on the results of this study, it is not unreasonable to conclude that a certain level of training is required to use MMH assessment methods. In all cases, there are limitations and sometimes assumptions that need to be considered when analyzing and interpreting the results. The user should be familiar with these limitations before using a particular method.

Conclusions for Risk Evaluation and Assessment

It is important that the assessment method chosen is appropriate for the question being answered. For example, checklists are designed to identify problematic elements of tasks and jobs, not to provide an assessment. Similarly, they often do not answer specifically what is "bad" about a job at the level of detail required to guide redesign. The same is true of active and passive surveillance methods. If a job is known to be hazardous and requires redesign, more detailed information available from direct observation or measurement techniques are often needed. These more detailed data are particularly useful when selecting and justifying recommended changes. The results often provide quantification of the stresses posed by different job components, and can be used with the loss source analysis to provide justification for the recommended changes.

Control Strategies:

The approach of ergonomics in industry is to design work to fit the capabilities and limitations of workers. Benefits of ergonomic job design are increased productivity from the elimination of wasted motion and improved morale, and decreased accidents and illnesses from a good match or fit between the worker and the job.

The traditional approaches to reducing manual material handling injuries are:

- Training workers in safe lifting procedures, and
- A generic physical examination to detect those who would be at substantial risk when performing manual handling tasks.

Both approaches have benefits and some inherent drawbacks. A successful program to control losses associated with manual material handling should include a comprehensive approach of ergonomics supplemented with training and medical components.

Task & Workplace Design

Ergonomics seeks to reduce or eliminate the occupational risk factors known to cause extensive low back disability. If we reduce or eliminate these risk factors then jobs are safer, more comfortable, and employees return to work sooner thus reducing the compensable costs of low back pain.

The concepts of manual task redesign include reducing both significant body motions and weights and forces involved with manual material handling. There are some general principles that need to be considered:

- Minimize body motions (reaching, bending, and twisting),
- Minimize weights and forces, and
- Minimize frequency of handling and rehandling.

The first step in determining possible task redesign solutions would be to select those priority body motions or handling forces identified as a problem for a particular task. Then all applicable alternatives should be selected from the principles of task redesign. Our hierarchy for interventions and solutions should include elimination of the task, modification or substitution of mechanical aids, engineering solutions to change workplace or layout, and administrative controls.

Engineering solutions and ergonomic redesign of the workplace or layout should be given preference as control measures. Administrative controls should be given less priority. However, a combination of engineering and administrative controls may be effective as a comprehensive control plan to reduce or eliminate low back pain.

Principles of task redesign are as follows:

BENDING

- Keep work at the mid-range level (knuckle height to shoulder height).
- Use lift tables, work dispensers, or other aids to raise the work-level.
- Provide material at work-level height.
- Keep material off the floor if the material must be raised later.

TWISTING

- Position all materials and tools in front of the worker.
- Use conveyors, chutes, slides, or turntables to change the direction of material flow.
- Provide adjustable swivel chairs for seated workers.
- Provide sufficient work area for whole body to turn.
- Improve workstation layout.

REACHING OUT

- Position tools, controls, materials, work pieces, and other essential equipment close to the worker.
- Reduce the size of cartons or pallets being loaded, or allow the worker to walk around or rotate them.
- Reduce the size of the object.
- Allow objects to be kept close to the body.

LIFTING AND LOWERING FORCES

- Eliminate or reduce the need to lift or lower by using aids such as lift tables, cranes, hoists, or conveyors.
- Raise the work-level.
- Reduce object weight by reducing the size or capacity of containers.
- Reduce the weight of the container.
- Reduce the load in the container.
- Reduce the number of containers lifted or lowered at one time.
- Increase the weight and handle mechanically.
- Reduce hand distance.

PUSHING AND PULLING FORCES

- Eliminate the need to push and pull by using aids such as powered conveyors or trucks.
- Reduce required force by reducing the weight of the load.
- Use four-wheel hand trucks with large wheels with bearings.
- Maintain floors and trucks properly.
- Reduce pushing and pulling distances by laying out storage areas close to workstations.

CARRYING FORCES

- Eliminate the need to carry by using such aids as lift trucks, conveyors, or dollies.
- Reduce the carrying distance by improving the layout of the work area and relocating production or storage areas.

TASK REDESIGN RULES-OF-THUMB

In addition to task redesign principles, there are some general task redesign rules of thumb we can use:

- Convert lifts and lowers, and/or carries, to pushes and pulls by using platform lifts and conveyors. Compared to lifting, individuals can handle approximately 40% more weight when carrying, and 400% more when pushing.

- Mid-range height (the area between the knuckles and shoulders) is the best height for manual handling. Handling at or about waist level or in the range between knuckle and waist height is the most efficient part of the mid-range.

- Pushing is preferable to pulling. Provide handles or push bars when possible.

- Wheels and casters on hand trucks and carts should be as large as practical, have good bearings, be compatible with the surfaces over which they travel, and be subject to a preventive maintenance program to clean, lubricate, and replace them as necessary.

- Do not set something on the floor which has to be picked up again later. Work procedures, layout, and use of equipment to transfer or keep objects at work level should be considered to eliminate multiple handling situations.

- Before you consider using mechanical aids, explore combinations of operations at a single workstation to eliminate transfers or carrying.

- At workstations and work areas, keep all materials to be handled within easy reach to eliminate reaching out and down, twisting, and carrying.

- Use fast-acting, easily-controllable hoists mounted on jibs or bridge rails, with well-designed grabs, and with the controls directly above the grab. Most workers will tend to lift a heavy object rather than try to use a conventional slower hoist with a poor grab attachment, or an otherwise inadequate hoist.

- Good handling aids or equipment cannot be used if they are unavailable when needed or down for repairs because of a lack of preventive maintenance.

- Anticipate occasional very heavy lifts required in maintenance, machine repair, and shipping and receiving operations. Specify in writing procedures and equipment to use in these situations.

- Handle objects close to the body. Avoid reaches and use mechanical assists for large, awkward, or bulky objects to avoid having to handle these manually.

- Sudden forces are also significant low back pain risk factors. These can occur when jerking at a stuck load to pick it up or get it moving, when a load slips because of a lack of a good handhold, and when trying to catch a falling load or object.

- The weight of standard or single-sized totes or pans in an operation is often excessive when loaded with small, dense parts. Administrative controls to limit loading is seldom effective. Substituting different-sized modular totes, stackable with each other, and otherwise compatible with the handling system can be a good solution. A particular size tote is then specified in the work order for each part. Totes are seldom handled only once. Consequently, a change in tote design many times improves several tasks at more than one workstation.

- Use bulk containers which are easily handled mechanically, to eliminate the manual handling of bags and drums of materials or ingredients.

- Never handle drums manually. There is a greater variety of good low-cost drum handling devices and aids available than for any other type of container. These include special hand trucks, hoist and forklift attachments, and elevating and dumping devices.

DETERMINING SOLUTIONS FOR TASK REDESIGN

Solutions for manual material handling loss sources can involve engineering controls and/or administrative controls.

Engineering controls, (i.e., manual task redesign), break down into four categories:

- **Complete Redesign**: The task, area, or operation is completely redesigned and changed to the extent that the need to manually handle is eliminated. While the most effective, this is generally a long-range solution that is best applied in the planning stages for contemplated operational changes. Occasionally, however, a relatively small change in a system can eliminate the manual handling task.

- **Mechanical Handling Design**: The task is redesigned with the use of mechanical handling equipment or handling aids to either eliminate the manual handling hazard or to substantially modify it. This category is the most common task redesign solution used and one to which a cost-effectiveness calculation is most easily applied. Often, several acceptable alternate solutions can be determined considering the variety of mechanical handling devices that are available.

- **Physical Environment**: Manual task redesign is achieved through changes in the locus of the task workplace. This could involve the layout of the work area, space requirements, reduction of distances carried or pushed, and the workstation itself. Tasks can be substantially modified or reduced, or at a minimum optimized, so that handling is performed in the most efficient manner.

- **Objects Handled**: Task redesign is focused on the object itself to make it easier to handle. Considerations include reducing or increasing the weight of the object, reducing the force required, reducing the object size, and the frequency of handling. There are many situations where this is a good solution. However, solutions of this type must be practical to implement. It may not be possible to change the weight or size of an object. The need for continued strong administrative controls could make a solution of this type relatively impractical and ineffective.

These engineering control categories are not inclusive; effective task redesign can combine two or more and may also include administrative controls when necessary. There are two categories of administrative controls:

- **Physical Aspects**: This includes provisions for adequate housekeeping in the area where the manual task is performed; preventive maintenance procedures and programs for all mechanical equipment, devices, and aids used; provisions to ensure the availability of equipment when needed; and other programs and procedures that might be necessary to ensure the implementation of the task redesign.

- **Personnel Aspects**: This includes training in proper equipment use; knowledgeable supervision; enforcement of procedures; and other personnel considerations including selection, placement, and return to work policies. Programs to train workers how to lift safely using generic guidelines are not acceptable as task redesign solutions, nor as alternates to engineering controls when such controls are indicated.

WHO GETS INVOLVED?

Solving the manual material handling problem involves a cooperative effort among people from many disciplines. Industrial engineers must use good ergonomic design principles when designing and redesigning workstations with ergonomic risk factors.

Supervisors must continually evaluate their workstations and be alert for elements of poor workstation design. They need to assist industrial engineers and others in workstation design, and be alert for "danger signals" from workers in their departments. They must also continually reinforce good manual handling practices.

Top management must ensure that all interested parties are aware of ergonomic problems, and provide adequate support. They must build ergonomic goals into overall company goals.

Employees must help in workstation design where possible, and use correctly designed workstations appropriately.

Summary for Task Redesign

- Heavy workloads associated with bending, reaching and twisting motions can bring on an initial episode or a recurrence of low back pain.

- Combining training and medical selection with ergonomic task redesign reduces low back disability and low back compensation by reducing the likelihood of low back pain and allowing injured workers to return to work sooner.

- Sound ergonomic programs consist of top management support and direction combined with employee involvement. Such programs will help secure the success of reducing or eliminating manual material handling exposures in the workplace.

Training

Experience has shown that training will not succeed as a control strategy if the job is inherently unsafe. In addition, training has a very short life expectancy if not continually reinforced. Many employees may return to old habits very quickly.

For training to succeed, behavior modification must take place. This rarely occurs with manual workload tasks. Observation and feedback can be used to promote safe manual handling work practices and reduce the risk of injury if there is a distinctively safer way to complete the task..

Other types of training include back schools and physical fitness programs. Studies of physical fitness and low back pain have varied results. The most referenced study, the Los Angeles firefighter study, concluded that the "most fit" firefighters had less incidence of first occurrence low back pain and returned to work sooner than the "least fit," and thus indemnity costs were lower.

One key obstacle is in defining what safe manual handling looks like. Seldom do we see this done well. Generic principles are typically used when job task specific guidance is needed.

Some research has been done that helps us know when manual handling is done as safely as possible. One study by Chang, 2001 used biomechanical modeling to help define safe lifting. The optimum lifting model requires the subject to:

- stand up slower to decrease the dynamic effect of the load and body weight,

- move the load closer to the body to reduce the moment arm of the load in the earlier stage of lifting;

- move the load quicker in the final stage to its destination because keeping the load closer to the body longer and then quickly tossing it to its final position may decrease the overall objective function value.

The study shows that, if followed, the motion prescribed by this system will reduce not only the overall joint moments during the lifting course, but also the compressive force on the L5/S1 disc.

Medical Management

Medical Placement

Selecting healthy workers without low back problems is difficult and the success rate limited. Rowe estimated that pre placement physical examinations could identify 7-10% of workers as very susceptible to low back pain episodes. Inappropriate medical selection, however, can violate equal employment opportunity regulations and requirements of the Americans with Disabilities Act. Today, many companies choose to do nothing based on fear of violating ADA and EEOC regulations.

The ADA does allow an employer to use testing to place applicants in a job based to their ability to complete essential job functions. It is critical that you have physical job demands established and design the strength testing based on the actual demands of the job. Some companies are effectively using strength testing as a medical screening tool. Medical screening can be effective for identifying some workers that should not perform strenuous work, but is not necessarily a technique that considers the relationship between job demands and worker capacity. The medical history of the individual, particularly a history of previous low-back disorders, has been found to be an important predictor of injury propensity. On the other hand, X-rays have not provided effective indication of future injury (Gibson, 1987).

Strength and fitness testing have been found the most effective method of job placement (Snook, 1987). Strength evaluations are used to determine mismatches between job demands and capacity for healthy workers. While numerous field studies have examined the effectiveness of strength evaluation, few studies have examined fitness measures such as aerobic capacity.

In short, in an effort to reduce MMH-related musculoskeletal disorders in healthy workers, it is recommended to first perform ergonomic job analyses. Jobs which do not accommodate the majority of the population should be redesigned or automated. If jobs cannot be altered to acceptable levels that are within the capacities of the majority of the population, strength evaluations should be considered as a means of properly matching worker capacity to task demands.

Medical Treatment

One study by Waddell reports that there is wide agreement that present medical services are largely inappropriate and ineffective for patients with nonspecific low back pain. The outcomes of LB pain treatment are similar regardless of the type of practitioner. Waddell notes that "In the United States, medical care for low back pain is overspecialized, overinvasive, and overexpensive, whereas in the United Kingdom, National Health Service care for back pain is underfunded, too little, and too late". Yet, there is little difference in clinical outcome or social impact of treatment in the two countries. Deyo observes that there are two very different populations of LB pain patients. One group (nearly 80% of the total) seems to get better no matter what we do. The other group (20%) seems destined to develop chronic LB pain no matter what we do. Frymoyer & Cats-Baril question whether medical professionals of all types have become part of the problem, rather than the solution. According to Waddell, medical care has not solved the LB pain problem, and may even be reinforcing and exacerbating the problem. "Back pain is a 20th century health care disaster." Perhaps this is the reason why 61% of adults with acute severe LB pain did not seek any health care during their most recent episode of pain.

Fortunately, 90% of patients with single episodes return to work within six weeks. However, the pain continues for most patients. For those experiencing LB pain for the first time, approximately 70% will still report pain one year later. Moreover, the recurrence rate of LB pain is very high. One study found the probability of recurrence to be four times greater after the initial episode.

Low Back Pain Versus Low Back Disability

"Pain and disability are not the same. They are obviously related but we must make a very clear conceptual distinction between them". LB pain is the subjective perception of pain in the lower back, buttocks, or leg (sciatica). There is no objective measure of pain; it can only be measured subjectively through self-report (e.g., pain drawings, pain analogs, pain scales, pain words, pain diaries, etc.). LB disability, on the other hand, is the lost time or restricted duty that results from LB pain. LB disability is obviously related to LB pain, but includes many other variables outside the medical realm that influence disability (e.g., type of job, management style, personality differences, supervisor conflicts, domestic problems, etc.) "Industry is coming to the realization that medicine alone cannot be relied on to resolve the problem".

LB pain is very common. At any given point in time, 15% to 20% of adults experience low back symptoms. The one-month period prevalence is estimated between 35% and 37%, and the lifetime prevalence ranges from 60% to 80%. However, the annual rate of LB disability in the United States is only 2%. Contrary to popular opinion, most people continue to work with LB pain.

LB pain and disability are very costly. In the United States, the total costs are estimated between 50 and 100 billion dollars per year. An earlier study of 88,766 LB pain workers' compensation claims filed with Liberty Mutual in 1996 revealed that LB pain represented 14.9% of workers' compensation claims, and 22.7% of compensation costs. The 8.3% LB pain claims that lasted 3 months or more accounted for 82.3% of total low back pain costs.

An occupational injury is defined as any damage inflicted to the body by energy transfer during work with a short duration between exposure and the health event. However, the onset of most LB pain is gradual and insidious, without any known energy transfer or exposure (e.g., a slip or fall, heavy lifting, or an awkward posture or movement). LB pain is very prevalent among sedentary workers as well as among manual workers. According to Burton the injury/damage model can no longer be used to explain the problem of occupational LB pain.

Unlike LB pain, LB disability is closely related to the type of job performed, and the policies and practices of management. Rowe maintains that good job design does not reduce LB pain, but allows the employee with LB pain to return to the job sooner, or in many instances, not to lose time at all. Management's positive acceptance of employee LB pain, and appropriate job modification to help the employee stay on the job, produced very positive results for Fitzler and Berger. The Michigan Disability Prevention Study demonstrated that lower levels of disability are associated with management policies and practices, particularly safety diligence, safety training, and proactive return-to-work programs. The Michigan Study concluded that "disability can be managed; and those who do it well can expect to be rewarded with lower disability costs, more satisfied workers, greater productivity and, ultimately, higher profits."

Disability Management

Dr. M. Laurens Rowe, an orthopedic surgeon with the Eastman Kodak Company, spent 20 years personally evaluating 1,500 men referred to him by the plant physicians because of chronic or recurrent LB pain. In 1983, Dr. Rowe offered the following advice:

> "Because medical science presently has no power to cure nor even significantly to alter the natural course of the diseases producing most LB pain, and very limited ability to select in advance those who will become its victims, it follows that the aim of a control program must be the prevention of low back disability - not the prevention of LB pain, which is impossible; nor the prevention of low back injury, which is unusual."

There are now a growing number of investigators who hold similar beliefs, i.e., that efforts at preventing LB pain are futile, and that LB pain is an unavoidable consequence of life that will afflict most people at some point in their lives, regardless of the nature of their work. These investigators believe that programs aimed at preventing disability from LB pain are likely to be much more effective and less costly.

Although LB pain may not be preventable at the present time, the good news is that we know how to reduce the disability from LB pain. There is sufficient evidence in the literature to suggest a disability management approach consisting of the following components:

Management Commitment. Occupational safety and health literature stresses the importance of management commitment in any successful safety and health effort. Specific ways in which management commitment can be demonstrated include establishing goals, evaluating results, assigning staff, providing staff time, making resources available, and providing written communication to all employees regarding the importance of the program in reducing LB disability. The intent is to create a corporate culture with a positive and supportive attitude regarding employees with LB pain. Trust building and employee advocacy are important ingredients.

Supervisor Training. Supervisors must be trained in the true nature of non-specific LB pain, i.e., that LB pain is a disorder of unknown cause that happens to practically everyone, that LB pain usually develops gradually and insidiously without an unusual or strenuous activity, that LB pain may recur frequently, and that LB pain does not respond well to treatment but usually resolves itself within a few days or weeks. The best way to respond to a disorder of this type is to show some concern for the needs of the employee, to avoid making judgments and setting up adversary relationships, to encourage the employee to seek appropriate medical treatment, and to consider adapting the workplace (or modifying the job) so the employee may continue working on the job. This was the approach used by Fitzler & Berger at American Biltrite, Inc., where LB pain compensation costs were reduced by 90%.

Communication with Employees. "Workers have come to believe that any back pain they may experience is a likely product of their work, and societal forces have tended to reinforce this belief......Attribution in particular is an important factor for compliance with intervention strategies, and it has been found that a simple educational program that detunes perception of attribution is capable of creating a positive shift in beliefs with a concomitant reduction in extended sickness absence". (Burton, 1997) As with supervisors, employees should also be trained in the true nature of LB pain - before an episode occurs. If a disabling episode does occur, the supervisor should call or visit the employee within the first day or two, not to intimidate the employee, but to let him/her know that the company is supportive. The message should be: "You are a vital part of our team, your work is important, and your job is waiting for you." This was the approach used by Wood with staff in a geriatric hospital, where long-term LB disability claims were reduced from 7.1% to 1.7%.

Coordination with Organized Labor. Traditionally, labor unions are opposed to early return to work after a disabling episode of LB pain. It is thought that the employee is entitled to time off for even a minor episode, despite sound medical evidence that activity and work will hasten healing. Organized labor must be involved in the planning and execution of a disability prevention program. There must be agreement between labor and management on what constitutes the best interests of the employee.

Workplace Redesign (Ergonomics). Workplaces must be designed for people with LB pain as well as for people without LB pain. Good workplace design will permit employees with LB pain to remain on the job, or to return to the job sooner. Hadler suggests that ergonomics "turn from the quest to prevent back 'injuries' to the quest for enhancing the ability of a person with a backache to cope." We should "provide workplaces that are comfortable when we are well and accommodating when we are ill." The involvement of employees in any kind of job redesign is essential.

Proactive Return to Work Program. Several studies have shown that the longer an employee is disabled by LB pain, the lower is the probability of getting off disability and returning to work by a certain time. For example, data presented by Hashemi et al indicate that an employee disabled for one month has a 62% chance of being off disability after one year; disabled for three months, 44%; disabled for six months, 28%; and disabled for nine months, 14%. These statistics emphasize the importance of providing modified, alternative or part-time work as a means of returning the disabled employee to the job as quickly as possible. A proactive return to work program is a supportive, company-based intervention for personally assisting the disabled employee from the beginning of the episode to its positive resolution. In a proactive program, the actions and responsibilities of individuals within the company and external providers are spelled out and related to the goal of resumption of employment. In the Michigan Disability Prevention Study, companies reporting a 10% greater level of achievement on the proactive return to work variable demonstrated a significant 13.6% lower rate of lost workday cases.

Selection of Appropriate Practitioners. Management should select practitioners who diagnose and treat LB pain according to accepted guidelines. Non-specific LB pain is benign. It should be treated and managed by primary care providers, and not referred to specialists without clear indications. According to the eminent orthopedic surgeon, Gordon Waddell, "orthopedic surgeons in particular are the wrong specialists to provide or control health care for non-specific LBP........physical therapy for non-specific LBP should change from symptomatic methods, which have been shown to be ineffective, to early activation and restoration of function....". The making of a "specific" diagnosis at the beginning of a compensated episode carries the message that the condition is serious and that a "specific" clinical procedure must be carried out. One consequence of this "labelling effect" is to investigate and treat the lesion suspected of being the cause of the pain, rather than focusing on the functional recovery. "This situation encourages patients to believe there is a cure for their problem when it is known that only a small number will respond to a specific therapy". Linton refers to "secondary prevention" as quality pain management at the primary care level. "The idea is to provide better multidimensional care, a little earlier, and with better coordination with other agents (e.g., the workplace, insurance companies, and authorities)." Linton reviews the "common denominators" of the most successful primary care programs. Every health care provider should be aware of them.

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