An Ergonomics Process for the Care and Use of Research Animals

Joshua Kerst

Abstract

Personnel who work with laboratory animals incur potential occupational health risks that can lead to the development of musculoskeletal disorders. Demanding manual tasks may also result in increased errors, worker fatigue, poor human performance, and decreased productivity. Studies have shown that a comprehensive ergonomics program that utilizes a systematic risk management approach can reduce the likelihood of exposure to musculoskeletal disorder risk factors and remove barriers to human performance. Research has characterized the risk factors of musculoskeletal disorder exposure in terms of force, frequency, posture, and muscle exertion. Ergonomic risk factors for typical animal handling tasks and work areas are identified, and a method is suggested for prioritizing interventions using interrelated data indicators. An initial review of potential control measures is offered to improve the health, safety, and effectiveness of people involved in the care and use of research animals.

Key Words: administrative controls; engineering controls; ergonomics program; ergonomics risk management; human performance; laboratory animal handling; laboratory safety; musculoskeletal disorders

Background

Stress and strain resulting from manual animal handling are among the most common conditions that adversely affect the health of workers who care and use animals for research purposes. The associated demanding manual tasks may result in increased occupational injuries, errors, and worker fatigue, as well as increased medical costs, poor human performance, and decreased productivity.

Sprains and strains are the second most prevalent type of occupational injury in the United States. When these data are considered along with repetitive motion injury data, the combined impact of musculoskeletal disorders (MSDs) in the United States exceeds 12 billion dollars per year (Liberty Mutual 2001) in direct costs and affects nearly one million people annually. However, a workplace injury can result in as much as three to five times the direct medical costs when all work-related factors are considered.

These injury and illness figures for general industry are daunting enough by themselves. However, they become magnified given the multitude of dynamic challenges biomedical research centers face every day. To operate in today’s research world effectively, institutions must manage changing scientific needs and research methods, increasing populations of animals, new housing requirements, and updated husbandry and animal care systems. Additionally, institutions supporting animal-related infrastructures must balance the need to support these rapid scientific changes and evolving research trends with limited available physical space, a lack of qualified personnel, and ever-increasing financial constraints.

The outcome is that personnel who work with laboratory animals incur health risks from musculoskeletal disorders. The costs of an animal-related infrastructure represent a major burden to organizations. Therefore, it is critical for the interface between the worker and the work environment to function effectively.

Research institutions that have recognized the risks of MSDs and have established preventive programs focused on developing a sustained ergonomics effort have experienced reduced injuries and illnesses, as well as improved worker performance. This article offers guidance based on industry “best practices” regarding how institutions can recognize, evaluate, and control potential MSD risks associated with animal handling.

Ergonomics Program Goals and Measures

The primary goal of a comprehensive ergonomics program in the animal research environment is to support an enhanced quality of work for those who care for and use the animals by improving the fit between the job and the person. As a result, a better ergonomic fit can help minimize exposure to musculoskeletal stressors and enhance human performance. A successful ergonomics process can therefore be defined as one that supports the institution’s research goals, is sustainable, and results in reduced injuries and a better quality of work life.

The benefits of adhering to quality of work life principles are supported by research. Work systems guru W. Edwards Deming has cited the job/person “fit” as one of the

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1Abbreviations used in this article: BRIEF, Baseline Risk Identification of Ergonomic Factors; LI, lifting index; MSD, musculoskeletal disorders; PDCA, Plan-Do-Check-Act; RWL, recommended weight limits.
basic 14 fundamental tenets of quality (Deming 1986). Point 12 states, “Nothing should stand between a worker and their right to pride of workmanship.” Removing barriers between people and pride in their work is an essential element of an ergonomic approach to animal handling. To allow this, an ergonomics process must focus on the following objectives:

- Reduce employee pain and suffering;
- Improve human performance by removing barriers between people and the tasks;
- Minimize the number of potential error-provoking situations;
- Avoid the direct costs of workplace injuries such as wage replacement payments and medical care expenses; and
- Prevent the indirect costs of work-related accidents, which include lower employee morale, lost productivity, employee turnover, and the cost of hiring or training overtime or temporary replacement workers.

It is no surprise that world-class research institutions have continued to focus on removing the barriers that stand between people and research success in the laboratory. Ergonomics represents one method to close this gap through a systematic review of health and safety issues for workers who may be exposed to MSD risk factors during primary animal handling activities. This process will help reduce the likelihood of musculoskeletal disorders, will limit costs of retrofitting equipment.

Management Planning and Roles

Ergonomics initiatives are most effective when applied in a systematic fashion consistent with existing best practices. A process model based on the Shewart Plan-Do-Check-Act (PDCA\(^1\)) continuous improvement cycle highlights the key elements to include in an ergonomics program (Shewart 1939). An effective ergonomics initiative integrates strategic (high-level) and tactical (front-line) activities. Strategic components are typically management activities that provide the infrastructure, support, and direction for ongoing tactical activities. Tactical activities are generally the responsibility of designated change agents such as environmental health and safety personnel, ergonomics teams, site-based facilities engineering staff members, and occupational health personnel. The result of such a systematic approach is an ergonomics initiative that represents an effective, efficient, and repeatable process to support the identification and reduction of ergonomic hazards in the workplace. In Tables 1 and 2, strategic and tactical activities carried out in the four phases—Plan, Do, Check, and Act—are described, and examples are provided.

### Integrating Ergonomics Activities with Existing Health and Safety Policies

An institution should select elements of an ergonomics program that can be integrated into the worker protection already afforded as part of the institution’s overall animal care and use program. Integrating ergonomics within these basic health and safety elements allows a site to use existing support mechanisms rather than create new ones to protect the occupational health and safety of animal handlers. For example, existing health and safety committees and suggestion systems may be used to evaluate MSD risk and propose countermeasures. The breadth and depth of each ergonomics program will vary dramatically between institutions according to the types of safety hazards present (e.g., biological, large/small animal) and the level of MSD hazard control sophistication available to the site.

Typical leaders for the ergonomics initiative are site health and safety specialists who have acquired sufficient tactical and strategic application skills and knowledge in appropriate human factors disciplines. These personnel should be involved both in assessing MSD risks associated with hazardous activities and in developing and planning high-level procedures to manage such risks. The extent to

### Table 1 Strategic activities: Managing the ergonomics initiative

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Examples</th>
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</thead>
</table>
| Plan | Understanding the current situation and develop goals and strategies | • Determine the problem scope  
• Set long-term goals and metrics  
• Form a steering team to lead ergonomics initiative  
• Establish responsibilities and resources  
• Train key individuals in ergonomic principles  
• Audit the ergonomics process  
• Track key metrics against set goals  
• Determine next area of focus for improvement  
• Address barriers to overall program effectiveness |
| Do | Implement a management process and infrastructure to meet the goals | |
| Check | Monitor progress toward meeting goals | |
| Act | Standardize effective activities and improve ineffective activities | |
which other personnel within the occupational health and safety program participate should be based on the following factors:

- MSD hazards posed by the animals and materials used;
- Task exposure intensity, duration, and frequency;
- Capability of the personnel; and
- History of occupational illness and injury in the particular workplace.

Operational and day-to-day responsibility for safety in the workplace ultimately resides with the laboratory or facility supervisor (principal investigator, facility director, or veterinarian) and should be reflected in safe work practices performed by all employees. Therefore, an effective framework must provide comprehensive methods to establish an occupational health and safety program that ensures that the MSD risks associated with the experimental use of animals are reduced to acceptable levels.

**Ergonomic Risk Management—Six-Step Approach**

Successful ergonomics processes follow a systematic, proactive approach driven by risk reduction strategies (Kerst 2001). A proactive approach to ergonomics identifies and addresses factors known to contribute to injury/illness before an incident occurs. Responding to risk, not simply to injury and illness, is why this element is referred to as Ergonomics Risk Management. Each institution recognizes, evaluates, and controls numerous potential site hazards daily. Each time an institution identifies a hazard, it typically works through a priority-setting process that rates the hazard based on severity. Once the severity of the hazard is determined, the institution can address it through a hierarchy of controls. Managing the activities for dealing with ergonomic issues in animal handling includes the same recognition, evaluation, and control process used to minimize or eliminate other potential workplace hazards. Table 3 provides a brief description of a six-step tactical approach to ergonomics risk management to help institutions streamline efforts in employing the ergonomics elements.

### Basic MSD Risk Factors

An introduction to the contributing factors that lead to musculoskeletal disorders can assist institutions in the “Do” portion of the Plan-Do-Check-Act process. Musculoskeletal disorders represent a class of illness that occurs as a result of prolonged or repeated strain on the body. Common musculoskeletal disorders include backache, shoulder pain, neck and wrist problems, and carpal tunnel syndrome. These disorders can be prevented by modifying work practices and equipment to better suit the user.

### Table 2 Tactical activities: Deploying workplace improvements

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Plan | Identify and prioritize opportunities for improvement | • Integrate ergonomics with existing health and safety policies  
• Prioritize tasks according to ergonomic risks  
• Identify planned equipment changes |
| Do   | Analyze jobs and implement improvements | • Analyze ergonomic hazards  
• Implement workstation and/or task redesign improvements |
| Check| Determine whether each action achieved desired results | • Track lagging metrics (e.g., recordable incidents)  
• Track risk metrics (e.g., ergonomic risk scores) |
| Act  | Revisit individual actions to ensure plan compliance | • Revisit jobs/tasks where risk exposure was not significantly reduced  
• Redeploy effective improvements to similar jobs and tasks |

### Table 3 Six steps to recognition, evaluation, and control of musculoskeletal disorders in caring for and using research animals

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify job tasks with potential risk and review animal handling concerns with employees in those areas</td>
</tr>
<tr>
<td>2</td>
<td>Evaluate risk areas using a risk survey (e.g., qualitative/quantitative) checklist, and prioritize highest risk tasks and their root cause contribution to musculoskeletal disorders</td>
</tr>
<tr>
<td>3</td>
<td>Apply appropriate hazard control measures</td>
</tr>
<tr>
<td>4</td>
<td>Train and educate exposed researchers and technicians on animal handling risks with documented prevention strategies to ensure proper equipment use</td>
</tr>
<tr>
<td>5</td>
<td>Confirm the effectiveness of the hazard prevention changes, and promote enhanced communication between researchers and caregivers regarding work factors to identify additional ergonomics issues</td>
</tr>
<tr>
<td>6</td>
<td>Anticipate future opportunities for musculoskeletal disorder risk reduction by repeating the process for additional problematic job tasks</td>
</tr>
</tbody>
</table>
of months and years of overuse of human joints, muscles, and connective tissues to the point that they become sore and sometimes unusable. One way to visualize musculoskeletal trauma is to think of your joint structures as a bucket with fixed capacity. Microtrauma from job- and non-job-related activities drips into each joint’s “trauma bucket.” Fortunately, the body can heal with time and safely absorb a certain amount of trauma. However, if we place more trauma into the bucket than the natural healing process can absorb, the result is impaired movement or, in the worst cases, a disabling injury (Figure 1).

Consequently, MSDs are based on a dose and exposure relation. Similar to hearing loss, MSDs occur gradually over a long period of exposure to low-level, potentially harmful risk factors. A brief exposure to these risk factors would not cause harm, but prolonged exposure results in reduced ability to function. Reducing the microtrauma to joints, muscles, and connective tissues is necessary to prevent MSDs from developing. A substantial body of credible epidemiological research provides strong evidence that the following three physical work-related factors contribute to this microtrauma (NIOSH 1997a,b): the force applied by the person, the frequency of the force application, and the posture assumed during this activity. An investigation into these factors will unveil the root causes of MSDs in typical animal handling activities.

**Force**

We understand how an acute injury occurs. If we press a knife against our skin with a small amount of pressure, nothing happens. If we increase the pressure, we may dent our skin, but eventually, the tissue returns to normal. Pressing harder, we can bruise the skin, and with even more force, break the skin. It is clear that an “acute” or short-term injury depends on the transfer of energy to the human tissue. When the energy transferred exceeds the energy-absorbing capacity of the tissue, an injury occurs. Acute injuries have very short cause/effect associations. For example, a misguided hammer transmits excessive energy to a bone and breaks a finger. Acute injury is easily understood when we view it from an energy transfer perspective. What if force is not excessive? Can it still cause injury over the long term? Absolutely!

Tasks that require forceful exertions place greater loads on the muscles, tendons, ligaments, and joints. Greater exerted force means increasing body demands such as greater muscle exertion along with other physiological changes necessary to sustain an increased effort (NIOSH 1997a,b). Prolonged or recurrent experiences of this type may lead not only to feelings of fatigue but also to musculoskeletal problems when there is inadequate time for rest and recovery. Exerted handling force requirements can also increase when the load is heavy or bulky, requires high-speed movements, and is slippery. Animal handling (e.g., canine transfer and related material handling activities such as cage cleaning) requires many, if not all, of these contributing factors. The end results are increased grip forces, increased joint loads and torques, and larger spinal loads placed on the body.

**Frequency**

We are familiar with what happens when we lightly squeeze a soft drink can with our hands. Initially the sides of the can crinkle, but the can regains its shape. The force applied was not strong enough to destroy the can immediately. However, if we repeatedly apply this same force (e.g., 15 or 20 times), the can develops a “fatigue debt” and progressively tears apart as it wears out. It is the same for the human body, but instead of 15 or 20 repetitions, the frequency is measured in the hundreds and thousands of repetitions. The repeated application of a force that is not strong enough to cause immediate damage can, over time, induce fatigue in our skin, muscles, tendons, ligaments, nerves, and blood vessels and can wear them out (Keyserling et al. 1993).

We can also create force without high-frequency external movements. For example, if we bend halfway to the floor, stop, and hold this posture, we are creating a static force load even though there is no external movement. Therefore, both high-frequency movements and low-frequency sustained postures contribute to fatigue debt and must be considered as contributing factors. Tendons and muscle, however, can often recover from the fatigue debt if sufficient time passes between exertions.

**Posture**

Body postures determine which joints and muscles are used in an activity and the amount of force or stresses generated.
or tolerated (Putz-Anderson 1988). Because the skeleton is essentially a lever system, there are certain postures in which it can absorb force more easily than in others. Phrased another way, there are certain postures in which the body is more susceptible to injury. Typically, the closer to the extremes of a joint’s range of movement, the less capable the joint is. For example, the spine can be subjected to significantly more load and intervertebral disc compression, and thus more injury potential, when animal handlers choose to stoop and lift rather than bend their knees with the back in column.

Combinations of Risk Factors

If the forces are extreme, an immediate injury will occur. If the force is below the threshold of immediate damage, the onset of a “wear and tear” injury will depend on the number of times per day the person is exposed to the force. Extreme postures, combined with force and frequency, will cause damage more quickly than when the postures are more natural or neutral. It is therefore the combination of force, frequency, and posture that contributes to wear and tear injuries. Effects of repetitive motions from performing the same work activities are increased only when awkward postures and forceful exertions are involved. It is therefore essential for any MSD hazard reduction process to remove one, two, or all three of the components of the MSD “triangle” (Figure 2).

Figure 2 “Triangle” of the combined causes of musculoskeletal disorders (MSD).

Additional Physical Work Factors

Additional physical work factors such as the duration of exposure, localized body contact stress, vibration, and temperature extremes can also contribute to accelerated MSD development. Duration refers to the amount of time a person is continually exposed to a risk factor or combination of risk factors. Long-duration animal handling tasks requiring continued use of similar muscles or motions (e.g., rodent transfer) increase the likelihood of fatigue. The longer the duration of this continuous work, the longer the required recovery time.

Other factors to consider include repeated or continuous contact with hard or sharp objects such as nonrounded cage edges or narrow forceps grips, which may create pressure over one area of the body, inhibiting nerve function and blood flow. Vibrations may lead to Raynaud’s phenomena (i.e., vibrational white finger), which may occur when a specific part of the body comes in contact with a vibrating object. Other workplace conditions that can influence the presence and magnitude of risk factors for MSDs include the following:

- Cold temperatures that contribute to reduced blood flow (vasoconstriction);
- Insufficient pauses and rest breaks for recovery; and
- Unfamiliar or unaccustomed work where potentially awkward positions and excessive forces may be applied.

Identification of MSD Indicators

Three types of interrelated data indicators are typically used to determine whether musculoskeletal problems are present and whether animal handling job conditions that pose a significant risk for such MSDs exist: medical records (past), employee survey (present), and risk assessment/job survey (future). It is advisable to address first those jobs that have been a problem in the past, have reports of problems currently, and are projected to be problems in the future.

Review of Medical Records (Past)

It is important to review injury and illness records to identify areas of ergonomic concern, to understand the magnitude and seriousness of such problems, and define opportunities for intervention. Medical records provide a historic look at occurrences of strains, sprains, and repeated trauma (musculoskeletal problems). Institution medical records and Occupational Safety and Health Administration (OSHA) Form 300 logs can be tallied for use in calculating the incidence of MSD. These injury and illness rates and incidents can yield valuable information about the types of MSDs present and help predict potential future losses stemming from the situation. Additionally, safety and health professionals should review past workers’ compensation records. These data from insurance carriers may provide...
even more detailed information about injuries than the OSHA logs. If the information reveals that workers in certain animal handling operations are confronted with given injuries or illnesses more so than other workers (and are exhibiting the same types of MSDs), those particular operations may be the best candidates for immediate study with regard to possible risk factors.

Furthermore, jobs with elevated rates of low back musculoskeletal disorders often have higher risks for acute injuries due to slips and trips or other safety hazards. In addition, these jobs may have higher absentee rates, job transfer rates, and workers’ compensation costs, which are also indicators of problematic jobs or tasks. Industry best practices suggest that institutions that have more than one work-related case of musculoskeletal disorder per 200,000 hr, or more than a twofold difference in MSD incidence rate between animal handling departments and other departments, should consider further problem evaluation.

Survey of Workers (Present)

A job- or task-based employee survey examining the likelihood of excessive physical fatigue or discomfort can also be an important indicator of potential MSD concerns. These surveys, which are typically administered on a one-on-one basis to avoid group bias, focus on relating discomfort sources to specific jobs or tasks. Animal handlers and technicians are asked to report experiences of routine pain or discomfort by body area (e.g., hands and wrists, neck, back, and legs). These job survey results can then be prioritized by the frequency and severity of discomfort by body area. The jobs or tasks ranked highest for discomfort that are also linked with an injury to similar body areas are primary candidates for immediate action (e.g., review of additional risk factors analysis and hazard control through risk reduction countermeasures).

Employee surveys also support early reporting of MSD signs and symptoms, which is a critical component of any successful ergonomics program. Management should strive to create a work culture in which employees feel free to report—as early as possible—any symptoms of physical stress. Early MSD reporting allows management to identify problems proactively and take corrective action to address specific issues before the effects of a problem job or task worsen. Following are a few guidelines to keep in mind when administering employee surveys:

- Following up on employee survey reports of MSD signs and symptoms is essential. A symptom survey should be conducted only if the institution is prepared to act on the results.
- No names should be required on the forms, and the collection process should ensure anonymity.
- Survey participation should be voluntary.
- The survey should be conducted during work hours.
- A second survey, using the same form, completed after ergonomic changes occur (typically after a minimum of 4 wk) should be conducted to indicate whether the intended goals have been achieved.

MSD Risk Assessment Job Surveys

The strongest evidence of MSD can be found through a review of the risk factors present in a job or task, although OSHA 300 medical records and employee discomfort surveys may provide some evidence of musculoskeletal problems in the workforce. Identifying jobs or tasks with documented MSD risk factors can provide the baseline measures for risk acceptability and a benchmark for future improvement. A comprehensive risk management strategy allows individuals to respond with proactive intervention. Many proactive ergonomic risk assessment tools that categorize risk in the workplace are available in ergonomics manuals.

The primary method of risk assessment is an observational checklist completed during a walk-through review of a job or task to identify obvious ergonomic concerns. The checklist, which helps to identify mismatches between applied force, frequency, and assumed postures, provides a systematic MSD risk screening method for people who are familiar with the tasks. Checklists provide assessors with an outline of the ergonomic issues and may aid in the identification of ergonomic mismatches.

A more detailed quantitative risk assessment is useful if the observational assessment does not provide sufficient data to uncover the root cause of the problem. This author suggests using the Baseline Risk Identification of Ergonomic Factors (BRIEF) survey (Humantech, Ann Arbor, Michigan), a job hazard analysis system that is based on a structured and formalized process of identifying MSD risk factors for individual tasks. The BRIEF survey provides, for each area of the body, a risk score that indicates the ergonomic acceptability of the task.

The BRIEF survey has been used successfully since the early 1990s to identify root causes of MSDs, and it meets all requirements for an OSHA-recognized MSD hazard analysis system. The rating structure is based on criteria derived from past and current epidemiological data on occupational factors contributing to MSDs. Risk factors are identified and tallied for posture, force, frequency, and duration for nine areas of the body. Risk ranking is determined by summing the scores for posture, force, frequency, and duration. Jobs that expose an area of the body to three or more risk factors are considered high risk, two risk factors indicate medium risk, and one or no risk factors indicate low risk.

Manual Material Handling Assessment Tools

Animal care activities require constant manual handling effort, presenting many opportunities for musculoskeletal in-
jury to the worker. Two additional risk assessment models, the National Institute for Occupational Safety and Health lifting calculation (NIOSH 1991) and psychophysical exertion tables (Snook and Cirello 1991), can help institutions prioritize manual handling concerns and thus reduce the likelihood of MSD injury during manual handling. These methods provide an additional level of screening for jobs with manual material handling issues by providing information such as

- Recommended weight limits (RWL);
- Relative measures of physical stress during lifting/lowering (lifting index, or LI); and
- Perceived maximum loads for carrying, pushing, and pulling.

The Revised NIOSH Lifting Equation considers lifting factors such as the location of the load, the lifting frequency, the hand-to-object coupling, and lift geometry to calculate RWL. The RWL value represents a load weight that is likely to be acceptable for at least 75% of female workers and 99% of male workers. The calculation also determines a measure of relative physical stress or LI—the ratio of the load weight to the RWL. In general, as the LI increases, a greater percentage of the population is at risk for injury from performing the lifting task:

<table>
<thead>
<tr>
<th>LI value</th>
<th>Indication of ergonomic risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.0</td>
<td>Low</td>
</tr>
<tr>
<td>1.0-3.0</td>
<td>Medium</td>
</tr>
<tr>
<td>&gt;3.0</td>
<td>High</td>
</tr>
</tbody>
</table>

Population data depicting human strength capacities can be helpful in designing and evaluating jobs (Snook and Cirello 1991). Comparing job analysis results with such references can yield estimates of the percentage of the population that may be especially affected by these job conditions.

**Animal Handling Tasks and MSD Risk**

Based on results from quantitative risk assessments (BRIEF, NIOSH, Snook and Cirello 1991), several animal handling tasks have been categorized as high risk for developing MSDs. Table 4 provides a partial list of the jobs in which at least one body area was identified as high risk.

The root causes and contributing factors of musculoskeletal disorders for animal handlers are primarily related to the level of manual material handling required each day. Ergonomic analyses have shown that handlers must frequently bend and twist while lifting and carrying cages, transferring animals, and replenishing feed. When these forces are combined with the exertion required to push and pull carts, or move and wash cages, the cumulative forces exerted per day by a handler range between 6000 kg for small animals with water bottles to 8500 kg for larger animals. The NIOSH Lifting Equation identified several animal handling activities that exceeded the recommended weight limit based on the levels of required force coupled with awkward postures. This potent combination of risk factors has a strong correlation with an increased risk of muscular sprain/strain injury, especially in the lower back and shoulders.

Activities requiring frequent or prolonged work above shoulder height (1.2 meters) can also be particularly stressful. When these tasks require repeated or sustained bending or twisting at the wrists, knees, hips, or shoulders, they also impose increased stresses on these joints. High-risk (large and small) animal handling activities and the particular areas of the body that are at risk for injury are listed in Tables 5 and 6.

**MSD Hazard Prevention**

As soon as MSD risk factors have been identified and measured, the analyst must devise an appropriate risk exposure control strategy, with the goal of increasing the overlap between worker capabilities and task demands to improve the fit of the job with the worker (NIOSH 1997). Which control options are selected depends on the experience and imagination of the analyst. Institutions should first consider engineering controls, which involve a change in the physical features of the workplace that may eliminate the risk altogether. In conjunction with engineering controls, administrative controls (which include the use of work practices) offer additional opportunities to reduce worker exposure to workplace hazards. Institutions should also be familiar with ergonomic design guidelines and standards that will help create a more ergonomically sound working environment in the future.

**Engineering Controls and Facility Design**

The preferred method for controlling ergonomic hazards is through engineering controls. When the design of the work-
place reduces the magnitude of risk factors, the likelihood of injury/illness is also reduced. Engineering controls include, for example, reducing the weight of feedbags, providing alternative or variable height work surfaces, and purchasing lifting assists. Table 7 provides suggested engineering controls for the animal handling environment.

To ensure proper facility design and equipment purchases, thus avoiding the risk of MSD, ergonomic design specifications should be considered from the inception of all facility projects. Proactively integrating ergonomics during the facility design review and planning process can prevent many potential problems and save considerable money by building (and equipping) a facility correctly the first time, avoiding costly renovations, retrofits, and replacements. Biomedical research centers should seize the opportunity to raise awareness of ergonomic issues early in the development cycle by creating policies that require ergonomic considerations for any equipment before purchase. Decision makers involved in planning new work processes must understand the ergonomic factors their site must accommodate. During initial planning sessions, they should solicit ideas from animal handlers for alleviating potential problems and be involved in project risk reviews to help uncover opportunities for new and more cost-effective equipment options.

Ergonomic design standards formalize the limits of human capabilities into a format that is easily applied when developing purchasing criteria. These standards can include rules, checklists, or guidelines and should address factors such as reach distances, working heights, force capabilities, and grip dimensions. This type of information is particularly useful because many engineers and facility planners work as system integrators. Facility designers should study the ergonomic impacts of past job designs against these standards and make enhancements that improve the interaction between people and the work requirements. For example, fa-

### Table 6 High-risk small animal handling activities resulting in musculoskeletal disorders by body area

<table>
<thead>
<tr>
<th>High-risk task</th>
<th>Body area</th>
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<tbody>
<tr>
<td></td>
<td>Hand/wrists</td>
</tr>
<tr>
<td>Transfer rodents with forceps</td>
<td>●</td>
</tr>
<tr>
<td>Handle containers, wire cages, cage lids</td>
<td>●</td>
</tr>
<tr>
<td>Prepare, transfer, replenish water bottles</td>
<td>●</td>
</tr>
<tr>
<td>Rodent dosing</td>
<td>●</td>
</tr>
<tr>
<td>Access high-density cages at unsuitable working heights</td>
<td>●</td>
</tr>
<tr>
<td>Lift feed bags</td>
<td>●</td>
</tr>
<tr>
<td>Positions adopted during animal surgery</td>
<td>●</td>
</tr>
<tr>
<td>Transport disassembled cages to conveyor style tunnel washers</td>
<td>●</td>
</tr>
<tr>
<td>Push, pull, rotate full carts</td>
<td>●</td>
</tr>
</tbody>
</table>

### Table 5 High-risk large animal handling activities resulting in musculoskeletal disorders by body area

<table>
<thead>
<tr>
<th>High-risk task</th>
<th>Body area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hand/wrists</td>
</tr>
<tr>
<td>Lift canines for cage cleaning</td>
<td>●</td>
</tr>
<tr>
<td>Lift cage floors and grating</td>
<td>●</td>
</tr>
<tr>
<td>Push, pull, rotate full cage carts</td>
<td>●</td>
</tr>
<tr>
<td>Disassemble cages</td>
<td>●</td>
</tr>
<tr>
<td>Clean cages with spray nozzle and scrub brush</td>
<td>●</td>
</tr>
<tr>
<td>Transport disassembled cages to conveyor style tunnel washers</td>
<td>●</td>
</tr>
<tr>
<td>Lift feed bags</td>
<td>●</td>
</tr>
<tr>
<td>Dispense food pellets into wire cages</td>
<td>●</td>
</tr>
<tr>
<td>Carry animals to surgery tables</td>
<td>●</td>
</tr>
</tbody>
</table>
Facility designers should consider incorporating automated systems for tasks that require frequent material handling and transport (e.g., water bottle handling, feeding, cage dumping, and cage washing) to eliminate the associated MSD risk exposures. Company policies can also require vendors who supply equipment and materials to do more to support the ergonomics process. For example, institutions may request that feed bags be available in smaller, more manageable size bags (20 kg maximum), or that biocontainment hoods meet more demanding ergonomic design criteria to benefit the workers.

### Administrative Controls

Administrative controls are workplace policies, procedures, and practices that minimize the exposure of workers to risk conditions. They are considered less effective than engineering controls in that they do not usually eliminate the hazard. Rather, they lessen the duration and frequency of exposure to the risk condition. Administrative controls are useful when the cost or practicalities of engineering controls are prohibitive. At a minimum, at-risk personnel should have access to clearly defined procedures for conducting their duties, should understand the musculoskeletal hazards involved, and should be proficient in implementing the required safeguards. Following are some examples of administrative controls:

- Improve communication between researcher and animal care staff regarding study length and termination dates to minimize handling;
- Broaden or vary the job content to offset certain risk factors (e.g., repetitive motions, static and awkward postures);
- Distribute equal workloads to minimize overloading individuals with daily tasks;
- Modify jobs or accommodate employees who have functional limitations secondary to MSDs (as determined by a health care provider) by reducing shift length or curtailing the amount of overtime;
- Rotate workers through several jobs with different physical demands to reduce the stress on limbs and body regions;
- Schedule more breaks to allow for rest and recovery;
- Adjust work pace to relieve repetitive motion risks and give the worker more control of the work process; and
- Give employee health care providers the opportunity to

### Table 7 Common animal handling engineering controls

<table>
<thead>
<tr>
<th>Large Animal Engineering Controls</th>
<th>Small Animal Engineering Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flush-mounted, in-floor stainless steel lift table (0-115 cm travel) for surgery that accommodates seated or standing work with 30 cm kneewell access</td>
<td>Height-adjustable (70-115 cm) biocontainment hoods with kneewell clearance and waste disposal chute</td>
</tr>
<tr>
<td>Sliding or power-assisted doors for operating rooms and aseptic areas</td>
<td>Ergonomic forceps with larger grips to minimize finger fatigue</td>
</tr>
<tr>
<td>Autoclave systems that minimize material handling and confined space entry</td>
<td>1.2 m maximum shelf height of rodent cages</td>
</tr>
<tr>
<td>Large (minimum 20 cm) roller-bearing casters on all movable cages</td>
<td>Replace glass water bottles with plastic or install automatic watering systems</td>
</tr>
<tr>
<td>Automatic cage waste disposal, dumping and washing systems</td>
<td>Minimize use of squeeze to open rodent cages. Use those with easy-slide handles and rounded edges</td>
</tr>
<tr>
<td>Vacuum disposal and delivery for cage bedding</td>
<td>Minimize 2 m between racks within rodent rooms to improve cart and equipment maneuverability</td>
</tr>
<tr>
<td>Feed bags, cages, and other items requiring repeated lifting stored 40-50 cm above floor (or store feed bags on lift and swivel tables)</td>
<td>Provide rodent surgeons with adjustable angled rodent tray or support stand for tail bleeding</td>
</tr>
<tr>
<td>Adjustable footrests for seated work and foot rails with antifatigue matting for standing work areas</td>
<td>Adjustable extended eyepieces for microscopy work</td>
</tr>
<tr>
<td>Centrally located feed bags (20 kg maximum) and all supplies</td>
<td>Cage lid support bars or shelving</td>
</tr>
</tbody>
</table>
become familiar with animal handling jobs and job tasks.

**Work Practice Controls**

Changes to work practices can reduce or control worker exposure to job risks; however, they do not eliminate the risk. Work practice controls focus on changing the way workers perform their physical work activities and, therefore, their effectiveness depends largely on employee acceptance. Employee acceptance is a critical element of the ergonomics process, and methods should be used to enable and empower animal handlers to contribute to effective work practices. Following are some examples of work practice controls:

- Train workers to recognize risk factors for MSDs, and teach others effective work practices and lifting principles that can ease the task demands or burden.
- Train workers to recognize MSD signs and symptoms, and teach the employer’s procedures for reporting MSDs.
- Encourage employees to report symptoms early, and ensure prompt evaluation by an appropriate health care provider.
- Practice effective teamwork that supports clear communication with coworkers.
- Provide strong upper management leadership including active support and participation.

**Conclusion**

The elements and selected approaches to addressing workplace ergonomic problems in animal handling have been summarized. Methods are offered that support developing a plan for identifying problems, specifically MSDs and job risk factors linked to them, and selecting and implementing measures for controlling the problems. Although reactive steps are the typical beginning point, proactive approaches should be instituted to prevent these kinds of problems from developing. This ongoing process should emphasize an institution’s efforts to review problems before an injury or illness occurs. Verifying risk factors and identifying corrective actions at the design stage of work processes can ensure that operations for the care and use of animals can be developed that impose no undue stress and strain on the worker.

**References**