

Industrial Ergonomics Backgrounder

Prepared by the Ergonomic Assist Safety & Equipment
(E.A.S.E. Council)

A Product Section of the
Material Handling Industry of America



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Introduction

In March 2001, the Federal Government revoked the new OSHA Standard on Ergonomics that had been in force for only two months. Critics of the standard contended that it focused on time-consuming and costly paperwork and procedures, but did not necessarily provide guidance for eliminating ergonomic hazards in specific work situations. Proponents contended that it would help improve worker well being.

In any event, there is no government-mandated ergonomics standard for industry in place at the present time. Because of societal and other pressures, it is likely that another standard, or perhaps set of standards, will be enacted into law in the future. Meanwhile, OSHA still requires that employers provide a safe workplace, as a general principle.

Enlightened companies that have established ergonomics programs in their facilities are finding that such programs are good business, whether they are mandated by law or not. The bottom-line benefits they are experiencing as a result of promoting good ergonomic practices include increased productivity, improved product quality, reduced medical claims and their associated costs, a more stable work staff, and improved morale. Not all the benefits can be quantified, but enough can be to provide a justification case to be made for implementing an ergonomics program as part of good business strategy. Moreover, in the event a new standard is enacted, companies with ergonomics programs in place will be in the best position to demonstrate ongoing compliance with the spirit, as well as, the letter of any new law.

The following discussion provides a general background on ergonomics and ergonomic injuries, and outlines solutions that can be applied to avoid such workplace hazards. Examples are included of how specific companies have achieved bottom-line benefits as a result of sound ergonomics practices. Finally, a cost justification methodology is provided to help managers develop a case for implementing an ongoing ergonomics program.

Definitions and General Background

Ergonomics comes from the Greek words for work (*ergon*) and law (*nomos*) and can be interpreted as "a study of the laws of work." However, we generally think of ergonomics in the workplace as the science of designing work to fit the capabilities of workers, thereby enhancing worker well being.

Some people call ergonomics human factors engineering. Let's look at an analogy with machinery. If a new machine is installed in a plant, the responsible engineer will read all the specifications in the manual that comes with the machine, including operating and maintenance information, before beginning to operate it. But how about workers? What are their "specs?"

Actually, years of ergonomics research have resulted in a database that can provide "spec sheets" on performance of joints and other aspects of human anatomy. This type of data should be used in designing work, so as to protect the investment in human capital at least as much as is regularly done for investments in equipment.

OSHA states that one third of all recordable worker injuries each year result from ergonomic hazards. Such injuries include upper extremity disorders, often associated with lifting and repetitive motion, which are on the rise every year. OSHA has estimated the cost of ergonomic injuries to amount to \$15 billion per year.

Obviously workplace injuries are costly to business, in the form of lost time, worker compensation claims, reduced productivity, and adverse effects on product quality. Whether good ergonomic practices are mandated by government or not, they should be mandated by good business sense, because they pay off.

Typical Ergonomic Injuries

What are ergonomic injuries? Contrasted with workplace accidents that result in immediate traumatic injury, ergonomic injuries tend to develop over a longer term, as a result of prolonged exposure to job characteristics that result in musculoskeletal disorders. Such disorders include *low back pain* (related to manual lifting), cumulative trauma disorder to tendons, such as *tendinitis* and *bursitis*, or nerve disorder conditions, such as *neuritis* and *carpal tunnel syndrome*.

Low back pain injuries are generally attributed to manual handling of objects, including lifting, lowering, pushing, pulling, carrying, bending, reaching, and twisting actions. On the other hand, cumulative trauma disorders are attributed to repetitive handling of tools and other objects. Involving repetitive motions of the upper extremities, these actions result in arm, elbow, shoulder, and hand and wrist injuries.

The Impact of Injuries on Industry

The cost to industry of ergonomic injuries is staggering. Consider the following data from the U.S. Bureau of Labor Statistics:

- Lost time from job-related injuries totals 105 million workdays each year.
- Manual material handling represents an estimated 35% of total workers' compensation claims.
- Back injuries account for 29% of all compensation claims, according to various studies.
- Medical expenses, lost wages, lower productivity, and other expenses from these injuries amount to \$116 billion annually.

Industry is facing the need to stay competitive and lead in a global economy. At the same time, worker shortages are providing great challenges to achieving that goal. Human capital, therefore, is an extremely valuable investment that must be well protected.

What are the Solutions?

Generally, there are three options for overcoming ergonomic hazards: 1) automation, 2) training, and 3) use of ergonomic assist equipment.

Automation implies elimination of the worker's presence from an ergonomic hazard. Examples might include use of robots or automatic transfer equipment in place of humans. Back in the late '70s and early 80's, some industry observers envisioned the "lights out" warehouse or factory, where all activities would be automated, and in the absence of humans, lighting would not be needed. That vision has not come to pass.

Certainly some tasks can be automated, particularly boring, repetitive jobs, or jobs in a hazardous environment. But over the years, management has learned that there are certain tasks that humans do best. Moreover, people react best to unforeseen circumstances. One story illustrating these points comes from a computer manufacturer, who had planned for its products to be assembled by robots. The product was redesigned so that everything snaps together--no screws, nuts, bolts, or clips were needed. After the redesign, the robots were removed from the assembly operation, because the ease with which humans could now do the work made the robots impractical.

Generally, the "thinking worker", armed with real-time information (such as a lift-truck operator with an onboard data terminal and bar-code scanner), provides a type of "flexible automation" that is often more effective than fixed automation.

Training of workers in proper ergonomic work habits can be helpful. For instance, employees can be advised to 1) avoid long reaches (over 16 in.); 2) keep hands and elbows down; 3) avoid using the first three inches of the work surface; 4) avoid tilting the head forward greater than thirty degrees; 5) avoid tilting the upper body forward; and 6) change posture occasionally.

The above are just a few guidelines that workers can follow to help avoid ergonomic injuries. And, workers can be trained in general ergonomic principles, and cautioned about using special care in known problem jobs. And, certain workers that may be physically fitted for particular kinds of jobs can be selected and trained for those jobs.

The training approach described above amounts to selecting and training the worker to fit the job. The more effective ergonomic approach is to design the job to fit the worker. Often assist equipment will be required to provide a truly ergonomically friendly job, and worker training then includes the appropriate use of such equipment.

Ergonomic assist equipment provides the solutions for overcoming ergonomic hazards associated with various tasks and jobs. This type of material handling equipment can be categorized within two broad classifications of motion, consisting of 1) moving the worker to the product, and 2) moving the product to the worker. Schematic diagrams of the various motions involved are shown in Fig. 1.

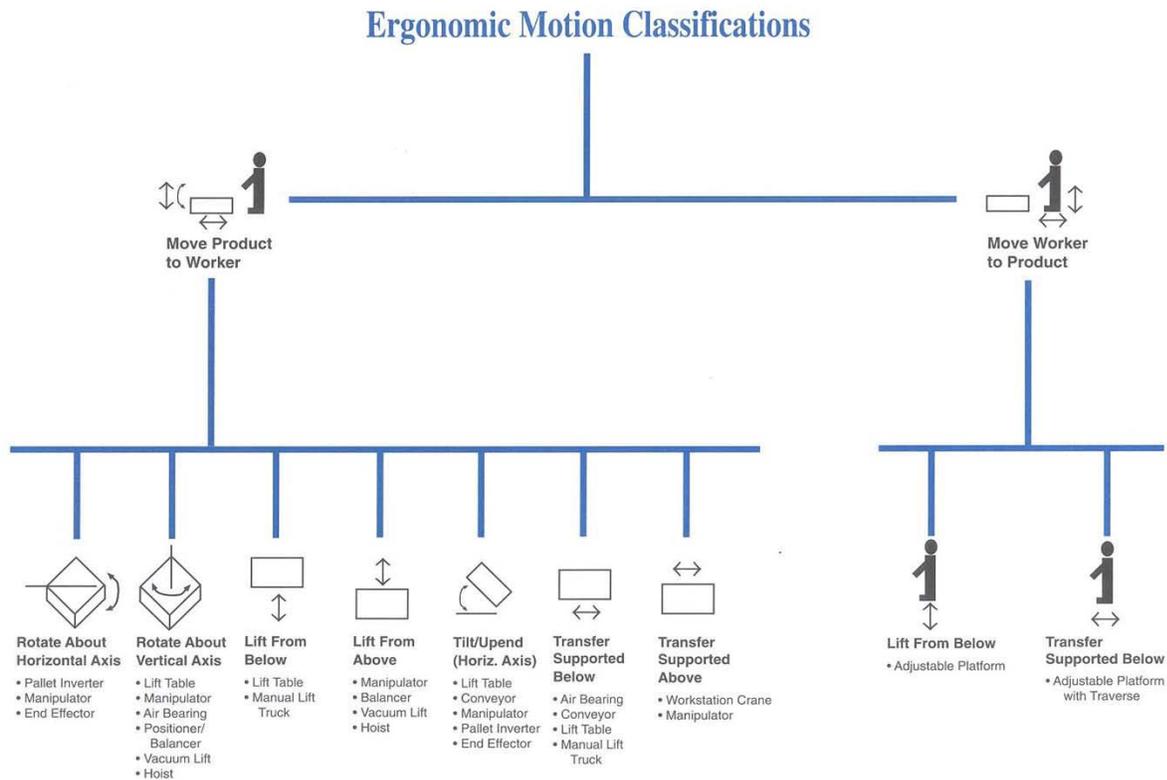


Figure 1

Moving the worker to the product involves equipment such as adjustable elevation platforms to bring the operator to easy access of the work. By eliminating manual reaching, lifting, and lowering, this type of assist equipment can help prevent various types of ergonomic injuries.

A broader and more diverse range of equipment is used to move the product to the worker, either by raising or lowering the load to a comfortable work height, or by providing assistance in lifting, lowering, and maneuvering loads. Equipment types in this broad category include lift tables, load balancers, manipulators, vacuum lifters, workstation cranes, ergonomic workstations, stackers, conveyors, tilters, and pallet rotators or inverters. Many companies have realized important productivity and quality benefits, while also reducing injuries and their associated costs, by applying these types of devices to numerous work situations.

Specific types of equipment are described in Appendix I.

What is the Payoff from Ergonomic Programs?

Many experts suggest that the best way to justify an ergonomics program is through productivity gains and quality benefits, while also keeping in mind the lowered cost of compensation claims and medical costs. Consider the experience of a hardware manufacturer, who initially stored materials on the floor next to a large number of individual workstations. Placing a mobile lift table at each station to provide temporary storage eliminated the extensive bending, twisting, and lifting motions previously experienced by employees. That simple solution improved productivity 13%. At the same time, the number of injuries dropped by 90%, and worker satisfaction and morale improved significantly.

Stories like the above can be repeated many times over. For example, installing three telescopic conveyors improved safety in the shipping department of a personal computer distribution center. The conveyors substantially cut the risks of back injuries caused by lifting products that sometimes exceeded 100 lb each. At the same time, the new system also eliminated a loading bottleneck, and improved productivity by 50%. This increased shipping productivity was needed to support more business.

Another example comes from a manufacturer of plastic products for health care industries. Several times a day, teams of workers had to grapple with heavy (150 lb to 250 lb) and awkward web-film rolls in order to insert them into packaging machines. The level of back injuries was approaching 30%, and the company had to change course quickly. The solution turned out to be a workstation crane system. A worker now moves an air-powered balancing hoist to a palletized roll, inserts a roll-lifting device into the roll core, and maneuvers the roll into the packaging machinery. The results? One worker can now do a job that used to take two. In addition, a greater diversity of workers, in terms of size and strength, can be used to manage the heavy loads. And, health problems related to this operation have been eliminated. The cost savings of these benefits are real and can be readily calculated. Perhaps not so easily quantified, though still a real factor, is the vast improvement that occurred in employee morale.

The above examples highlight the benefits of ergonomic assist equipment to avoid injuries associated with lifting. But even more insidious, and less obvious, are cumulative trauma disorders resulting from repetitive motions. Examples have been publicized from the food industry, in which employees developed carpal tunnel syndrome from repetitive processing work performed on poultry moving on overhead conveyors in an assembly line. Numerous others can be cited. Steps taken to avoid such cumulative injuries can provide significant long-term benefits.

The answer for enlightened companies is clear: Whether there is a mandate from government or not, an ergonomics program makes good business sense, in terms of improved productivity, better product quality, and decreased costs of compensation claims and other related injury costs. And, when the time comes that a new standard is promulgated into law, those companies that can demonstrate having an ongoing ergonomics program in place will be at an advantage in terms of their compliance status.

Justification Approaches

Sound ergonomics programs have been shown to enhance worker well being in industry. However, because they also provide demonstrated improvements in productivity and quality as well, many such programs can be cost justified on the basis of the latter benefits alone. The following discussion provides several examples.

Consider a plant operation involving a repetitive activity of manually inserting a component into a subassembly on an assembly line. Management has noted a recent increase in cumulative disorder complaints, along with a rise in attendant medical claims. At the same time, it has been felt that the operation can be made more efficient and productive with the aid of some type of assist equipment. Thus, management can "kill two birds with one stone," by providing a safer as well as more productive workplace. The question is, how can the cost of such equipment be justified?

The solution being considered consists of an ergonomic assist device that will manipulate the insert into place with a minimum of manual effort. The basic equipment and job factors are as follows:

Equipment cost: \$ 3,000
Worker salary: \$45,000
Worker cost per minute: $\frac{\$45,000/\text{yr}}{120,000 \text{ min/yr}} = \$0.375/\text{min}$

I. Time savings

How much worker time would the equipment have to save in order to justify its acquisition?

$$\frac{\text{Equipment cost}}{\text{Worker cost/min}} = \frac{\$3,000}{0.375} = 8000 \text{ minutes/yr needs to be saved}$$

$$\frac{8,000 \text{ minutes/yr}}{250 \text{ work days /yr}} = 32 \text{ min/day; round off to 30 min or a half hour per day.}$$

Thus, the minimum level of productivity improvement is

$$\frac{0.5 \text{ hr}}{8 \text{ hr}} = 6.25\%$$

If it can be demonstrated that the equipment can save a half hour of worker time per day, or provide the equivalent of an additional half hour of worker time to an 8 hr shift, the purchase of the equipment can be justified.

II. Simple payback

$$\begin{aligned} \text{Payback} &= \frac{\text{Equipment cost}}{\text{Worker cost x anticipated productivity improvement}} = \frac{\$3,000}{\$45,000/\text{yr} \times 0.0625} \\ &= \frac{\$3,000}{\$2,812.5} = 1.067 \text{ yr} \end{aligned}$$

Thus, the equipment cost will be repaid in a little over one year.

III. Net present value

From the above analysis, the annual savings from anticipated productivity improvement is
 $\$45,000 \times 0.0625 = \$2,812.5$

Assume the annual savings will be realized for at least four years following implementation. Considering the time value of money, this amount cannot just be multiplied by 4 to calculate total savings.

In the first year, the savings will likely be less because a learning curve will be needed to develop experience with the new equipment and method. Assume as a conservative estimate that the first year's earnings will only be 75% of the savings figure above.

Next, the company will have a minimum acceptable rate of return (MARR) on investments. Assume the MARR in this case to be 15%. This discount factor must be applied to annual cash flows, recognizing that the further into the future is a savings stream; the lower will be its annual contribution to net present value. The annual savings are calculated as follows:

Year	Estimated savings, dollars		Present value factor*	=	Net present value (NPV), dollars
1	2,109	x	0.8696	=	1,834
2	2,812.5	x	0.7561	=	2,126
3	2,812.5	x	0.6575	=	1,849
4	2,812.5	x	0.5718	=	<u>1,608</u>
				Total NPV =	\$7,417

The net present value of savings exceeds the equipment cost by:

$$\begin{array}{r} \$7,417 \\ -3,000 \\ \hline \$4,417 \end{array}$$

The investment in the equipment is therefore justified.

*Factor is derived from $F = P(1 + i)^n$, where

F = future value of an investment

P = present value of the investment

i = interest rate

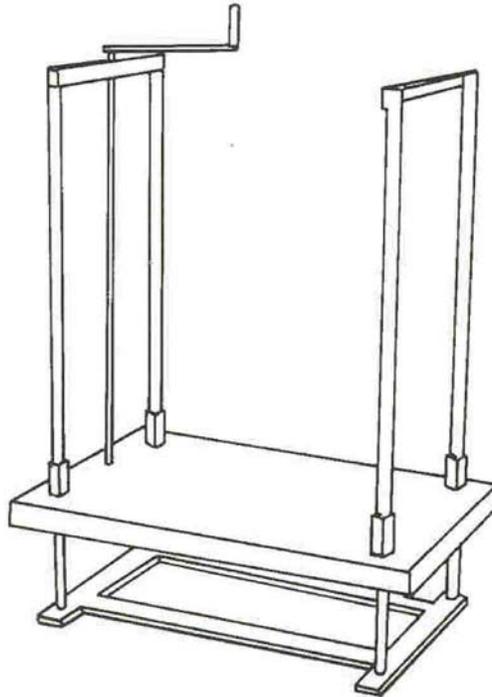
n = a period in the life of the investment, usually a compounded annual interest period.

Appendix I

Categories of Ergonomic Assist Equipment

Moving the worker. *The adjustable worker elevation platform (AWEP)* positions the worker to the job at hand. This type of unit can be mechanically driven, and manually adjusted, or it can be activated with electricity or shop air. Because the work platform is adjustable, employees of different heights are easily accommodated. The operator can control his or her own position in relation to the job, and in order to secure a biomechanical advantage during the work. The unit can lift the worker from below, or it may be equipped with a traverse function to move the operator horizontally.

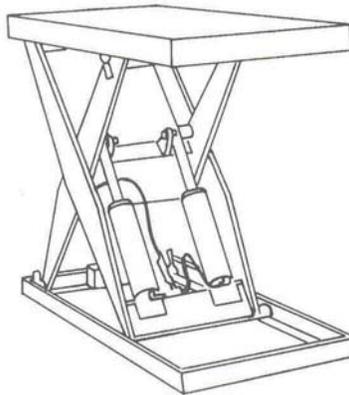
AWEP



Moving the product. Various types of material handling equipment can provide ergonomic functions, as described below.

Lift tables or scissors lifts provide bottom-up movement. They position materials so operators do not have to lift excessive loads, lift repetitively, or bend to do their jobs. The table platform or deck can be equipped with a conveyor or ball transfer to provide horizontal movement as well. Tilting capability also can be provided. The lift table can be fixed in place or equipped with wheels for mobility

Lift Table

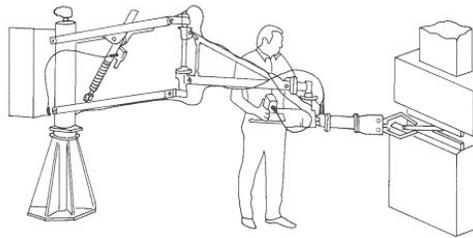


Balancers help operators lift and lower loads of up to 500 lb in a manner similar to that of overhead hoists. Because they balance the load in a near weightless condition, balancers also permit loads to be maneuvered easily. They are often used to suspend equipment used repetitively, such as tools. These air- or electric-powered units are typically supported on small jibs, light or tubular track monorail systems, or as part of workstations.

Balancer



Manipulators move loads horizontally, vertically, and through pick, move, and place functions. The manipulator uses a combination of mechanical arm, cylinders and motors, and application-specific load handling or "end effector" devices. The load is in a near weightless condition, so manipulators provide ergonomic-friendly handling in difficult, rapid, repetitive, or awkward applications. They can be floor or column mounted, attached to a ceiling, or mounted overhead on a rail system.



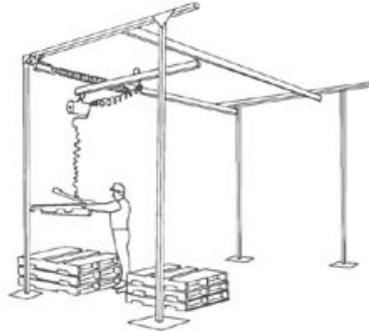
Manipulators

Vacuum lifters perform repetitive lifting tasks ergonomically, thus helping to reduce back strain and injuries. Their vacuum heads provide a suction action to lift loads of from 40 lb to 1000 lb., using a regenerative blower. Typically heads can be twisted or snapped off to facilitate quick changes for specific applications. These units can be used in close quarters with little room for maneuverability, and for handling packages, sacks, cartons, drums, or wood or metal sheets.



Vacuum Lifters

Workstation cranes provide ergonomic handling of overhead loads in specific work areas. Crane trolleys run on enclosed tracks, and can be pushed easily--typically 1 lb of force for every 100 lb of load. Loads typically range from 150 lb to 4000 lb. Powered systems also are available. Vertical lifting can be done with hoists, balancers, vacuum lifters, and manipulators, containing holding/orienting devices such as hooks, slings, grabs, end effectors, and magnets.



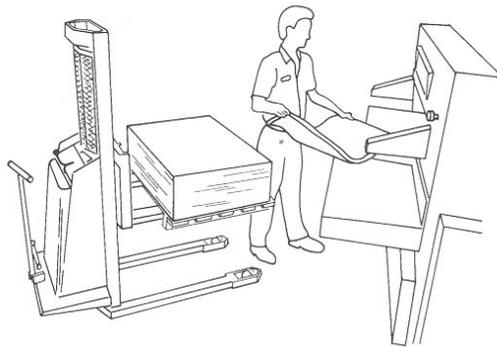
Workstation Cranes

Ergonomic workstations provide vertical adjustment of the work surface, to accommodate workers of different heights and physical characteristics. Vertical height adjustment of work components can also be done as manufacturing or assembly work changes. Everything the operator needs for the task is available without the need for stretching or reaching, or heavy manual handling. Mechanical assists are provided when needed.



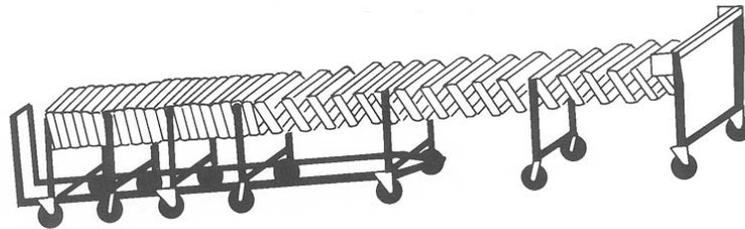
Workstation

Stackers or *manually propelled lift trucks* are used to transport work between workstations, and to elevate loads to comfortable working heights. Stackers are available with platforms or adjustable or fixed forks. They handle load capacities from 250 lb to 3000 lb. Lifting is often done with a hydraulic system. Actuation can be with a control lever, hand pendant, or foot control. Various work heights can be attained from floor level to 12 ft, within a small footprint.



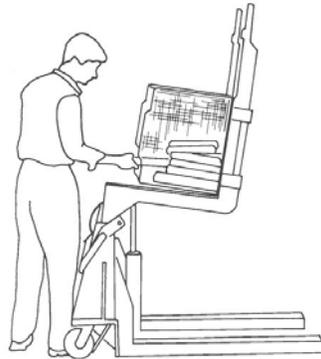
Stackers

Conveyors move units and packages to the worker for assembly in manufacturing, or processing orders in warehousing/distribution. Work heights can be adjusted in some versions. Expandable conveyors assist workers in loading and unloading trucks and trailers. Work procedures must be designed to minimize bending, twisting, and reaching motions when loads are placed on or removed from conveyors.



Conveyors

Tilters reduce the need for stooping, bending, reaching, and lifting as workers remove parts and products from containers, boxes, and baskets. Mobile units allow containers to be picked up, moved into position, and tilted for easy access. Stationary models allow containers to be placed directly on the tilter by hand pallet trucks or fork trucks. Also available are floor-height pivot point devices and tilters that mount on lift tables and other bases.



Tilters

Pallet rotators or inverters are ideal for maneuvering pallet loads in various situations. Pulling damaged containers or bags from the bottom of stacked loads can be accomplished easily by simply rotating the entire stack to provide access. To transfer a load from one pallet to another, or to a skid or slip-sheet, the load is placed in the rotator by fork truck. The base onto which the load is to be transferred is placed on top of the load, and the entire stack is rotated 180 deg to affect the transfer.



Pallet Rotator or Inverter

Appendix II

Sources of Further Information About Ergonomic Solutions

Ergonomic Assist Systems and Equipment (EASE)

Product Council of Material Handling Industry of America

Bobbie S. Curtis, Managing Executive

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www.EASEcouncil.org

The EASE Council offers its "Ergonomics Toolbox", which is a multi-media CD that provides an introduction to ergonomics, and information about analyzing ergonomic problems and identifying their solutions. Various ergonomic hazards are described in a video/text format, and guidelines are offered for evaluating typical plant and warehouse tasks. Solutions provided by material handling equipment designed for ergonomic applications are highlighted.

National Institute of Occupational Safety and Health (NIOSH), U.S. Department of Health and Human Services. NIOSH has developed a series of lifting equations that take into account torsion effects as well as direct lifting actions. The publication *Work Practices Guide for Manual Lifting* is available from NIOSH.

Contact Information: **1-800-35-NIOSH** (1-800-356-4674)

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(202) 401-6997

National Academy of Sciences (NAS)

500 Fifth Street, N.W.

Washington, D. C. 20001

(202) 334-2000 or consider using our [staff e-mail directory](#).

Liberty Mutual Insurance Company
Loss Prevention Research Center

175 Berkeley Street
Boston, MA 02117

This organization has done considerable research into prevention of ergonomic injuries, including general guidelines for workplace design, an evaluation worksheet for manual handling tasks, and a study on the cost of injuries avoided through an ergonomics program.