Applied Occupational and Environmental Hygiene

ISSN: 1047-322X (Print) 1521-0898 (Online) Journal homepage: http://www.tandfonline.com/loi/uaoh20

Ergonomics Awareness Training for Workplace Design Engineers

David T. Ridyard , Thomas G. Bobick & Barry S. Starkman

To cite this article: David T. Ridyard , Thomas G. Bobick & Barry S. Starkman (1990) Ergonomics Awareness Training for Workplace Design Engineers, Applied Occupational and Environmental Hygiene, 5:11, 771-781, DOI: 10.1080/1047322X.1990.10387788

To link to this article: https://doi.org/10.1080/1047322X.1990.10387788

Published online: 24 Feb 2011.

Ergonomics Awareness Training for Workplace Design Engineers

David T. Ridyard,[A,D] Thomas G. Bobick,[B] and Barry S. Starkman[C]
[A]Assistant Manager, Safety & Industrial Hygiene Department, Merck & Co., Inc., West Point, Pennsylvania; [B]Safety Engineer/Industrial Hygienist, National Institute for Occupational Safety and Health, Morgantown, West Virginia; [C]Manager, Safety & Industrial Hygiene Department, Merck & Co., Inc., West Point, Pennsylvania
[D]Present address: President, Applied Ergonomics Technology, 270 Mather Road, Jenkintown, Pennsylvania 19046

This article presents an overview of an ergonomics awareness training program that has been developed for the design engineers at a major pharmaceutical manufacturer. The purpose of this training is to provide engineers with practical working knowledge of some common principles of ergonomic job design. The main objective is to ensure that these ergonomic principles are used by design engineers to increase the effectiveness of newly designed systems without adversely stressing the workers.

In addition to site-specific slides and case studies, the training program utilizes a series of seven detailed checklists and practical classroom demonstrations to emphasize the ergonomic hazards that are common to this industry. Specific examples were used to demonstrate techniques that will prevent back injuries and cumulative trauma disorders such as carpal tunnel syndrome.

The checklists proved to be an effective method of communicating the rather complex ergonomic concepts in a clear and concise format. The engineers and other project team members are currently using the checklists when reviewing process design drawings and concepts. As an additional benefit, the checklists are an excellent reference for industrial hygienists and line management when conducting ergonomic audits of facilities and work activities. **Ridyard, D.T.; Bobick, T.G.; Starkman, B.S.: Ergonomics Awareness Training for Workplace Design Engineers. Appl. Occup. Environ. Hyg. 5:771–781; 1990.**

Introduction

The National Safety Council (NSC)[1] reports that back injuries account for about 22 percent of all occupational cases involving disability in the United States. Based on this percentage, approximately 400,000 disabling back injuries occur at work each year. The NSC estimates that the cost to industry ranges from $6 billion to $8 billion in direct compensation as well as legal expenses, employee training, and other administrative costs. Nelson[2] cites figures reported by the International Conference on Injuries in the Workplace (1984) that work-related back injuries and their associated costs amounted to an estimated $14 billion per year. Morris[3] estimates that the total costs for direct and indirect compensation of occupational back injuries may be as high as $30 billion.

In addition to back injuries, cumulative trauma disorders (CTDs) of the upper extremities are costing industry hundreds of millions and possibly billions of dollars each year. The NSC[1] conservatively estimates that CTDs, such as carpal tunnel syndrome, tenosynovitis, and tendonitis, were the most prevalent occupational illness in 1987 with approximately 45,000 recognized or diagnosed cases nationwide. The total cost to industry can only be estimated at this time, but the cost per case is enormous. According to Ohio workers' compensation authorities,[4] the average compensation per CTD case in the early 1980s exceeded $8,500 in that state.

The total lost workday case incidence rate for pharmaceutical manufacturing companies (Standard Industrial Classification codes 2831, 2833, and 2834) is approximately 40 percent below the national average for manufacturing. However, a recent unpublished survey[5] of nine major pharmaceutical manufacturing companies indicates that back injuries and CTD (repetitive motion) injuries are a major source of lost time.

According to the results of this survey, back injuries accounted for approximately 25 percent of the total lost-time incidents and 26 percent of the lost workdays during the time period 1985–1987. Repetitive motion or CTD injuries accounted for approximately 12 percent of the total lost-time cases and 25 percent of the lost workdays during the same time period.

The lost workday case incidence rate (all injuries) for one large pharmaceutical manufacturing facility was reported as approximately 65 percent below the national manufacturing industry average and 27 percent below the pharmaceutical manufacturing average. The 1988 injury

 1047-322X/90/0511-771$3.00/11

FIGURE 1. Manipulator for lifting rolls of circulars.

statistics at this site show impressive reductions of 70 and 52 percent in the lost workday case incidence rate for back injuries and upper extremity CTDs, respectively, when compared to the 1985–1987 statistics. A review of the workers' compensation data indicates that this reduction in injuries can be attributed to the recent installation of extensive materials handling equipment, automated container packaging and inspection equipment, and other process and procedural modifications.

However, many of these ergonomic improvements were made by modifying existing facilities and processes. These changes were often expensive and disruptive to production. There was a definite need to develop ergonomically acceptable work stations and processes at the engineering design stages to eliminate the significant process redesign costs.

Numerous researchers have discussed the need to incorporate ergonomic principles and philosophy into the design of work situations.[6–11] Process design concepts and drawings should be reviewed by a project team including engineering, safety, and line management to ensure that ergonomic hazards are eliminated during the design stages. A critical component of this review process is to ensure that all project team members have appropriate ergonomics training.

Such a training program was developed for the facilities and process engineering departments of a major pharmaceutical manufacturer. The purpose of this training is to provide engineers with practical working knowledge of some common principles of ergonomic job design. The main objective is to ensure that these ergonomic principles are used by design engineers to eliminate the risk factors associated with back injuries, carpal tunnel syndrome, and other cumulative trauma disorders.

Seven state-of-the-art design checklists were developed for the training to outline methods for identifying and eliminating "poorly designed" conceptual work activities at the very early stages of a project. The checklists proved to be an effective method of communicating the rather complex ergonomic concepts in a clear and concise format. The engineers and other project team members are currently using the checklists when reviewing process design drawings and concepts. As an additional benefit, the checklists are an excellent reference for industrial hygienists and line management when conducting ergonomic audits of their facilities and work activities.

Training Program

The training program consists of lecture with slides and classroom demonstrations by a Certified Industrial Hygienist with experience in occupational ergonomics. Slides and classroom demonstrations are used to show the ergonomic hazards associated with repetitive hand/wrist activities, including container labeling and inspection, and the use of poorly designed hand tools. Details of the training program are summarized below.

The program begins with an overview of the purpose and objectives of the training as outlined in the "Introduction" section of this article. A statistical analysis of the incidence and severity of materials handling-related injuries that occurred at the site is then presented. This information demonstrates that a significant number of lost-workday injuries can be prevented with additional ergonomic controls. It also emphasizes that ergonomics plays an important role in secondary injury prevention by al-

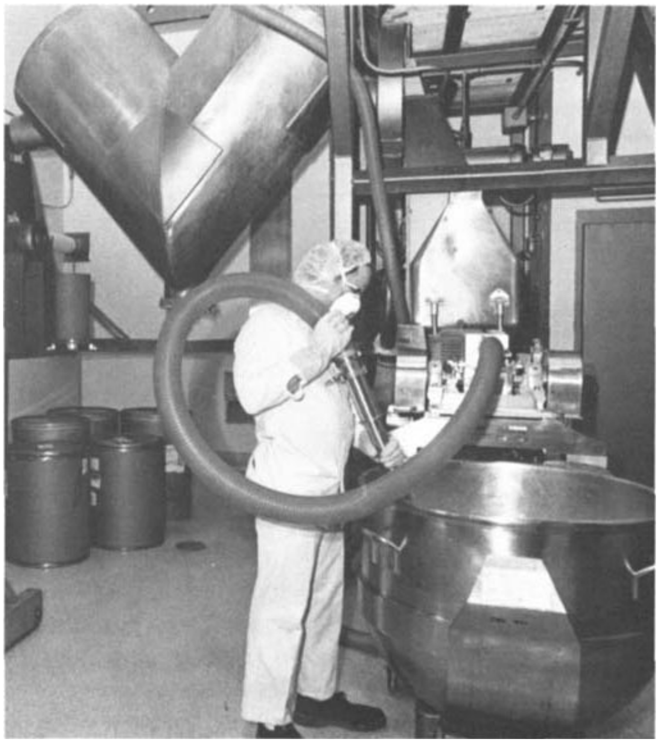

FIGURE 2. Pneumatic powder transfer system.

FIGURE 3. Fully automated vial inspection machine.

lowing the worker with moderate symptoms to stay on the job longer and by permitting the disabled worker to return to the job sooner.

Other positive benefits,[8] such as higher productivity and product quality, are compared to the costs of increased labor turnover, higher absenteeism, and increased workers' compensation costs which result from ignoring ergonomics in the workplace. The economic and practical benefits of incorporating ergonomic principles into the design stages of a project are also emphasized.

Slides, including those presented as Figures 1 through 6, are shown to highlight the various ergonomic controls recently implemented at the site to control the incidence and severity of low back and upper extremity CTD injuries.

Figure 1 shows a print shop worker using a manipulator to lift, rotate, and position a 35-kg roll of product circulars on an automated folding machine. Use of the manipulator eliminated the need for two employees to bend, lift, position, and lower the rolls into place.

Figure 2 demonstrates the use of a vacuum wand to move powders from a mixing bowl to the top of a blender. This pneumatic powder-transfer system, which eliminated manual rolling and lowering of drums to charge the blender, can also be used with the drum-charging equipment shown on the left side of the room.

The high-speed vial inspection line, shown in Figure 3, projects a beam of light through liquid vials onto a computer diode programmed with appropriate meniscus level and particle size specifications. The vials are automatically rejected from the line if they fail to meet the specifications. This machine eliminated the need to pick up and shake the vials manually (repetitive wrist flexion and extension) during inspection.

Figure 4 demonstrates the use of a banding machine to wrap rubber bands around product circulars. The banding machine eliminated both the significant finger extension to open the rubber band and the repetitive wrist flexion and extension to wrap the bands around the circulars.

The deblistering machine, shown in Figure 5, uses pneumatic punches to remove tablets from foil blister packs. This machine, designed and constructed by site engineering, eliminates the repetitive thumb force required to remove the tablets manually.

The bottle decapping machine, shown in Figure 6, was also designed by site engineering to remove child-resistant caps from bottles. Employees are no longer required to forcefully push and twist the caps to open the bottles.

The remainder of the training session discussed the ergonomic design checklists that are presented in Figures 7 through 13. Similar ergonomic design information has been presented in the literature.[8,11–15] We developed our checklists to address the specific types of materials han-

FIGURE 4. Circular banding machine.

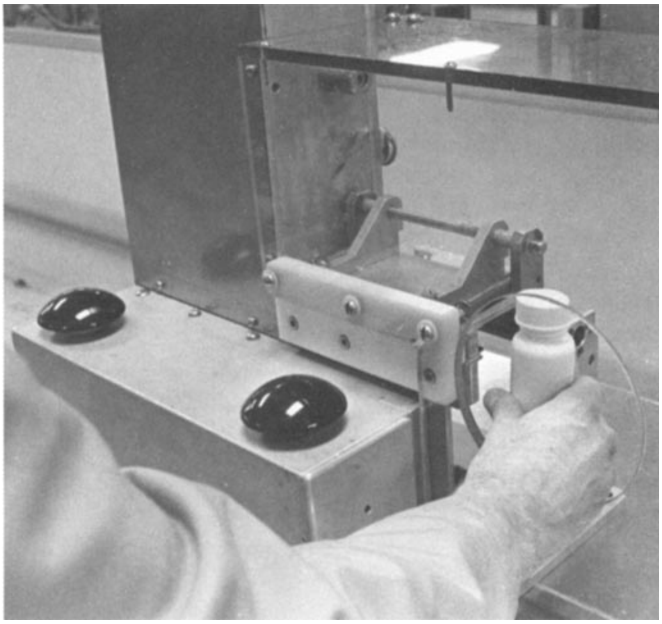

FIGURE 6. Decapping machine for child-resistant bottles.

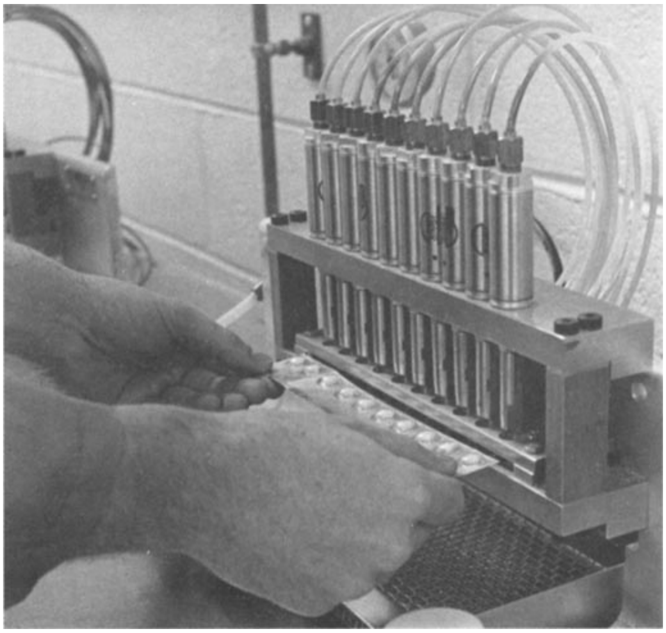

FIGURE 5. Tablet deblistering machine.

dling and upper extremity CTD hazards that were identified via a thorough review of our site's injury/illness records and workplace ergonomic audit reports. The checklists, which are distributed to each attendee along with a brief summary of the other materials covered during the training, serve two main purposes. They provide a concise, easy-to-follow format for the training, and they also serve as reference documents during the engineering design work. We strongly recommend that the ergonomic design principles outlined in the seven checklists be utilized when designing a new facility, process, or job task.

Figure 7 provides an outline of general ergonomic design criteria that can be used for designing any type of work area or job task. The main points include providing a flexible, adjustable workstation to eliminate static muscle fatigue and excessive reaching, bending, fixed work postures, and twisting of the body.

Figure 8 outlines the various manual materials handling risk factors associated with overexertion strains and sprains of the musculoskeletal system. The risk factors include lifting, lowering, pushing, pulling, and carrying heavy loads, as well as excessive reaching, bending, and twisting of the body. This checklist can be used at the project design stages to identify potentially hazardous materials handling tasks.

Figures 9, 10, and 11 outline the ergonomic controls that should be designed into an activity to provide safe lifting and lowering, pushing and pulling, and carrying tasks, respectively.

Sections 1, 2, and 3 of Figure 9 provide three general techniques for eliminating manual lifting or lowering of materials in the workplace. Section 4 outlines methods for reducing the weight of objects or materials that are lifted (or lowered), and section 5 provides ideas for keeping the materials as close to the body as possible to reduce the strain on the lower back. The materials handling equipment in section 6 can be used to replace a lifting or lowering task with a pushing or pulling task.

Figures 10 and 11 outline similar types of controls that can be used to eliminate pushing, pulling, and carrying tasks, or to reduce the potential overexertion hazard when materials must be moved manually in the workplace.

Figure 12 outlines the ergonomic controls that should be designed into repetitive hand and wrist tasks to control the incidence of upper extremity CTDs. The checklist items include provisions for reducing the number of repetitive hand motions, maintaining neutral wrist postures, and reducing pressure on the wrists and hands. Other significant ergonomic controls for safe hand and wrist activities include eliminating excessive reaching; avoiding exposure of the hands to vibration, cold and humid environments; and using properly designed hand tools.

Bottles and other containers are used to demonstrate the bent wrist postures and repetitive forceful exertions associated with packaging jobs that have since been eliminated with line automations. Other risk factors, such as repetitive pinch grips, are also emphasized using these containers.

Figure 13 provides guidelines for selecting hand tools that will help prevent injuries and enhance productivity and product quality. Properly designed hand tools are used to demonstrate how a worker can grasp, hold, and use the tool with a straight wrist, avoid static muscle fatigue, and avoid stress on the soft tissues of the fingers and hand. Other tools are used to emphasize the importance of providing proper grip spans to avoid repetitive trigger finger actions and other awkward finger motions.

The training session, which lasts approximately 3 hours, ends with a summary of the role of the process and design engineers in the occupational ergonomics program. Questions and comments were addressed by the trainer. All attendees are encouraged to use the checklists in their design of new facilities, processes, work areas, and job

Use of the following set of general workstation design principles will help achieve an optimum match between the work requirements and operator capabilities. This, in turn, will maximize the performance of the operator and the total system while maintaining human comfort, well-being, efficiency, and safety.

___ 1. Make the workstation adjustable so that the tall person will fit, and the small person can reach easily.

___ 2. Provide all materials and tools in front of the worker to reduce twisting motions. Provide sufficient work space for the whole body to turn.

___ 3. Avoid static loads and fixed work postures. Avoid job requirements where operator must:

- lean to the front or the sides
- hold an extremity in a bent or extended position
- tilt the head forward more than 15 degrees
- bend the torso forward or backward more than 15 degrees
- support the body's weight with one leg

___ 4. Set the work height at 5 cm below the elbows.

___ 5. Provide adjustable, properly designed chairs with the following features:

- Adjustable seat height.
- Adjustable back rest including a lumbar (lower-back) support.
- Padding which will not compress more than an inch under the weight of a seated individual.
- Chair should be stable to floor at all times.

___ 6. Allow the workers, at their discretion, to alternate between sitting and standing. Provide floor mats or padded surfaces for prolonged standing.

___ 7. Support the limbs. Provide elbow, wrist, arm, foot and back rests where needed.

___ 8. Use gravity to move materials.

___ 9. Design the workstation so arm movements are continuous and curved. Avoid straight-line, jerking arm motions.

___ 10. Design so arm movements pivot about the elbow rather than the shoulder to avoid stress on shoulder, neck and upper back.

___ 11. Keep arm movements in the normal work area to eliminate excessive reaches over 40 cm.

___ 12. Provide dials and displays that are simple, logical, and easy to read, reach, and operate.

___ 13. Eliminate or minimize the effects of undesirable environmental conditions such as excessive noise, heat, humidity, cold, and poor illumination.

FIGURE 7. General workstation design principles.

We can define a "poorly designed" materials handling task as one where the strength requirements to complete the task exceed the strength capabilities of most workers (i.e., most workers would not be able to perform the task without overexertion).

Poorly designed tasks will generally require workers to lift, lower, push, pull or carry heavy loads. Additional significant injury risk factors include excessive bending, reaching, or twisting of the body. We can consider a task to be potentially hazardous if it requires one or, more significantly, a number of the following activities:

___ 1. Lifting, lowering, or carrying more than 10 kg.

___ 2. Lifting or lowering items with one hand and/or rough, jerking motions rather than with a two-handed, smooth motion.

___ 3. Lifting, lowering, or carrying bulky objects that cannot be held close to the body.

___ 4. Repetitively handling materials more than 50 times per 8-hour workshift.

___ 5. Lifting or lowering between floor and waist height.

___ 6. Lifting or lowering above shoulder height.

___ 7. Lifting or lowering objects in cramped work areas that may result in twisting the torso (i.e., lifting and twisting in one motion).

___ 8. Exerting forces in awkward positions - to the side, overhead, or at extended reaches.

___ 9. Handling difficult-to-grasp items (no handles).

___ 10. Handling items that place high pressure on the hands from thin edges, such as pail handles or sheet metal edges.

___ 11. Pushing or pulling carts, boxes, etc., that require large break-away forces to get started.

___ 12. Lifting and carrying items where the walkways are obstructed, poorly illuminated, slippery, too narrow, or congested with vehicle and/or pedestrian traffic.

FIGURE 8. Materials handling risk factors.

tasks, and to call the safety and industrial hygiene department for assistance as needed.

Summary

A recent survey of nine major pharmaceutical manufacturing companies indicates that back injuries and upper extremity cumulative trauma disorder injuries are a major source of lost time. One large pharmaceutical manufacturing facility has reduced their lost workday case incidence rate for back injuries and upper extremity cumulative trauma disorders in 1988 by 70 and 52 percent, respectively. Much of this reduction can be attributed to the installation of extensive materials handling equipment, automated container packaging and inspection equipment, and other process and procedural modifications.

Another major component of this facility's ergonomics program is a recently developed "Ergonomics Awareness Training Session" that provides facilities and process engineers with practical working knowledge of some common principles for ergonomic job design. The main objective of the training is the subsequent use of these ergonomic principles by design engineers to eliminate the risk factors associated with back injuries, carpal tunnel syndrome, and other cumulative trauma disorders. The training utilizes seven state-of-the-art design checklists, practical classroom demonstrations, and slides of recent ergonomic improvements to outline methods for identifying and eliminating poorly designed work activities in the pharmaceutical industry.

Feedback from the engineers six months after they attended the training indicates that the checklists are an effective method of communicating the rather complex ergonomic concepts in a clear and concise format. The checklists have been used successfully by site engineers and industrial hygienists to eliminate potential materials handling hazards during the process design stages. These ergonomic improvements help eliminate the adverse economic effects including low productivity, poor product quality, increased absenteeism, and increased medical and workers' compensation costs associated with poorly designed work environments. Improvements made at the initial stages of a project also eliminate the need for costly redesign changes which are often expensive and disruptive to production.

Recommendations

Basic principles of ergonomics and human factors engineering should be incorporated into the design of new facilities, processes, work areas, or job tasks. A project team including engineering, safety, and line management should review design concepts and drawings to ensure that ergonomic hazards are eliminated during the design stage.

A recent injury analysis study[6] estimates that approximately 50% all compensable back pain injuries are related to the manual lifting of objects.

The following checklist should be used to eliminate the need to manually lift heavy or bulky materials, and reduce unnecessary bending, twisting and reaching when lifting materials:

1. Optimize Material Flow Through the Workplace:
   - __ Reduce Manual Handling of Materials to a Minimum.
   - __ Establish Adequate Receiving, Storage, and Shipping Facilities.
   - __ Maintain Adequate Aisle and Access Areas.
2. Eliminate the Need to Lift or Lower Manually:
   - __ Lift Tables and Platforms
   - __ Lift Trucks
   - __ Cranes and Hoists
   - __ Drum and Barrel Dumpers
   - __ Elevating Conveyors
   - __ Elevated Pallets
   - __ Gravity Dump Systems
   - __ Gravity Chute Systems
   - __ Vacuum Systems
   - __ Automatic Feed System
3. Increase the Weight to a Point where It Must be Mechanically Handled:
   - __ Palletized Handling Of Raw Materials and Products.
   - __ Unit Load Concept (Bulk Handling in Large Bins or Containers).
4. Reduce the Weight of the Object:
   - __ Reduce the Weight and Capacity of the Container.
   - __ Reduce the Load in the Container.
   - __ Specify the Quantity per Container to Suppliers.
   - __ Assign the Job to Two or More Persons.
5. Reduce the Hand Distance From the Body:
   - __ Change the Shape of the Object or Container.
   - __ Provide Grips or Handles.
   - __ Provide Better Access to Objects.
6. Convert Lift/Lower Combined With a Carry to a Push or Pull:
   - __ Conveyor
   - __ Hand Trucks
   - __ Ball Caster Tables
   - __ Four Wheel Carts

FIGURE 9. Proper design of lifting and lowering tasks.

A recent injury analysis study[6] estimates that manually pushing materials and objects has been implicated in approximately 9% to 16% of all compensable back injury cases. Another 6% to 9% of compensable back injuries are related to manually pulling materials.

The following checklist should be used to eliminate the need to manually push or pull heavy materials, and to reduce the potential overexertion hazard when materials must be pushed or pulled:

1. Eliminate the Need to Push or Pull:

   __ Conveyors (Powered and Non-powered).

   __ Powered Trucks.

   __ Lift Tables.

   __ Slides or Chutes.

2. Reduce Force Required to Push or Pull:

   __ Reduce Size and/or Weight of Load.

   __ Utilize Four-wheel Trucks or Dollies.

   __ Utilize non-powered Conveyors.

   __ Require that Wheels & Casters on Hand-Trucks & Dollies Have:

   - Periodic Lubrications of Bearings.
   - Adequate Maintenance.
   - Proper Sizing (Provide Larger Diameter Wheels & Casters).

   __ Maintain the Floors to Eliminate Holes & Bumps.

   __ Require Surface Treatment of Floors to Reduce Friction.

3. Reduce the Distance of the Push or Pull:

   __ Relocate Receiving, Storage, Production, or Shipping Areas.

   __ Improve Production Process to Eliminate Unnecessary Materials Handling Steps.

4. Optimize Technique of the Push or Pull:

   __ Provide variable-height Handles so that both Short and Tall Employees can Maintain an Elbow Bend of 80 to 100°.

   __ Replace Pull with a Push Whenever Possible.

   __ Use Ramps with Slope Less Than 10%.

FIGURE 10. Proper design of pushing and pulling tasks.

It is recommended that the project review team and others involved in the review of new or modified workstations have appropriate training in occupational ergonomics.

Design checklists similar to those presented in this article are an effective means of providing ergonomics awareness training. The checklists should be customized to address specific ergonomic hazards identified by company illness/injury statistics, audits, or inspections. The awareness training can then focus on the real ergonomic concerns at a facility and the checklists can be used as reference documents by the design engineers. In addition, industrial hygienists and line management can use the checklists to conduct workplace ergonomic audits.

References

1. National Safety Council: Accident Facts. NSC, Chicago, IL (1989).
2. Nelson, R.M.: Prevention—A Government Perspective. Ergonomics (Special issue: Musculoskeletal Injuries in the Workplace) 30(2):221 (1987).
3. Morris, A.: Identifying Workers at Risk to Back Injury is No Guesswork. Occup. Health Saf. 55(12):16 (1985).
4. National Safety Council: Accident Facts. NSC, Chicago, IL (1988).
5. Starkman, B.S.: Ergonomic Injury Claim Survey for the Pharmaceutical Manufacturing Industry. Merck & Co., Inc., West Point, PA; (215) 661-7045 (1989).
6. Stover, H.S.: Comparison of Different Approaches for the Prevention of Low Back Pain. Appl. Ind. Hyg. 3(3):73 (1988).
7. Sanders, M.S.; McCormick, E.J.: Human Factors in Engineering and Design. McGraw-Hill, Inc., New York (1987).

8. Institute of Industrial Engineers: Industrial Ergonomics. D.C. Alexander and B.M. Pulat, Eds. Industrial Engineering & Management Press, Norcross, GA (1985).
9. Alexander, D.C.: The Practice and Management of Industrial Ergonomics. Prentice-Hall, Inc., Englewood Cliffs, NJ (1986).
10. National Institute for Occupational Safety and Health: Work Practices Guide for Manual Lifting. DHHS (NIOSH) Pub. No. 81-122; NTIS No. PB-82-178-948/A09. National Technical Information Service, Springfield, VA (1981).
11. Kroemer, K.H.E.: Material Handling. Loss Control Through Ergonomics, 2nd (Rev.) ed. Alliance of American Insurers, Schaumburg, IL (1983).
12. Lifshitz, Y.; Armstrong, T.: A Design Checklist for Control and Prediction of Cumulative Trauma Disorders in Hand Intensive Manual Jobs. In: Proceedings of the 30th Annual Meeting of Human Factors Society. Human Factors Society, Santa Monica, CA (1986).
13. Armstrong, T.J.: An Ergonomics Guide to Carpal Tunnel Syndrome. Ergonomics Guide Series. American Industrial Hygiene Association, Akron, OH (1983).
14. Benson, J.D.: Control of Low Back Pain in Industry through Ergonomic Design of Manual Materials Handling Tasks. In: Trends in Ergonomics/Human Factors III. W. Karwowski, Ed. Elsevier Science Publishers B.V., North-Holland (1986).
15. National Safety Council: Ergonomics Checklist. NSC, Chicago, IL (1983).

11/30/90; review decision 1/29/90; revision 3/29/90; 4/13/90

A recent injury analysis study[6] estimates that carrying objects has been implicated in approximately 5% to 8% of all compensable back injuries. Carrying materials that are too heavy or too bulky are important risk factors that are associated with musculoskeletal strains & sprains.

The following checklist should be used to eliminate the need to carry heavy objects, and to reduce the sprain/strain hazard when materials must be carried:

1. Eliminate the Need to Carry:

__ Rearrange the Workplace to Eliminate Unnecessary Materials Movement.

__ Utilize the following Mechanical Handling Aids, when Applicable:

- Conveyors (all kinds).
- Lift Trucks and Hand Trucks.
- Tables or Slides Between Work Stations.
- Four-wheel Carts or Dollies.
- Air or Gravity Press Ejection Systems.

2. Reduce the Weight That is Carried:

__ Reduce the Weight of the Object.

__ Reduce the Weight of the Container.

__ Reduce the Load in the Container.

__ Specify Quantity per Container to Suppliers.

3. Reduce the Bulk of Materials That are Carried:

__ Reduce the Size or Shape of the Object or Container.

__ Provide Handles or Hand-grips that Allow Materials to be Held Close to the Body.

__ Assign the Job to Two or More Persons.

4. Reduce the Carrying Distance:

__ Relocate Receiving, Storage, Production or Shipping Areas.

__ Use Powered and Non-powered Conveyors.

5. Convert Carry to Push or Pull

__ Use Non-powered Conveyors.

__ Use Hand Trucks and Push Carts.

FIGURE 11. Proper design of carrying tasks.

Job tasks such as manual packaging and inspection may require workers to perform a large number of highly repetitive motions with the wrist in an abnormal (other than a handshake) position. Workers may experience pain, discomfort, and disabling hand and wrist disorders such as carpal tunnel syndrome if the high number of repetitions are combined with abnormal wrist postures and excessive forces on the wrist, hands, or fingers.

The following checklist should be used as a guide for designing safe hand and wrist activities:

___ 1. **Reduce the number of repetitions per shift.** A job may be considered repetitive if there are more than 1000 repetitions (i.e., the cycle time to complete a task is less than 30 seconds) per 8-hour shift.

Automated systems should be used whenever possible.

___ 2. **Maintain neutral (handshake) wrist positions.** Design jobs and tools so that the wrist does not need to be flexed forward, extended backwards, or bent from side to side.

Avoid inward and outward rotation of the forearm when the wrist is bent to minimize elbow disorders (i.e., tennis elbow).

___ 3. **Reduce the force or pressure on the wrists and hands.** Reduce the weight and size of objects that must be handled repetitively.

Avoid tools that create pressure on the base of the palm which can obstruct blood flow and nerve function. Avoid repetitive pounding with the base of the palm.

Avoid repetitive pressing with the fingertips.

___ 4. **Design tasks so that a power grip rather than a finger pinch grip can be used to grasp materials.** Note that a pinch grip is five times more stressful than a power grip.

___ 5. **Avoid reaching more than 40 cm in front of the body for materials.**

Avoid reaching above shoulder height, below waist level, or behind the body to minimize shoulder disorders. Also, avoid repetitive work that requires the elbow to be held straight and the arm extended.

___ 6. **Provide support devices where awkward body postures (elevated hands, elbows and extended arms) must be maintained.**

___ 7. **Avoid tools & equipment that transmit vibration to the hands.**

___ 8. **Avoid exposure of the hands to cold, hot, and humid environments.**

___ 9. **Avoid wearing gloves whenever possible** (gloves can increase grip strength requirements and reduce manual dexterity). Provide a selection of sizes if gloves are required.

___ 10. **Select and use properly designed hand tools** (see Figure 13).

FIGURE 12. Design of safe hand/wrist job activities.

Tools that are designed to fit the capabilities of the human hand and arm will help prevent injuries, improve productivity, and enhance quality by minimizing worker stress and fatigue. However, poorly designed hand tools that combine repetitive forceful grip exertions with bent wrist postures can cause carpal tunnel syndrome and other cumulative trauma disorders.

A classic example of a repetitive task that can cause various cumulative trauma disorders is using a screwdriver for an extended period of time. The wrist is bent to the side, there is some degree of force to set each screw which causes pressure on the base of the palm, and there may be a relatively high number of repetitive forearm rotations with a fully extended elbow to set all the screws. A simple ergonomic solution to the problem is to use an electric screwdriver with a well-designed handle.

The following checklist can be used as a guide for selecting properly designed hand tools:

___ 1. **Maintain straight wrists**. Avoid bending or rotating the wrists. Remember, bend the tool, not the wrist. A variety of bent-handle tools are commercially available.

___ 2. **Avoid static muscle loading**. Reduce both the weight and size of the tool. Do not raise or extend elbows when working with heavy tools. Provide counter-balanced support devices for larger, heavier tools.

___ 3. **Avoid stress on soft tissues**. Stress concentrations result from poorly designed tools that exert pressure on the palms or fingers. Examples include short-handled pliers and tools with finger grooves that do not fit the worker's hand.

___ 4. **Reduce grip force requirements**. The greater the effort to maintain control of a hand tool, the higher the potential for injury. A compressible gripping surface rather than hard plastic is best.

Whenever possible, select tools that utilize a full-hand power grip rather than a precision finger grip.

___ 5. **Maintain optimal grip span**. Optimum grip spans for pliers, scissors, or tongs, measured from the fingers to the base of the thumb, range from 6 to 9 cm. The recommended handle diameters for circular-handle tools such as screwdrivers are 3 to 5 cm when a power grip is required, and 0.75 to 1.5 cm when a precision finger grip is needed.

___ 6. **Avoid sharp edges and pinch points.** Select tools that will not cut or pinch the hands even when gloves are not worn.

___ 7. **Avoid repetitive trigger-finger actions**. Select tools with large switches that can be operated with all four fingers. Also, use of the thumb is preferred over using a single finger for trigger action. Proximity switches are the most desirable triggering mechanism.

___ 8. **Protect hands from heat, cold, and vibration**. Heat and cold can cause loss of manual dexterity and increased grip strength requirements. Excessive vibration can cause reduced blood circulation in the hands causing a painful condition known as vibration white-finger syndrome.

___ 9. **Wear gloves that fit**. Gloves reduce both strength and dexterity. Tight-fitting gloves can put pressure on the hands, while loose-fitting gloves reduce grip strength and pose other safety hazards.

FIGURE 13. Selection of hand tools.