Ergonomic Issues in a Non-Primate Small Animal Facility in a Laboratory Setting

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ABSTRACT

Workers who handle small animals in a research laboratory are exposed to many risk factors which, if not addressed, can lead to work related musculoskeletal disorders (WMSDs). Little data have been published that address the awkward postures, force, and repetition to which these workers are constantly exposed while providing care to maintain healthy animal colonies. This paper outlines a program for identifying and correcting ergonomic deficiencies and instituting prevention strategies. A guideline is provided for developing an interdisciplinary ergonomics team with occupational and environmental health nurses taking the lead, and the roles of other members of this team identified. A successful ergonomics program will lead to fewer work related musculoskeletal disorders and a healthier work force.

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CHAPTER 1

INTRODUCTION

Overview of Animal Care Setting with Small Animals

Research animal models provide invaluable and irreplaceable insights into human systems because there are striking similarities between the genetic physiological systems of animals and humans (Foundation of Biomedical Research, 2002). In a small animal laboratory facility, approximately 97% of animals are mice and rats (Foundation of Biomedical Research, 2002), and the remainder are guinea pigs, hamsters, gerbils, and rabbits. The mouse is believed to contain the same complement of genes found in humans, so studying how genes work in mice is an effective way of discovering the role of genes in human health and disease.

A variety of each mouse species is bred for research purposes and in recent years scientists have developed genetically altered rodents that mimic human conditions such as aging, Parkinson's disease, cancer, cystic fibrosis, heart disease, memory loss, muscular dystrophy, and spinal cord injuries. Rabbits are used because the physiology of their cells, tissues, and organs is similar to humans, providing an excellent model for many human diseases including cardiovascular disease, especially hypertension and atherosclerosis.

Poor animal health can result in unreliable research data. For results to be valid, animal subjects must be in good condition and healthy. Basic needs of these animals, such as housing, food, water, husbandry, environment, growth, and handling must be met. Animal handlers must also be able to observe behavior to recognize and address pain and distress.

As the field of biomedical research continues to grow and change, the animal housing facility (Vivarium) requires increasing populations of animals, additional housing to accommodate the animals, and updated husbandry and animal care systems. The need to support the changing scientific requirements must be balanced with limited available space, lack of qualified personnel, and ever-increasing financial constraints (Kerst, 2003).

However, the use of animals in research is controversial. As a result, much has been written to protect the animals used in research and the obligations of organizations that participate in animal research (National Research Council, 1997). The health and safety of the persons who provide the care and use of the animals has not been well addressed.

Employees who work with small laboratory animals are at risk for injuries/illnesses associated with musculoskeletal disorders. The cost of an animal facility is a major line item to an institution so it is imperative to provide an environment where employees can safely perform their duties.

Purpose

This paper will identify and address ergonomic issues that put Vivarium workers at increased risk for musculoskeletal injuries and will investigate the incidence, prevalence, and severity of work related musculoskeletal disorders (WMSDs). A prevention and control program for ergonomic strategies appropriate for this setting will be outlined. The role of occupational and environmental health nurses (OEHNs) will be described in providing occupational and environmental health nursing intervention and prevention strategies.

CHAPTER 2

LITERATURE REVIEW

Ergonomics

Ergonomics is an evolving multidisciplinary science and is defined as "the science of fitting workplace conditions and job demands to the capabilities of the working population" (National Institute of Occupational Safety and Health [NIOSH], 1997). Employees face physical and mental stressors on the job. By making adjustments to tasks, workstations, tools, equipment, or procedures to minimize fatigue, discomfort, and injuries, employees can meet the demands of the job while working toward the mission of the organization (LaDou, 1997). The goals of an effective ergonomics program are to reduce the risks of injury and illness to improve performance, minimize discomfort, and improve the quality of corporate culture. If stressors are not reduced or alleviated, negative consequences can occur, among them work related musculoskeletal disorders.

Work Related Musculoskeletal Disorders (WMSDs)

WMSDs can arise from ordinary movements such as gripping, twisting, reaching, moving, etc. These repetitive actions are not any more hazardous than the same actions performed at home. However, chronic repetition in a forceful and awkward manner with insufficient rest can make these actions hazardous. Musculoskeletal disorders can arise from non-work activities but the distinction of WMSDs is limited to those that are work related.

NIOSH (1997) described musculoskeletal disorders as:

- A group of conditions that involve the nerves, tendons, muscles, and supporting structures (ligaments, joints, cartilage, or spinal discs),
- A wide range of disorders, which can differ in severity from mild periodic symptoms to severe chronic and debilitating conditions,
- Not typically the result of any instantaneous or acute event (such as a slip, trip or fall) but reflect a more gradual or chronic development (nevertheless, acute events such as slips and trips are very common causes of musculoskeletal problems such as low back pain),
- Diagnosed by a medical history, physical examination, or other medical tests that can range in severity from mild and intermittent to debilitating and chronic, and
- Having several distinct features (such as carpal tunnel syndrome) as well as disorders defined primarily by the location of the pain (i.e., low back pain) (p. 1).

The term "work related musculoskeletal disorders" refers to (1) musculoskeletal disorders to which the work environment and the performance of work contribute significantly, or (2) musculoskeletal disorders that are exacerbated by work conditions. These workplace conditions, along with personal characteristics (e.g., physical limitations or existing health problems) and societal factors, are thought to contribute to the development of WMSDs (Armstrong et al, 1993). Specific risk factors that can lead to WMSDs include awkward postures, forceful exertions (including lifting, pushing, and pulling), repetitive motions, duration, contact stresses, and vibrations. Other conditions in the workplace that can exacerbate WMSDs include cold temperatures, insufficient pauses and rest breaks for recovery, machine paced work, and unfamiliar or unaccustomed work. The level of risk depends on the intensity, frequency, duration of the exposure, and individual tolerance to these conditions. According to the Bureau of Labor Statistics (2004a), WMSDs include cases where:

> The nature of the injury or illness is sprains, strains, tears; back pain, hurt back; soreness, pain, hurt, except the back; carpal tunnel syndrome; hernia; or musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is bodily reaction/bending, climbing, crawling, reaching, twisting; overexertion; or repetition. Cases of Raynaud's phenomenon, tarsal tunnel syndrome, and herniated spinal discs are not included (p. 3).

Impact of WMSDs on the Workplace

The Bureau of Labor Statistics (2004a) indicate that WMSDs accounted for 487,900 or 34% of the injuries and illnesses with days away from work in 2002. Median days away from work were the key measure of severity. As Tables 2.1 and 2.2 indicate, carpal tunnel syndrome had more median days away from work than any other injury, and wrist and shoulder injuries lead the events with the most days away from work.

Exposure Data

Effective 2002, OSHA revised the recordkeeping requirements to include the use of calendar days instead of workdays. This change affects the calculation

Table 2.1

Median Days Away from Work Due to Nonfatal Occupational Injury or Illness by Nature, 2002

Injury/Illness Type	Days Away From Work
All Injuries	7
Carpal Tunnel Syndrome	30
Fractures	29
Amputations	26
Tendonitis	15
Multiple traumatic injuries	9
Sprains, strains, tears	7

Source: Bureau of Labor Statistics, U. S. Department of Labor, Survey of Occupational Injuries and Illnesses. (nd.a). Retrieved July 28, 2004 from http://www.bls.gov/iif/oshwc/osh/case/osch0027.pdf, p. 16.

Table 2.2

Median Days Away from Work Due to Nonfatal Occupational Injury or Illness by Part of Body, 2002

Part of Body	Days Away From Work
All parts of body	7
Wrist	15
Shoulder	15
Knee	14
Multiple parts	10
Lower extremities	9
Trunk	8
Foot, except toe	7
Upper extremities	7
Back	7
Neck	7

Source: Bureau of Labor Statistics, U. S. Department of Labor, Survey of Occupational Injuries and Illnesses. (nd.b). Retrieved July 28, 2004 from http://www.bls.gov/iif/oshwc/osh/case/osch0027.pdf, p. 17.

of median days away from work and therefore makes the data non-comparable with prior years.

Of the 487,915 WMSD cases involving days away from work (BLS, 2004a), Table 2.3 indicates that 202,814 of these injuries involved lifting and another 66,214 were associated with bending, climbing, crawling, reaching, and twisting; approximately 50% of overexertion injuries affected the back and 75.8% were due to strains and sprains; the median number of days away from work due to WMSDs was 9 days compared to 7 days for all injuries and illness events combined. However, more than 34% of the cases involved more than 20 days away from work, and almost 27% involved more than 30 days away from work; 53,673 injuries or illnesses occurred as a result of repetitive motion, including typing and key entry, repetitive use of tools, and repetitive placing, grasping, or moving of objects other than tools; approximately 62% of the workers reporting MSDs were males and 38% were females; industries with the largest numbers of MSDs were services, manufacturing, and retail trade, with 28.7%, 20.8%, and 17.4% respectively; approximately 52% of the MSD cases resulted from one of two sources – working with containers or worker motion or position; the most frequently reported WMSDs affect the hand and wrist. The most widely recognized WMSD, carpal tunnel syndrome, occurred at a rate of 2.6 per 10,000 full-time workers in private industry in 2002. This required the longest recuperation period of all conditions resulting in lost workdays, with a median of 30 days away from work; there is a 2.5% higher incidence of low back pain in nurses aides and licensed practical nurses than other female workers. There is a 2

Table 2.3

Number of Nonfatal Occupational Injuries and Illnesses with Days Away from Work Involving Musculoskeletal Disorders by Selected Worker and Case Characteristics, 2002

Characteristic	All Events	Musculoskeletal Disorders
Total:	1,436,194	487,915
Sex:		
Men	930,925	300,128
Women	500,592	186,966
Event or Exposure:		
Overexertion	381,048	368,027
Overexertion in lifting	208,260	202,814
Bending, climbing, crawling, reaching, twisting	69,218	66,214
Repetitive motion	58,576	53,673
Nature of injury, illness:		
Sprain, strains	617,186	369,785
Carpal tunnel syndrome	22,651	22,583
Musculoskeletal system and connective tissue diseases and disorders	20,689	16,740
Tendonitis	9,275	8,105
Soreness, Pain	116,956	56,887
Back pain	46,504	30,953
Part of body affected:		
Back	345,294	246,103
Hand (except finger)	55,894	4,091
Finger	121,562	4,487
Wrist	69,187	40,292
Number of days away from work:		
Cases involving 1 – 10 days	821,638	261,259
Cases involving 11 – 20 days	158,609	59,024
Cases involving 21 – 30 days	95,886	36,604
Cases involving 31 or more days	360,061	131,028
Median	7	9
Major industry division:		
Services	372,159	140,163
Manufacturing	280,005	101,437
Retail trade	263,401	85,059
Source of injury, illness:		
Containers	193,146	138,187
Worker motion or position	220,795	117,768
Parts and materials	147,553	57,458
Health care patient	69,994	56,146

Source: Bureau of Labor Statistics, U. S. Department of Labor, Survey of Occupational Injuries and Illnesses. (2004a). Retrieved July 28, 2004 from http://www.bls.gov/iif/oshwc/osh/case/ostb1266.pdf times higher incidence of low back disorder in construction workers, carpenters, and truck operators than other male workers.

Types of WMSDs and Workers Affected

Musculoskeletal disorders include a wide range of inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels. These include syndromes such as tendon inflammation and nerve compression disorders as well as myalgia and low back pain.

Tendonitis

Tendons connect muscles to bones. When muscles in the forearm are contracted, the tendons pull on the bones in the hand and create movement. The same movement mechanics apply to other areas of the body. All of the force from the muscles is transmitted through the tendons. If continually stressed, the tendons become irritated and sore, resulting in tendonitis, which is common in the wrist, elbow, and shoulder (Humantech, 2000). Symptoms of tendonitis are pain, swelling, stiffness, and weakness which can develop from performing repetitive tasks with elbows above mid-torso height, such as working in a fume hood. Other tendonitis diagnoses include tennis elbow and rotator cuff tendonitis.

Tenosynovitis

Tenosynovitis is a disorder of the tendon sheath. Tissue builds up on the tendon sheath wall, resulting in bumps on the sheath. Symptoms are pain and swelling; diagnoses include de Quervain's disease (occurs from forceful grasping and turning), trigger finger (occurs from repetitive use of tools that have handles with sharp, hard edges), and ganglion cyst (appears after wrist strain). Work that may contribute to tenosynovitis are screwing a sipper onto an animal water bottle, using pipetters, and adjusting microscopes.

Carpal Tunnel Syndrome

Carpal tunnel syndrome is a condition that occurs from pressure on the median nerve as it passes through the carpal tunnel in the wrist. It occurs typically from external stressors or from compression from swollen tendons and/or tendon sheaths. The median nerve and tendons for flexing the fingers pass through the carpal tunnel from the forearm to the hand. These tissues are bound by the carpal bones and the carpal ligament. If the tendon sheaths become irritated and begin to swell, the median nerve may be pinched (Humantech, 2000). Chronic swelling of the finger flexor tendons can lead to carpal tunnel syndrome. Symptoms may include pain in the first three fingers and the thumb, along with numbness and tingling. Carpal tunnel syndrome is caused by repetitive hand or finger actions such as in data entry.

Neurovascular Disorders

Neurovascular disorders affect nerves and the nearby blood vessels. The affected areas can have reduced circulation resulting in less oxygen and fewer nutrients to the muscle. For example, thoracic outlet syndrome occurs when there is compression of the nerves and blood vessels between the neck and shoulders, caused by frequent reaching above shoulder level and carrying heavy objects. Symptoms include the arms “falling asleep”, weakened pulse, and numbness in the fingers. Table 2.4 lists examples of common musculoskeletal disorders

Table 2.4

Characteristics of Musculoskeletal Disorders

Disease/ Disorder	Body Part Affected	Symptoms	Possible Causes	Workers Affected
de Quervain's Disease	Thumbs	Pain at the base of the thumbs	Twisting and gripping	Butchers, housekeepers, packers, seamstresses, cutters
Trigger Finger	Fingers	Difficulty moving finger; snapping and jerking movements	Repeatedly using the index fingers	Meatpackers, poultry workers, carpenters, electronic assemblers
Rotator Cuff Tendonitis	Shoulders	Pain, stiffness	Working with the hands above the head	Power press operators, welders, painters, assembly line workers
Tenosynovitis	Hands, wrists	Pain, swelling	Repetitive or forceful hand and wrist motion	Cake makers, poultry processers, meatpackers
Raynaud's Syndrome (white finger)	Fingers, hands	Numbness, tingling; ashen skin; loss of feeling and control	Exposure to vibration	Chain saw, pneumatic hammer, and gasoline-powered tool operators
Carpal Tunnel Syndrome	Fingers, wrists	Tingling, numbness, severe pain; loss of strength, sensation in the thumbs, index, or middle or half of the ring finger	Repetitive and forceful manual tasks without time to recover	Meat and poultry and garment workers, upholsters, assemblers, VDT operators, cashiers
Back Disability	Back	Low back pain, shooting pain or numbness in the upper legs	Whole body vibration	Truck and bus drivers, tractor and subway operators; warehouse workers; nurses aides; grocery cashiers; baggage handlers

Source: Rogers, B. (2003). Occupational and environmental health nursing: Concepts and practice. Philadelphia: Saunders, p. 163.

indicating body parts affected, symptoms, possible causes, and types of workers affected.

Patterns of Overexertion Injuries and Illnesses

According to the Bureau of Labor Statistics (2004b), sprains, strains, and tears accounted for 76% of the musculoskeletal disorders resulting in days away from work. WMSDs include cases where the nature of the injury or illness is sprains, strains, tears; back pain, hurt back; soreness, pain, except the back; carpal tunnel syndrome; hernia; or musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is bodily reaction/bending, climbing, crawling, reaching, twisting; overexertion; or repetition. Cases of Raynaud's phenomenon, tarsal tunnel syndrome, and herniated spinal discs were not included. Table 2.5 lists the number and percent of nonfatal occupational injuries and illnesses involving days away from work resulting from repetitive motion by selected worker and case characteristics.

Costs Associated with WMSD Injury

Estimates of the costs of work related MSDs vary. In 2001, the National Occupational Research Agenda (NORA) for Musculoskeletal Disorders estimated that costs associated with work related musculoskeletal disorders range from $13 to $54 billion annually (NORA, 2001). Regardless of the estimate used, this is an enormous problem that needs to be addressed in terms of health and economics.

Work related MSDs are a major component of the costs of work related illnesses in the United States. The average cost of a workers' compensation claim for low back disorder was $8,300, which was more than twice the average cost of

Table 2.5

Nonfatal Occupational Injuries and Illnesses Involving Days Away from Work Resulting from Repetitive Motion by Selected Worker and Case Characteristics, 2002

Characteristic	Musculoskeletal Disorders		Repetitive Motion		Repetitive Typing or Key Entry		Repetitive Use of Tools		Repetitive Placing, Grasping, or Moving Objects, Except Tools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	487,915	100.0	58,576	100.0	10,750	100.0	7,949	100.0	18,006	100.0
Sex:										
Men	300,128	61.6	22,526	38.5	1,277	11.9	4,691	59.0	7,278	40.4
Women	186,966	38.3	35,967	61.4	9,471	88.1	3,230	40.6	10,683	59.3
Nature of injury, illnesses:										
Sprains, strains	369,785	75.8	13,326	22.7	1,208	11.2	2,176	27.4	5,362	29.8
Carpal tunnel syndrome	22,583	4.6	22,478	38.4	5,670	52.7	3,046	38.3	5,670	31.5
Tendonitis	8,105	1.6	5,887	10.1	847	7.9	802	10.1	1,809	10.0
Back pain	30,953	6.3	823	1.4	-	-	174	2.2	273	1.5

Source: Bureau of Labor Statistics, U. S. Department of Labor, Survey of Occupational Injuries and Illnesses. (2004b). Retrieved May 20, 2004 from http://www.bls.gov/iif/oshwc/osh/case/ostb1258.pdf

NOTE: Because of rounding and data exclusion of nonclassifiable responses, data may not sum to the totals.

$4,075 for all compensable claims combined (NORA, 2001). Estimates of the total cost of low back pain to society in 1990 were between $50 billion and $100 billion per year, with about $11 billion of that paid by workers' compensation.

OSHA estimates that WMSDs now account for $1 out of every $3 spent on workers' compensation. It is estimated that employers spend as much as $20 billion a year on direct costs for MSD-related workers' compensation, and up to 5 times that much for indirect costs, such as those associated with hiring and training replacement workers (NORA, 2001). Direct costs are the costs of resources consumed because of an illness, such as the medical costs associated with an illness, including the labor of health professionals, and the equipment, buildings, and supplies used in the detection, treatment, and prevention of disease. Other direct costs include costs of an injured worker's time to seek medical care and recovery from an injury, the costs of transportation to and from medical care, the costs of extra household help during periods of illness, and the costs of retraining if an illness results in permanent disability. Indirect costs include losses of potential output, at work or home, associated with morbidity or premature mortality, and reductions in health-related quality of time (Baldwin, 2004). In addition to monetary costs, WMSDs impose a personal toll on affected workers who can no longer perform daily tasks easily.

Risk Factors Contributing to WMSDs

In 1713, Ramazzini recognized that workers were negatively affected by certain tasks. His writings revealed that:

> The maladies that affect the clerks arise from three causes: first, constant sitting, secondly, the incessant movement of the hand and always in the same direction, thirdly, the strain on the mind from the effort not to disfigure the books by errors or cause loss to their employers when they add, subtract, or do other sums in arithmetics (Ramazzini, 1964, p. 421).

These observations have been expanded and are now referred to as ergonomic factors, which may lead to work related musculoskeletal disorders. These ergonomic factors include awkward and static postures, forceful exertions, repetitive motions, duration, localized contact stressors, vibration, temperature extremes, insufficient pauses and breaks, machine paced work, unfamiliar work, and psychological stresses (NIOSH, 1997).

Awkward and Static Postures

The human body acts as a lever system and force is absorbed in certain postures more easily than in others, making employees more susceptible to injury. As one approaches the extremes of a joint's range of motion, the less capable the joint is when the forces are extreme, and immediate injury can occur. If the force is below the threshold of immediate damage, a wear and tear injury can occur, depending on the number of times per day the person is exposed to the force. If the postures are extreme, the combination of force and frequency can cause damage more quickly than if postures were more neutral (Humantech, 2000).

Posture affects the employee's ability to reach, hold, and use equipment. Awkward and static postures can occur by raising the arms over the head, extending the arms out in front unsupported, leaning or bending, especially if carrying or lifting a load, and standing or sitting for extended periods of time. If one bends over half way to the floor and holds that position, a static force load is created. Therefore, sustained postures as well as high frequency movements can contribute to body fatigue. Allowing workers to sit while working reduces fatigue and discomfort to the legs and feet and provides more stability in the upper body.

To reduce awkward postures, hands should not work above mid-chest height; shoulders should not be elevated; shoulder abduction should not be more than 30°; shoulder flexion should be minimized; overhead reaches should be minimized; elbow/forearm pronation and supination should be minimized; and wrists should not deviate more than 20° so that wrist flexion/extension are minimized (DiNardi, 1997).

Forceful Exertions

When the whole body is used in strenuous lifting, pushing, or pulling, injuries can occur particularly in the back. Even lighter loads can require force. NIOSH developed guidelines for evaluating jobs that require manual lifting. The guidelines consider factors such as lift frequency, work duration, workplace geometry, and posture to establish the amount of weight that a person can safely lift (Levy & Wegman, 2000). This lifting equation is designed to assess certain lifting and lowering tasks (e.g., standing, two-handed, smooth lifting of stable objects in unrestricted spaces). The six factors of this equation include:

1. Horizontal location of the load relative to the body,
2. Vertical location of the load relative to the floor,

3. Vertical distance the load is moved,
4. Frequency and duration of the lifting activity,
5. Asymmetry (lifts requiring twisting or rotation of the trunk or body), and
6. Quality of the worker's grip on the load.

These guidelines represent a load that nearly all (i.e., 90% of the adult population) can lift for up to 8 hours without substantially increasing the risk of musculoskeletal disorders to the lower back.

Force can be minimized by:

- Reducing the weight and bulk of tools or parts,
- Reducing reach by reducing obstructions allowing load to be held closer to the body,
- Controlling the balance of the objects being lifted,
- Using gravity or mechanical aids to assist or eliminate exertion (this includes use of power tools, suspension devices to support weights, and lift tables),
- Reducing speed and number of manipulations,
- Having the ability to get a good grip on the object (by use of appropriate gloves or a wider handle allowing the whole hand to grip the object),
- Minimizing vibrations of the work, and

- Using the whole hand to grip an object instead of the index finger and thumb used as a pinch grip which requires 5 times more force than a power grip (DiNardi, 1997).

Repetitive Motions

Repeated force that is not strong enough to cause immediate damage can, over time, induce fatigue in the tissues. The fatigue can wear out tissues in the skin, muscles, tendons, ligaments, nerves, and blood tissues. If there is sufficient rest time between each exertion, the tendons and muscles can frequently recover. However, when the same motions are repeated without rest, fatigue will occur. When force and duration factors are also involved, there is an even greater chance for injury.

NIOSH indicated that a task cycle time of less than 30 seconds is considered "repetitive". When the activity involves the use of force or awkward posture or there is not enough recovery time for the fatigue or strain to minimize, there is an increased risk of musculoskeletal strain. Additionally, high repetitiveness when combined with high external forces and extreme postures probably represents the highest risk of WMSDs (NIOSH, 1997). Repetitiveness can result from factors such as the line speed of an assembly line, or numbers of products to be assembled or processed. These can be minimized by job rotation (therefore using different muscle groups to minimize high repetition jobs), slowing the assembly line speed, mechanical aids (such as robots or lifts), and hiring additional people. Repetitive motion injuries affect the soft tissues of the fingers, hand, wrist, elbows, shoulders, neck, and upper back in a wide variety of occupations. The highest rates of these disorders occur in the industries with a substantial amount of repetitive, forceful work.

Duration

Duration refers to the amount of time an employee holds a posture or repeats a task over an extended period of time. If the same muscles or motions are used continuously, the muscles become fatigued due to a lack of circulation. The lack of blood flow decreases the nutrients getting to these muscles which can lead to an injury (Humantech, 2000). The more extended the duration of the work task, the longer the time required for recovery.

Localized Contact Stressors

When there is continued pressure between body tissues and an object, local mechanical stresses can result. Hand tools with sharp or small diameter handles can irritate nerves and tendons in the palm or fingers, affecting the circulation (Levy & Wegman, 2000). When the diameter of the grip is increased or padded, the pressure is minimized. Enlarging the contact area will reduce pressure. When one rests the forearms on the edge of an object, the contact stress can be reduced by padding the edge or providing a wrist support. Sitting for extended periods can decrease circulation to the legs if chairs are not adjusted to the worker. This can be reduced by the use of adjustable seats or with the use of footrests.

Vibration

Vibration can occur to the whole body (with tasks such as driving trucks or fork lifts, or standing on a vibrating floor as is found in a stamping factory) or to specific parts of the body (such as when using a hand powered tool such as a palm sander, grinder, or jack hammer). Localized vibration causes over-gripping of a tool and leads to higher forearm muscle activation and higher muscle loads that can cause development of hand-arm vibration syndromes such as vibration white finger (Raynaud's Syndrome) (Levy & Wegman, 2000). Vibration can be reduced by changing the process or by the use of alternative tools or devices designed to minimize vibration.

Temperature Extremes

When handling hot or cold parts, gloves may be required and these might increase the force requirements necessary for the job. When the hands become cold, manual dexterity can be affected, causing numbness, decreased blood flow, and tactile sensitivity. The employee may unconsciously grip more tightly than necessary, causing strain and possible injury to the tendons. Providing appropriate gloves and insulating tool handles can reduce injury. Increased temperatures can cause sweating, which increases the slipperiness of hand tools. Additionally, high temperatures can decrease a worker's capacity for doing heavy physical work. NIOSH has recommended exposure limits for work under hot environmental conditions (NIOSH, 1997).

Insufficient Pauses and Breaks

When a muscle contracts, its blood vessels are compressed by the adjacent contractile tissue. Vascular resistance increases with the level of muscle tension and the blood supply to the working muscle decreases. If the muscle cannot relax periodically, the demand for metabolic nutrients exceeds the supply and the metabolic wastes accumulate. The short-term effects of this condition include ischemic pain, tremor, or a reduced capacity to produce tension. Any of these effects can severely affect work performance. Work activities should be designed so that static exertions are of limited duration and adequate recovery time is built into the job (Levy & Wegman, 2000). An effective administrative control is providing additional rest allowances to prevent excessive fatigue.

Machine Paced Work

When work is machine paced, such as when the cages come out of the cage washer, the work must be balanced between workers and the line speed must be adjustable so workers aren't always playing "catch up". There must be adequate recovery time between each task. Self-pacing with adequate recovery is preferred to machine pacing. When conveyor belts or moving equipment is used, there are additional safety concerns of being physically caught up in the equipment or having loads fall.

Unfamiliar Work

When an employee is unfamiliar with the task or procedure, adequate training has not been performed. The employee must have the skills and knowledge of the job, perception to understand the parameters and responsibilities of the job, and know who can answer any questions. The employee must know the proper use of the equipment to perform the job, the correct use and fit of PPE, and how to recognize and report early symptoms of WMSDs. Without this information, employees are at greater risk for physical and mental stressors and may put coworkers in the immediate area at greater risk. The employer has a responsibility to provide training, inform staff of the health and safety rules, the standard operating procedures, and how to recognize and report early symptoms of WMSDs.

Psychological Stresses

When employees cannot concentrate on the task to be done, there is a greater potential for injury. Employees cannot always leave personal problems at home and may be distracted in their duties, thus causing injury. Financial and marital difficulties are two main sources of stress, as are those of the sandwich generation who are caring for elderly relatives as well as their own children. Many large organizations use an Employee Assistance Program to provide counseling to employees and their families. Occupational and environmental health nurses frequently provide first point of contact and/or stress and relaxation programs. Stress may increase when employees have high accountability and little or no tolerance for error in the job, if they have little control over the work process, when there are extended work hours or shift work, or when the tasks are repetitive or monotonous. Other health and safety issues such as noise, lighting, glare, and size of workspace can increase psychological stressors.

Impact of WMSDs in a Small Animal Housing Facility

Kerst (2003) reported that 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. According to Liberty Mutual, when sprains and strains are considered with repetitive motion injury data, the U. S. direct costs exceed 12 billion dollars per year and affect nearly one million people annually; workplace injuries can actually cost three to five times the direct medical costs when all work related factors are considered (Liberty Mutual, 2001).

A biomedical research laboratory has continuous changes in scientific needs and research methods, increased population of animals, new housing requirements, and updated husbandry and animal care systems (Kerst, 2003). A lack of qualified personnel contributes to additional burdens.

Vivarium Exposure Data

Ergonomics has moved to the forefront of public awareness during the last decade. While the majority of ergonomic studies addressed the office setting, other settings such as the laboratory, where workers experience repetitive motion injuries, also have room for improvement. There are no data specifically addressing injuries and illnesses, including WMSDs, for animal handlers.

Although the National Institutes of Health and OSHA recognized laboratory work as an occupation with risk for musculoskeletal disorders and repetitive stress injuries, ergonomics in the biomedical research laboratories has not received the level of attention that non-laboratory settings have received (Jones & Eagleson, 2003).

Types of WMSDs and Workers Affected in a Small Animal Housing Facility

The primary causes of work related musculoskeletal disorders affecting animal handlers are related to amount of manual materials handled daily. When employees lift and carry cages, transfer animals, or provide bedding and food, they frequently twist and bend. These staff also move cages and racks with water bottles, with an average cumulative force of 6,000 kg. 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 combination is strongly associated with an increased risk of muscular sprain/strain injury (Kerst, 2003).

Working above the shoulder can cause physical stresses. When the posture is not in a neutral position and the force and frequency are increased, especially if twisting or bending is involved, the joints are additionally stressed. High-risk small animal handling activities and the specific areas of the body at risk for injury are listed in Table 2.6.

Overexertion Injuries and Illnesses in a Small Animal Housing Facility

OSHA does not specifically track animal care providers as part of their yearly statistical data. Based on results from quantitative risks assessments, including Snook & Cirello (as cited in Kerst, 2003), several animal handling tasks have been categorized as high risk for developing MSDs. High risk job tasks in which at least one body area was affected include: rodent cannulation, tail bleeding, dosing (subcutaneous and by gavage), and necropsy; handling animals with forceps; cage cleaning, material storage and setup; changing rabbit pans; cart handling; handling bags of feed and bedding; high-density rodent cage changing; water bottle handling; and autoclave access (Kerst, 2003).

Table 2.6

High Risk Small Animal Handling Activities Resulting in Musculoskeletal Disorders by Body Area

	Musculoskeletal Disorders by Body Area					
High-Risk Task	**Hand/wrists**	**Elbow**	**Shoulders**	**Neck**	**Back**	**Legs**
Transfer rodents with forceps	X	X	X	X	X	
Handle containers, wire cages, cage lids	X	X	X		X	
Prepare, transfer, replenish water bottles	X	X	X		X	X
Dose rodents	X		X			
Access high-density cages at unsuitable working heights	X	X	X	X	X	X
Lift feed bags	X	X	X		X	X
Adopt awkward positions during animal surgery					X	
Transport disassembled cages to conveyor style tunnel washers	X	X	X	X	X	
Push, pull, rotate full carts			X		X	

Source: Kerst, J. (2003). An ergonomics process for the care and use of research animals. ILAR, 44(1), p. 10.

Populations at Risk in a Laboratory Animal Environment

Animal Care Workers

Animal care workers provide the daily care required by small laboratory animals. Consequently, the Vivarium staff must be trained to provide this care and learn how to protect themselves from exposures. Many attend training programs such as accredited programs in veterinary technology which range from 2 year programs (Associate of Science degree) to 4 year programs (Bachelor of Science degree). Non-degree training with certification on programs for laboratory animal technicians and technologists can be obtained from the American Association for Laboratory Animal Science (AALAS). There is a 3-tiered technician certification program to recognize an individual's level of knowledge of laboratory animal science. The Assistant Laboratory Animal Technician (ALAT) certification stresses knowledge on animal husbandry, health and welfare. The Laboratory Animal Technician (LAT) certification is the next level and stresses knowledge on facility administration and management, as well as general knowledge in the highest level of certification, Laboratory Animal Technologist (LATG). A combination of education and experience is required at each level, although a high school diploma or General Education Development (GED) equivalency, required for the LAT and LATG certification, is not listed as a requirement for the ALAT exam (AALAS, 2004). To remain on an AALAS certification registry, a certain number of continuing education units are required every 2 years. Training programs, frequently on-line, are commercially available for self-study. Employers frequently support and encourage attendance at local AALAS meetings and seminars.

Job titles may include various levels of technicians, technical coordinator, operations coordinator, and manager. Technicians are responsible for:

- Washing cages,
- Processing cages and equipment,
- Cleaning and making minor repairs of cage washing machines,
- Cleaning, sanitizing, stocking, and documenting ancillary rooms such as storeroom, feed room, and gowning room,
- Participating in animal husbandry to include feeding, watering, changing cages, handling and restraint procedures, and monitoring the health of various species,
- Providing technical support to research investigators performing duties such as blood and tissue collections, anesthesia induction, euthanasia, treatments, surgical assistance, injections, and immunizations,
- Performing daily health treatments,
- Providing routine care of animals including brushing, weighing, and nail clipping of rabbits, and
- Maintaining an animal database to include data entry and cage cards.

The technical coordinator schedules and ensures implementation of procedural requests from researchers; performs laboratory procedures; and provides post-operative animal monitoring and care. Supervisors and managers are responsible for all supervisory requirements such as scheduling, conducting staff reviews, training, checking inventory, recordkeeping, maintaining animal breeding colonies, and supporting other staff in laboratory procedures.

Job tasks for animal care workers begin with the daily care of the animals. Mouse, rat, and hamster cages must be changed regularly. This requires having a clean cage ready, taking the "in use" cage to a biological safety cabinet (because of the concern of rodent urine exposure which can lead to laboratory animal allergies), lifting the animals into the clean cage by using forceps and grabbing the animals by the scruff of the neck, and sliding the clean cage back into the rack. The dirty cages are removed to the dirty side of cage washing where they are emptied into biohazard trash. The emptied cages are placed in an inverted position on a conveyor belt that takes them into a cage washing system that washes, sanitizes, and dries the cage. The cages emerge on the clean side of cage washing where they are automatically filled with animal bedding and stacked for future use. Changing cages may require the replacement of water bottles if ventilated racks with automatic water systems are not in use. Food is added daily and an enrichment activity for the animal is provided. Rodents are given a compacted cotton pad that they can pull apart to make bedding.

Rabbit cages have liner pans beneath them to catch excrement. These liners must be removed regularly and replaced with clean pans. After the dirty pans are emptied into biohazard trash, they are placed onto racks that go through a tunnel washer. The rabbit cages and mouse racks that support the mouse cages are periodically washed and sanitized in the tunnel washer.

Animal care workers are involved with animal procedures that include drawing blood, injecting chemicals into the animals, milking mice, performing surgical procedures or necropsy, providing anesthesia, confirming death, and disposing of carcasses. These procedures may require manipulation and transportation of non-anesthetized animals or restrained animals and may be performed on a bench top, in a biosafety cabinet, or in a surgical suite. Staff operate autoclaves for the sterilization of surgical equipment as well as all bedding, food, and cages for mice (but not for rats), and all food for rabbits. Animal caretakers are also responsible for cleaning the animal rooms, maintaining health and husbandry records of all animals, performing recordkeeping and documentation, and ordering and stocking supplies as needed.

Most animal care workers who are not college educated are entry-level employees who are encouraged to move up on the AALAS technician certification ladder. They vary in age and are evenly distributed between men and women. The Bureau of Labor Statistics (2003) data indicate that there are 62,740 laboratory animal caretakers in the United States with 1,840 employed in scientific research and development services. The mean annual wage for this occupation is $18,870, and the median wage is $17,790.

Service Workers

Service workers are all other non-scientific staff that enter the animal housing facility. They may include the engineers and maintenance responsible for laboratory ventilation, plumbing, electricity, lighting, and any repairs that must be made on the facility; telecommunications staff who address phone and computer line issues; safety staff who perform laboratory inspections, job task analyses, and industrial hygiene monitoring; health staff who monitor the health and safety of Vivarium staff, address noise and respiratory issues, and monitor controlled substances logs; fire and rescue personnel who have emergency access to the facility; repairmen responsible for the maintenance and upkeep of biosafety cabinets, chemical fume hoods, and autoclaves; and inspectors who monitor the activities of x-ray equipment, gamma irradiators, or perform unannounced inspections.

All service workers who may enter the animal facility are required to read and sign a training document indicating awareness of potential exposures to chemical, physical, and biomechanical factors, required personal protective equipment (PPE), and emergency and evacuation procedures. Outside contractors or other untrained visitors must be escorted at all times in the secure facility by a Vivarium employee.

Veterinary Staff

Veterinarians, who may not be on site full time, oversee all policies, procedures, and animal care, and are members of the Institutional Animal Care and Use Committee (IACUC). Major responsibilities of laboratory veterinarians include:

- Providing clinical care and preventative health services for animals,
- Supervising programs for disease prevention and parasite control,
- Performing standard surgical procedures as needed,

- Overseeing and providing guidance to investigators and Vivarium staff in technical procedures, animal surgery, and post operative care,
- Monitoring the use of anesthetics, analgesics, tranquilizing drugs, and euthanasia to ensure humane treatment of research animals,
- Providing advice and input in developing standard operating procedures related to clinical care of animals or minimization of pain and distress,
- Consulting and coordinating with investigators research projects involving animals,
- Providing training to assure proficiency in performance of standard operating procedures (SOPs), and
- Providing guidance for compliance with federal, state, and institutional guidelines.

Veterinarians must be registered by the state to practice veterinary science. This requires a Doctor of Veterinary Medicine degree from an accredited college or university.

Biological Scientific Staff

Others who enter or work within the animal facility are biological scientific staff. These staff have a minimum of a bachelor's degree, usually in a biologic science. Many use the job experience as a stepping stone for continuing their graduate education in medical school, veterinary sciences, or scientific research. They report to investigators who design the research project, which must be approved by the Institutional Animal Care and Use Committee before implementation.

The duties of the scientific staff vary according to the research project. They include: performing surgical procedures; developing genetically altered mouse strains that may ultimately become a model for a human condition; injecting mice and rabbits to develop monoclonal and polyclonal antibodies for further study; and doing necropsy. Because the staff frequently leave and move on to graduate school, the employees (other than the principal investigators) tend to be young, often just out of college, and change jobs frequently.

Ergonomic Regulations Governing Laboratory Animal Facility

There are no specific federal regulations that address ergonomics in a laboratory animal facility. However, as in other workplaces, the OSHA General Duty Clause indicates, "that the general duty of all employers is to provide their employees with a workplace free from recognized serious hazards. This includes the prevention and control of ergonomic hazards" (OSHA, 1991). The Safety and Health Program Management Guidelines (OSHA, 1989) are recommended to employers as a foundation for the company health and safety program and a framework for the ergonomics programs. Additionally, OSHA has published guidelines specific for meatpacking, nursing homes, the poultry industry, and retail grocery stores because of the higher incidences of WMSDs in these fields. Although ergonomics regulations have been proposed, they have not survived the regulatory approval process.

There are federal laws from the United States Department of Agriculture that govern the use of animals in biomedical research and these are more extensive than those covering human research subjects. The Animal Welfare Act sets high standards of care for research animals with regard to the feeding, cleanliness, ventilation, and medical needs, while requiring the use of anesthetics or analgesics for potentially painful procedures. Federal laws also require that all animal protocols be reviewed by an Institutional Care and Use Committee to justify the use, species, and numbers of animals to be used and to ensure that all animals are treated responsibly and humanely (Office of Laboratory Animal Welfare, 2002). The U. S. Public Health Service Act requires that all institutions that receive research funds from the National Institutes of Health, the Food and Drug Administration or the Centers for Disease Control and Prevention adhere to the standards set out in the Guide for the Care and Use of Laboratory Animals. The National Research Council has published Occupational Health and Safety in the Care and Use of Research Animals (National Research Council, 1997) in which three paragraphs address ergonomic hazards in a laboratory animal setting. General information is provided about physical trauma, which can occur from repetitive motions or heavy lifting, and indicate that cumulative injuries are not associated with a specific exposure incident.

Although there are many federal regulations addressing the care and use of small animals in laboratory research, there is very little addressing the ergonomic health and safety of staff working with animals.

People for the Ethical Treatment of Animals (PETA) is an animal watch-dog group dedicated to protecting the rights of all animals. They believe that animals should not be used for research purposes and that current regulatory processes are weak and poorly enforced. Because of their (sometimes radical) interventions, public perception is affected. Most research laboratories have a communications department to deal with public inquiries; limited access and security measures are also part of a Vivarium design.

CHAPTER 3

WMSD RISK FACTORS IN A LABORATORY ANIMAL FACILITY

Vivarium workers are susceptible to musculoskeletal disorders from exposure to various risk factors. Physical trauma can occur when workers perform repetitive tasks or lift heavy items over and over. Risk factors that need to be evaluated in an animal care facility include awkward postures, forceful exertions, repetition, localized contact stresses, vibration, noise and temperature extremes, and psychological stresses.

Awkward/Static Posture, Duration

Replacing Mouse Cages

Different animal species are caged separately; genetically altered mice are kept in isolation rooms. All mice are housed in cages resembling clear plastic shoe bins with 5 mice per cage. Static (non-air supplied and not automated) cages contain bedding, food, water bottles, and stimulation with ventilation coming from room air. Ventilated cages provide high efficiency particular air (HEPA) which is purified and filtered. These cages may have automatic watering systems so that changing water bottles is not required. There may be as many as 168 cages on each mouse rack and up to 4 mouse racks per room. It is not unusual to see 3,000 to 5,000 mice in a laboratory setting. Static cages are changed 2 times per week and ventilated cages once every 2 weeks. Rats, gerbils, and hamsters are housed individually or in pairs, depending on weight.

To replace the cages, the dirty cage is pulled out (like a drawer), the mice lifted into a prepared clean cage in a biosafety cabinet (BSC), and the clean cage "slid" back into the rack. This same process may be repeated 672 times per room. The motions include pulling the cage, turning to the BSC, removing the cage lid, using a pinch grip with forceps to lift each rodent by the scruff of the neck and dropping them with wrist abduction into the clean cage, replacing the lid, turning, and pushing the cage back into the rack. Due to the varying levels of the cage rack, there is additional bending and stooping to reach the lower cages. Additional awkward postures include reaching above the shoulders to remove and replace the upper cages, and pushing the racks around to access the cages on the back side of them. Once the cages are emptied and stacked onto one another, they are taken by cart to the dirty side of cage washing.

Emptying Rabbit Litter Pans

Rabbits are housed individually in large cages with litter pans beneath so dander, urine, and feces will drop below the cages. These litter pans are changed twice per week. There can be several racks, containing three cages each on two levels, per rabbit room. The process of changing a litter pan requires pulling the pan out, stacking it onto a cart for transport to the dirty side of cage washing, lifting up a clean pan with a paper liner, and sliding the pan back into the rack. This process, repeated at different levels, also includes stooping and bending for the lower cages, and working above shoulder level for the upper cages.

Performing Dissection/Surgery

Separate surgical suites are available for performing both survival and non-survival surgical procedures. These rooms must be well lit. Surgery for small animals may require magnification for the surgeon or a microscope.

Procedures require the surgeon to bend forward frequently with the neck down, generally while in a seated position. Tools for small animals are very fine and require swift movement and pinch grips. Dissection can be done at a bench top, in a biological safety cabinet, or in an animal treatment room. These tasks require the same movements and forces as surgery.

Performing Procedures Using a Biosafety Cabinet

Some procedures are performed in a biological safety cabinet. Staff might be seated at the cabinet, if there is adequate leg room, or standing. They frequently perform work with arms stretched forward and unsupported. Animals may or may not be anesthetized or physically restrained. For instance, dosing a mouse may involve holding the mouse in one hand, while injecting with the other. Rabbits are restrained for non-painful procedures such as drawing blood. Painful procedures for any animal require anesthesia. Since procedures require multiple tasks such as injections to many animals, staff may spend several hours at a time at the hood. They may also make additional movements such as twisting to one side to discard trash, dropping sharps into a sharps container, or reaching for other items.

Documenting Information

Each cage of rodents has a computer generated cage card that indicates the species, date of birth, the principle investigator, and the animal protocol number. Staff may add dates of procedures, weights, or other pertinent information which requires them to write in small letters to fit onto the cage card. This requires pronation (an awkward posture), force, and a pinch grip. When this procedure is performed multiple times, repetition and duration are added risk factors.

Data entry is performed at the nearest computer often located on workbenches and operated while standing. In this case, there is no arm support, and there might be contact stressors if the arms press against the workbench edge. Other data entry may be done at shared computers making it difficult to adjust the chair and computer setup each time a person uses it.

Forceful Exertions

Unloading Pallets of Bedding and Food

There is usually limited space in a Vivarium so bedding and food is ordered weekly or bi-weekly. Additionally, these items can attract unwanted feral mice or pests. Food and bedding are delivered in 50 pound bags each on a pallet. They are moved from a pallet on the loading dock to a hand cart, pushed to the storage area, and unloaded. Forces involved in these procedures include lifting heavy bedding, stooping and bending, pushing the cart, and repetition.

Pushing Cage Racks

Cage racks are frequently moved. Since rodent cages are on both sides of the racks, the racks may have to be moved to access cages, to clean the floor, or periodically pushed down corridors to be put into the automatic tunnel washer. This requires pushing, maneuvering around items that might be stored in the hallways, and walking on floors that might be wet and slippery due to the warm and humid environment. Animal cages are removed from racks prior to being pushed down corridors to the tunnel washer.

Operating Cage and Rack Washers

Staff working on the dirty side of cage washing have a variety of health, safety, and ergonomic concerns that must be addressed. In cage washing, staff unstack each dirty mouse cage (radial deviation, grip force, and arm extension), and empty by turning the cage upside down (ulnar deviation and pinch grip). The cages are placed onto a moving conveyor belt which takes them into the cage washer. A separate tunnel washer, which is the size of a large walk-in refrigerator, is used to automatically wash racks. It has a large door that must be swung open to push in the racks, then closed; buttons are then pushed to start the wash cycle. This area is warm from the heated water and the floors are slippery and wet. Because employees need to wear steel-toed shoes, dust/mist respirators, gloves and protective clothing for safety purposes, they are at risk for hyperthermia.

Providing Rabbit Care

Rabbits are lifted out of their cages when undergoing procedures or when cages need to be cleaned. Since the rabbits weigh between 10 and 15 pounds, there is force and grip involved in lifting these animals. Rabbits are generally housed one per cage, six cages per rack, and two racks per room with the cages facing each other. Animal caretakers need to file the teeth and clip the toenails of the rabbits regularly. It is best to hold these animals close to the body when transporting them by hand, or putting them into a covered cage transported on a handcart.

Repetition

Putting Bedding, Food, and Water Bottles into Cages

Fifty pound bags of rodent bedding are lifted and dumped into a container on the clean side of cage washing where it is automatically dispensed into clean rodent cages as they exit the cage washer. Cages are then stacked either for autoclaving or for use. These processes may be machine paced and include repetition and force. Food, cages, and bedding for rats are not autoclaved.

Each mouse cage has a wire mesh hanging down from the top containing pellets of appropriate food. The animals can then eat their food on demand. The bags of rodent food are emptied into a bin in each rodent room. When cages are changed, fresh food is scooped from the bin (requiring bending and wrist supination in a repetitive motion), and a similar motion to drop it into the food holder. Rabbits have a food container attached to the outside of the cage which opens to the inside for them to feed. The food is dumped into a bin in the rabbit room and the motions for filling the food holders are similar to those on the mouse cages.

Rabbit and static mouse cages need to have water bottles changed and affixed regularly. The old bottles are removed and replaced with clean bottles that have been washed, sterilized, and filled, requiring repetitive movements. The ventilated rodent cages have an automatic watering system so this procedure is not required.

Performing Frequent Common Procedures

Repetitive movements are also performed during frequent procedures such as phlebotomy, ear tagging, and weighing. Mice have blood drawn from the retro-orbital sinuses. Using a twisting movement of the hand, the worker makes a tiny cut using a hematocrit tube and draws the blood into a micropipette. For other animals, blood is drawn from a tail vein (rats) and from ear arteries (rabbits). Workers perform these procedures on multiple animals, one after the other. While animals are frequently restrained though not anesthetized for these procedures, sudden movements cause additional stress and health and safety concerns to the employee performing these tasks.

Emptying Mouse Cage Litter

Workers empty the mouse cage litter into biohazardous waste containers on the dirty side of cage washing. Each cage, weighing about 4 pounds, has to be removed from the stack, dumped into the bedding station, and then placed upside down on the cage washer. This process is repeated over and over as several hundred cages are washed daily. Workers may also twist their body while bending and reaching for the cages.

Localized Contact Stresses

Autoclaves are at fixed heights although they are available at different heights. They are used to sterilize food, bedding, cages, water bottles, and equipment for surgical procedures. Most animal facility autoclaves have a rack that is pulled out onto which unsterilized items are placed. Many of these racks have a bar on each side to prevent items from falling. These sidebars may require workers to stand on a step stool or reach down over a side into the rack to remove the items. Heat from the metal sides can cause burns; items can still be warm if there is inappropriate cooling time, and areas around an autoclave are usually quite warm. To operate the autoclave, workers open the door by turning a large diameter (about 20 inches) wheel, remove the rack, load the items, push the rack back into place, close the door using the wheel, and then use fine movements to program the autoclave. Other tasks that involve repeated or continuous contact with hard or sharp objects include working in a biosafety cabinet (the arm may rest on the outside of cabinet) and the use of narrow surgical tools.

Physical Hazards

Vivarium workers are exposed to vibration, noise, and temperature extremes. Vibration in a small animal facility can come from a variety of machines, specifically the cage and tunnel washers. The washers can cause whole body vibration to the nearby workers, specifically those in both dirty and clean sides of cage washing.

Noise is an issue in the areas of the cage washer and tunnel washer although they are designed to keep the noise levels below 85 dB. Noise also comes from staff yelling to make themselves heard down the hall over the sounds of the machinery and any pumps or equipment that might be in use. Most small animals in a laboratory do not make a lot of high-pitched sounds so that is not an issue.

Temperature issues are a major concern in a Vivarium. Heat sources include the tunnel and cage washers, any heat producing equipment used in small treatment rooms, and autoclaves. Additionally, staff might be wearing various PPE such as dust/mist respirators, Tyvek jumpsuits, gloves (latex, nitrile, work gloves, or heavy gloves for removing items from the autoclave), hearing protection, and safety glasses. These PPE may increase the heat load and reduce the time a person can stay in warm, humid conditions. There is generally not a concern for cold temperatures unless food and bedding are stored in walk in refrigerators.

Psychologic Stresses

Working in Isolation

Employees periodically work together, but most of their chores are done alone while isolated in an animal room. They talk to, pet, and can get a social response from the rabbits, but not with the mice or rats. Some employees wear a headset and listen to music. Others play soft music in the animal rooms which provides stimulation and animal enrichment.

Varying Work Schedule

Animal care must be provided every day, including holidays and weekends, which requires a rotation of workers as everyone has to periodically work on weekends. When the building is closed due to adverse weather, employees have to find transportation to work, frequently relying on mass transportation, which might be impacted by the weather. There may be incentive pay for weekend and holiday work at time and a half. Since most of the animal care workers are low paid, extra money is usually appreciated.

Continuing Employee Turnover

Employee turnover affects everyone in an animal facility. The work must be performed and staff have to adjust their work schedules to accommodate those who call in sick, are on vacation, or who leave their job. Many temporary agencies are used to provide staff until a vacant position is filled. Meanwhile there are additional workloads for all staff members. When new employees are hired, existing staff assist in orienting them to the job.

CHAPTER 4

PREVENTION AND CONTROL PROGRAM FOR ERGONOMIC STRATEGIES

The key to addressing musculoskeletal injuries is to develop a comprehensive prevention and control program for ergonomic strategies. An effective program should address ergonomics from proactive (before injury) and reactive (after injury) perspectives. An effective prevention and control program includes management commitment through a written program, employee involvement, and regular program review and evaluation. The program must include a worksite analysis, hazard prevention and control, medical management, and training and education.

Management Commitment

Ergonomic issues need to be addressed in the same way as other health and safety issues in the workplace. In order to be successful, management commitment for an ergonomics program is essential for providing resources and direction. There must also be employee input so that potential hazards are identified and effective and accepted interventions can be implemented.

The Ergonomics Program Management Guidelines for Meatpacking Plants identify management commitment as providing a visible involvement of top management "so that all employees from management to line workers fully understand that management has a serious commitment to the program" (OSHA, 1991, p. 2). A team approach with management acting as the team leader is essential.

With management's involvement there is emphasis on the health and safety of employees. Management support across the board lets staff know what is expected of them. If each level of mid and lower level management knows that they are accountable for the health and safety of their staff, there is more incentive to be proactive in their involvement and support of ergonomic issues. Because of management involvement, budget issues are addressed and the best solutions possible are recommended.

Written Program

A key component of any health and safety program is a written policy with upper management signatures and visible support that includes communication, presence and participation in meetings, encouragement, and monetary support. The written policy addresses the scope of the problem, identifies goals and objectives, states what is expected of all staff who will be working together to develop effective interventions, and outlines how management will assist in providing support to attain the goals.

Employee Involvement

Employee involvement is essential in addressing ergonomic issues. Employees need to know that their input is valued and that their issues are considered. They must be encouraged to report symptoms of WMSDs early so appropriate treatment can be provided and further injury prevented.

Occupational and environmental health nurses and safety committees can track areas of concern and work with the ergonomics team to perform risk assessment and task analyses before making recommendations to ameliorate the situation. Members of the ergonomics team can include safety and hygiene personnel, health care providers, human resources personnel, engineering personnel, maintenance personnel, and ergonomics specialists, as well as representatives of the workforce and management (NIOSH, 1997). The ergonomics team has or works together to develop skills necessary to conduct job risk analyses and then recommends ergonomic solutions.

Program Review and Evaluation

Measures of success of an ergonomics program are decreased incidence and severity of WMSDs, and increased productivity. As employees are trained, the WMSD rates may increase initially, but as the severity decreases, the incidence rates will eventually decrease. It may take several years to see cumulative effects of an effective program. Thus, it is important to sustain the quality of the program, document successes and failures, and make changes to improve the ergonomics program.

Periodic evaluation of the program will determine if goals are being achieved, how the budget is impacted, whether the programs in place are cost effective, if injuries are reduced, and if injury claim costs are reduced. Symptom or satisfaction surveys can be periodically disseminated and collected for evaluation. These evaluation procedures can identify what areas need further study.

It is important to evaluate the results of any interventions to determine their effectiveness. OSHA recommends that the program be reviewed semiannually by top management to determine success in meeting objectives. This can include:

- Analysis of trends in injury/illness rates,
- Employee surveys,
- Before and after surveys of worksite changes,
- Review of results of evaluations, and
- Up-to-date records of job improvements tried or implemented (OSHA, 1991, p. 3).

Management should prepare a written review of the program and communicate the findings to all employees. Any deficiencies should be corrected and goals and objectives updated.

Worksite Analysis

A worksite analysis needs to be performed for newly identified tasks, new work processes, and/or modifications of old processes. The job needs to fit the worker because 'one size doesn't fit all'! The ergonomics team can review non-confidential aggregated health statistics, surveys and questionnaires, OSHA logs, and injury reports to determine what other areas need to be addressed.

Job Task Analysis

It is critical to understand how the job processes can impact the development of WMSDs. The in-house expert (whether the trained occupational and environmental health nurse or consultant) can screen jobs for musculoskeletal risk factors. The process starts with a current job description. The expert observes the employee performing the task and provides input about different ways the same task might be performed. Each risk factor is identified and evaluated.

Individuals performing the job task analysis look at "the (1) tools, equipment, and materials used to perform the job, (2) the workstation layout and physical environment, and (3) the task demands and organizational climate in which the work is performed" (NIOSH, 1997, p. 23). There are a variety of tools that can be used in performing the job task analyses.

Checklist

A checklist is useful to assist the ergonomics team in evaluating risk factors of various jobs, identifying work relatedness of injuries, and developing a plan to address those issues. This can be done by performing a walk-through of each work area. A checklist is used to evaluate multiple workers for each job category. The ergonomics expert assesses the scope of the problem, and members of the ergonomics team evaluate the aggregated data to develop a plan of action. The team then ranks the priorities to identify changes that will have the biggest impact.

Checklists are useful to evaluate the work process. There are a variety of checklists available. The Elements of Ergonomics Programs (NIOSH, 1997) contains "a 'toolbox,' which is a collection of techniques, methods, reference materials, and sources for other information that can help in program development" (p. v). An example of an Ergonomics Risk Assessment for Small Animal Handlers is provided in Appendix A. An Ergonomic Risk Analysis checklist (tray 5-A) (NIOSH, 1997) identifies basic categories of job demands and conditions that may be a problem. Any "Yes" answers may require further analysis. Tray 5-B provides a general checklist to identify specific ergonomic hazards and focuses on primary job activities. Other checklists available in the Ergonomics Toolbox include: a workstation layout (Tray 5-C); task analysis (Tray 5-D); handtool analysis (Tray 5-E); materials handling (Tray 5-F); and computer workstation (Tray 5-G). These checklists could be used as is, adapted, or used together to address the tasks of each workstation. Further investigation is necessary for any "No" answers to these questions. By evaluating several workers performing the same task, the ergonomics team is better able to identify differences in several persons performing the same tasks, while determining the root cause of the problem.

Symptom Survey

A symptom survey is a good data gathering tool to determine if musculoskeletal problems exist and if the job conditions pose a significant risk. The survey gives workers an opportunity to provide information that may be instrumental in identifying risks. It should be distributed to all workers to identify parts of their bodies that experience discomfort, when the discomfort occurs, the severity, how long it lasts, what employees have done to alleviate or address the problem, and what treatment has been provided. Employees should be given work time to complete the survey individually or in a group with a facilitator; it should be anonymous and voluntary. A sample symptoms survey form can be found in the Ergonomics Toolbox Tray 4-A (NIOSH, 1997, p. 87).

Surveys are only effective if the results of the surveys are used. The ergonomics team can evaluate the results by number and severity of complaints by body part affected. They can then compare the complaints to the jobs/tasks being performed. After interventions are addressed, surveys should be re-administered on the same time and day of the week as the initial surveys to evaluate if the changes are effective.

The NIOSH Ergonomics Primer (NIOSH, 1997) further indicates that follow up activities can provide additional information. These activities can include:

- Time motion studies to furnish job task and cycle data,
- Measures of workstation layouts,
- Measures of tool handle sizes, weights, and vibration levels,
- Measures of exposures to whole body vibration and thermal conditions, and
- Biomechanical and physiological determinations.

Videotaping is a good way to assess potential problem jobs. NIOSH developed a protocol for videotaping jobs for risk factors, and it is available in Tray 5-H in the Ergonomics Toolbox (NIOSH, 1997). Appropriately trained persons (trained in-house staff or a consultant ergonomist) can then analyze the videotape to rate repetitiveness, force, and postural factors to determine if there is an increased risk of WMSDs.

Hazard Prevention and Control

Engineering controls, administrative/work practice controls, and personal protective equipment (PPE) are the traditional hierarchy of controls to minimize and control employee exposure. Ideally, the control measures are anticipated and recognized before the process is designed so that factors can be eliminated or modified from the beginning. By being proactive and eliminating or mitigating the problems that can lead to a musculoskeletal disorder, the incidence and prevalence rates should be reduced, as well as the severity of the injury. This should increase productivity and enhance corporate spirit. Tray 9 in the Ergonomics Toolbox (NIOSH, 1997) deals with proactive ergonomics, specifically general workstation engineering design principles (9-A), and work practice principles for repetitive hand and wrist tasks (9-B), hand tool use and selection (9-C), lifting and lowering tasks (9-D), pushing and pulling tasks (9-E), and carrying tasks (9-F). These principles offer ideas for correcting existing problems in addition to preventing problems when new processes or job tasks are planned. "It is a matter of timing. Proactive ergonomics, by stressing these principles at the early design stages of developing work processes and job tasks, avoids finding retrofit solutions and any economic and human costs associated with an after-the-fact approach" (NIOSH, 1997, p. 124).

Engineering Controls

Engineering controls include substitution, process automation, enclosure, process elimination, isolation, process change, and ventilation. To address WMSDs, engineering controls could include workstation design, selection and use of tools, and work methods, while taking into account the abilities and individual differences in employees. The NIOSH Ergonomics Primer (NIOSH,

1997) includes the following engineering control strategies to reduce ergonomic risks:

(1) *Changing how materials, parts, and products are transported.*

Mechanical devices such as hand trucks, carts, or pallet jacks, can be used to move heavy and awkward materials thus reducing employee effort. Proper casters and unobstructed, flat floors make moving easier.

(2) *Changing the process or product to reduce worker exposure.*

When designing a new facility, engineering controls can be built into the process. Vivarium automation is becoming more widely available. Robotics and automation can reduce worker risk as well as freeing personnel for other tasks. Incorporating mechanical and automated systems can help increase health and safety, improve efficiency, and promote overall Vivarium function and research performance (Galvin, 2003). Standard rack washers are already more automated than when cages were washed by hand. The newest automated cage processing systems will replace personnel in the cage wash room for dumping soiled cages and water bottles, removal of waste from the facility, placement of cages and bottles in the cage washer, removal of clean equipment from the cage washer, dispensing bedding into clean cages, filling water bottles, and the assembly of equipment for transport.

Gantry style automated cage handling equipment is under design for handling cages. An advantage of this system is that it does not have to be integrated with an indexing washer. It can be retrofitted onto the load and unload ends of existing tunnel washers (Cosgrove et. al., 2003).

The automation processes are designed to promote a healthy work environment and prevent injury. The down draft disposal component eliminates allergen exposure while the automated process removes the repetitive, frequent, and awkward postures that are required when performing the task manually.

Bedding is frequently dispensed manually by bending, scooping, and dumping into cages. New systems drop bedding into newly washed and dried cages, eliminating the manual task.

Other common small animal handling engineering controls are identified in Table 4.1.

(3) *Modifying containers and parts presentation.*

Equipment such as lift tables and tilt tables are available. Food and bedding bags can be lifted to a workable height that does not require bending or lifting. Edges of counters and biological safety cabinets can be padded or rounded to prevent contact stressors. Tools, friction reducing coatings, and matting that minimize vibration are essential.

(4) *Changing workstation layout.*

Adjustable height work tables for animal procedures and surgery accommodate seated or standing work and can be adjusted to the individual worker. Newer models of biological safety cabinets are height adjustable and provide kneewell clearance so work can be done in a sitting position. By keeping all items within easy reach and minimizing contact stressors on the forearms reduces risk factors. Employees can stand on a raised platform to bring work to a proper height and minimize working above the shoulders.

Table 4.1

Common Small Animal Handling Engineering Controls

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

Source: Adapted from Kerst, J. (2003). An ergonomics process for the care and use of research animals. ILAR, 44(1), p. 11.

(5) *Changing how parts, tools, and materials are handled.*

Repetitive tasks can be injurious over time. By reducing the number of repetitive task cycles, the risks are reduced. This can be accomplished by switching hands to do simple tasks or redesigning the process flow so the number of manipulations is reduced. For example, automated bottle capping, washing, and filling stations are available. When bottles are filled manually, workers handle each bottle individually, screwing the sipper on by hand, and placing the bottles in a container that weighs about 40 pounds. Since workers handle several hundred water bottles daily, an automated process would reduce the risk of MSDs. Automated animal watering systems can be built into new cage racks so that water is delivered to the cage rack directly, eliminating the use of water bottles.

(6) *Changing tool designs.*

Pistol handle grips on tools will decrease wrist bending or squeeze-grip versus finger-grip tool manipulations. Angled devices for holding water bottles improve the angle of access and reduce wrist bending. Surgical equipment is also available with larger grip handles to minimize grasp strength required to manipulate. Tools properly designed to reduce wrist deviations are becoming more widely available.

Administrative/Work Practice Controls

Administrative/work practice controls are often used to supplement engineering controls to reduce exposure. Examples of administrative controls include changing the job procedures, providing more rest breaks, rotating jobs so that no one muscle system is over stressed, and providing training so that workers can recognize risk factors and learn how to reduce their risk of acquiring a WMSD. These controls do not eliminate the hazards; management must make sure that policies and procedures are in place to minimize exposure. Controls and tasks need to be monitored and regularly evaluated to determine if changes need to be made, determine efficacy, and institute additional changes. The NIOSH Ergonomics Primer (NIOSH, 1997) gives common examples of administrative control strategies for reducing the risk of WMSDs:

(1) *Reducing shift length or eliminating overtime.*

Animal care must be provided every day, including holidays and weekends. Ideally, Vivarium staff should be able to provide input into the weekend and holiday scheduling. They should be given the opportunity to take on-line courses or leave work early when work is done. The employer must also identify the need to modify jobs or accommodate employees who have functional limitations secondary to WMSDs (as determined by a health care provider) by reducing shift length or curtailing the amount of overtime. It is important to distribute equal workloads to minimize overloading individuals with daily tasks.

(2) *Rotating jobs with different physical demands at each job.*

Jobs in the Vivarium that require prolonged duration or a series of repetitive tasks can be minimized by sharing job tasks (job rotation) that use different muscle groups at each job.

(3) *Scheduling more rest periods to provide recovery time.*

This will reduce the frequency and duration of exposure, and give muscle groups a chance to rest. Increased breaks will allow time for muscle rest and recovery, and can be accomplished by broadening or varying the job content to offset certain risk factors (e.g., repetitive motions, static and awkward postures).

(4) *Adjusting the work pace to give employee control of his immediate work environment.*

The basic animal care is constant and the workers learn what work must be accomplished daily. However, research staff may have last minute requests. With improved communications between research and animal care staff regarding study length, procedures, and termination dates, this should minimize additional animal handling and unnecessary rushing to complete tasks on time.

(5) *Training employees.*

Teaching employees effective work practices and proper lifting techniques is an important part of the ergonomic process that can ease the task demands or burden. For instance, moving cages is easier when pushing rather than pulling.

Work practice controls reduce but do not eliminate the exposure to risk. They focus on changing how employees perform their work activities. Employees have to buy in to the process and if they have input, they will be more compliant. Some examples of work practice controls are:

- Practice effective teamwork that supports clear communication with coworkers,
- Lessen the weight – order smaller bags, carry smaller loads; do not overload carts,

- Make sure equipment is working; wheels and casters on racks and carts should roll easily, the path should be flat, without obstacles, and the floor should be smooth,
- Use smaller racks to hold water bottles thus reducing the weight, and
- Provide strong upper management leadership including active support and participation (Kerst, 2003, p. 12).

Personal Protective Equipment (PPE)

PPE is used when risk remains after engineering and administrative/work practice controls have been implemented. PPE typically worn in a Vivarium include gloves, lab coats, steel-toed shoes, respirators, safety glasses, and face shields. Many animal caretakers wear company-provided and laundered scrubs that are removed at the end of the work day. Steel-toed waterproof shoes or boots are required to prevent injury if cages or equipment are dropped. Latex or nitrile gloves minimize biological exposure. Long, heat resistant gloves are needed for removing items from the autoclave. Respirators may be required when working around the animal dump stations to prevent inhalation of dander and air-borne allergens. Eye protection is required when working around chemicals or when performing animal treatments/procedures. The use of back belts or wrist supports continues to be studied but no significant data support their use.

Medical Management

Injuries and illnesses can occur even with effective health and safety programs. Early reporting, diagnosis, and intervention can limit the severity of an injury, improve effectiveness of treatment, minimize the likelihood of disability or permanent damage, and reduce workers' compensation costs. Many employers have found that early reporting, combined with appropriate medical treatment and/or work restrictions, can help employees recover fully without more serious and costly consequences (OSHA, 2004b).

Early Detection

Employees must be trained to recognize the signs and symptoms of WMSDs and encouraged to report symptoms promptly to occupational and environmental health nurses. The sooner treatment is initiated and the injury allowed time to rest and recover, the faster the recovery and the less loss of productivity to the employer. When employees know that there are no repercussions to reporting symptoms, they will more likely report early and be a more active participant in their own care.

The use of medical screening tests or examinations have not been validated as predictive procedures for determining the risk of workers developing WMSDs. A baseline assessment can be performed and used to compare future assessments. This can include medical history and physical examination to include Tinel's, Phalen's, and Finkelstein's tests. When starting a new task, a period of conditioning will help build up muscle capacity.

Occupational and environmental health nurses (OEHNs) or physicians with training in the prevention and treatment of WMSDs should supervise the program. OEHNs are active participants in planning, providing on-site care, and implementing policy. There should be a consistent plan of treatment by a health care provider (HCP) with knowledge of the work processes, specific tasks, and the capabilities of the individual employee. The HCP can then recommend alternative work that will not aggravate the injury, providing time for it to heal, and thus encourage employees to remain productive workers. A consistent treatment plan by a HCP knowledgeable about WMSDs and the work process is encouraged so that time away from work is minimized and the employee gets appropriate treatment.

Treatment

Treatment starts with examination and removal from or reduction of exposure from the tasks aggravating the injury. The nurse practitioner or physician can prescribe non-steroidal anti-inflammatory agents if the employee does not have liver or kidney concerns. Protective devices, such as wrist supports, may be used during periods of sleep and time away from work. When used during the work processes, the devices can cause increased stress to other joint areas.

Depending on severity of the injury, the treatment can last up to several months. In some cases, surgery may be required; however, if the symptoms are reported early enough, surgery may be avoided.

The physician will also talk with the employee to examine non-work related activities, which may exacerbate the WMSD. These could include activities such as knitting, bowling, and fly-fishing.

Following a WMSD, the employee can be put to work in a productive job that uses different muscle systems. By alternating jobs, no one muscle system is overworked. Occupational and environmental health nurses can, by identifying jobs based on worker capabilities, work with the health care provider (HCP) to get the employee back to work quickly and safely. If the HCP and occupational and environmental health nurses work together to determine the employee capabilities, a short term reduced activity, temporary transfer, or (preferably) alternate tasks can be identified.

Return to Work

If the employee is returned to work quickly, occupational and environmental health nurses and occupational physicians can provide care and follow up treatment as appropriate. This might include periodic breaks, heat or ice compresses, physical therapy, and/or non-steroidal anti-inflammatory agents. OEHNs can encourage range of motion exercises, or resistance or strengthening exercises.

Monitoring

During the periodic contact with the employee, OEHNs can continue to reinforce signs and symptoms of a musculoskeletal injury, encourage early reporting, and build a stronger rapport with the employee. Stress reduction techniques can also be discussed, as increased stress is frequently associated with muscle stiffness.

Referral

Evaluation of the employee may determine that more than palliative treatment is required. An orthopedic surgeon may need to treat more severe injuries. OEHNs work within company policies to make sure the employee is seen by a competent physician who may need to conduct diagnostic tests (such as electromyography or x-ray) or perform surgery. OEHNs can provide case management to return the employee to the workplace when feasible and safe for the employee. They can also provide detailed information about the job and work with the physician to identify capabilities of the employee rather than just addressing the disability.

Training and Education

Training is essential to any health and safety program. Kuorinka and Forcier (as cited in NIOSH, 1997) indicate that the overall goal of an ergonomics training program is to "identify the job tasks that may increase a worker's risk of developing WMSDs, recognize the signs and symptoms of the disorders, and participate in the development of strategies to control or prevent them" (p. 13). Table 4.2 lists employees who should receive specific training.

It is important to train workers to recognize risk factors for WMSDs and how to report them. Employees should be encouraged to report symptoms early and be evaluated promptly by an appropriate health care provider. Employees should know the standard operating procedures, understand the WMSD hazards to which they are exposed, and be involved in suggesting safeguards.

All employees exposed to WMSD hazards should receive general training so they can learn the type of WMSDs that are associated with their job, what the risk factors are, how to recognize and report symptoms, and how they can prevent these WMSDs from happening. Annual training is recommended in addition to training new employees and those assigned to new job tasks. Employee training must include care, use, and handling techniques of specific equipment; use of

Table 4.2

Ergonomics Training for Various Categories of Employees

Training Elements	All Employees	Every Employee in Suspect Problem Jobs	Every Supervisor of Jobs with Suspect Problems	Every Employee Involved in Job Analysis and Control Development	Ergonomics Team or Work Group Members[1]
General ergonomics awareness information[2]	X	X	X	X	X
Formal awareness instruction and job-specific training		X	X	X	X
Training in job analysis and controlling risk factors				X	X
Training in problem solving and the team approach					X

[1] If ergonomics teams are formed, added instruction is needed in team-building and consensus development processes, apart from application of ergonomics techniques.
[2] General ergonomics awareness information for all employees need not require class instruction; it can be disseminated via handouts and all-hands meetings.

Source: NIOSH. (1997). Elements of ergonomics programs: A primer based on workplace evaluations of musculoskeletal disorders (p. 14). Cincinnati, OH: NIOSH.

specific tools at specific workstations; use of guards and safety equipment (including PPE); and use of lifting devices and proper lifting techniques. Supervisors must be trained to ensure that all employees follow safe practices and participate in training and use of proper ergonomics. Managers must be made aware of their responsibilities for the health and safety of their staff which includes understanding and participating in the ergonomics program. Engineers and facility maintenance staff must also be aware of the ergonomic deficiencies, the corrections process, workstation design, and proper maintenance.

"Identifying and solving workplace WMSD problems require some level of ergonomic knowledge and skills. Recognizing and filling different training needs is an important step in building an effective program" (NIOSH, 1997, p. 13). In-house expertise is ongoing, evolving, and continually addressing the needs of the worker. Staff provide perspectives of varying backgrounds and can not only work together to develop and deliver a program, but can also adjust training as needed following feedback. Training can be in a variety of formats, ranging from awareness to specific training for performing job task analyses and problem solving. Tray 3 of the Ergonomics Toolbox (NIOSH, 1997) used the same key elements developed by OSHA in their Training Requirements in OSHA Standards and Training Guidelines (OSHA, 1988). The steps necessary for training include: determine if training is needed (checking health records and results of job analyses to evaluate risk factors, then involving employees so they can learn how to implement control measures); identify training needs (including language and educational needs of the workers); identify goals and objectives;

develop learning activities (lectures, demonstrations, and interactive videos); conduct the training; evaluate training effectiveness (question and answer sessions, quizzes, hands on demonstration of training learned, observation of the task at the workstation after training, and evaluation of the training session); and improve the program if the objectives are not achieved.

There are other primers and training manuals available to provide additional resources for ergonomics training which are listed in Tray 10 of the Ergonomics Toolbox (NIOSH, 1997). These resources are not job title specific and therefore do not directly address laboratory animal workers, but they provide relevant information on lifting and moving materials; standing, lifting and carrying; preventing strains and sprains; and implementing ergonomic interventions to prevent musculoskeletal injuries. Many of the movements are similar between tasks in different industries and can, therefore, provide additional insight. In addition, NIOSH has training centers throughout the country that can provide additional resources. A list of the training centers can be found at www.cdc.gov/niosh.homepage.html, the NIOSH website.

Role of Interdisciplinary Team

The interdisciplinary team works together to provide a safe and healthy work environment for all. The members have different roles and each brings varying backgrounds, experience, and expertise. By working together, they can preserve, protect, and improve the work life of the employee.

Occupational and Environmental Health Nurses

Occupational and environmental health nurses are vital members of the team. As knowledgeable, competent, and caring professionals, they are able to develop a rapport with employees. OEHNs perform worksite assessments, observe and evaluate job tasks, and interact directly with staff. Being available, accessible, visible, and proactive, occupational and environmental health nurses can encourage communication with line staff, advocate for their needs, and maintain confidentiality. Yet, they are often part of management and provide valued input to the team.

Certified occupational and environmental health nurses have varied backgrounds that includes knowledge of safety, ergonomics, and industrial hygiene which helps foster collaboration among occupational health and safety professional disciplines to "better understand the effects of work and workplace exposure on human health" (Rogers, 2003, p. 147). As part of the recertification process, certified occupational and environmental health nurses are required to participate in continuing education. With an ever-changing scope of practice, it is critical that OEHNs remain current in their skills.

Occupational and environmental health nurses are frequently the first point of contact for employees with a WMSD. In providing care to the employees, they must recognize the symptoms of a WMSD, develop clinical guidelines approved by the occupational physician to treat employees, and make referrals. OEHNs provide case management services to injured employees to assure prompt and adequate care; work with management and occupational physicians to establish early return to work programs, alternate work, and modified duty; and monitor trends to promptly address and prevent musculoskeletal injuries and illnesses. Occupational and environmental health nurses provide general ergonomics training including classes on stress reduction and strengthening exercises.

Occupational Physicians

Occupational physicians have varying roles in an occupational health setting. Many companies either have one occupational and environmental health nurse who contracts with a local physician or hospital to provide medical services. Other companies have a large medical service with multiple OEHNs and on-site physicians.

Occupational physicians who are knowledgeable about the individual tasks, work processes, management commitment, and the vision and mission of the organization, develop medical policy, and are in an excellent position to provide individual care while keeping the injured employee as functional as possible. The main responsibilities of occupational physicians are: prevention and early detection of occupational injury and disease, diagnosis and treatment of occupational injuries and disease (with an emphasis on returning employees to work), and diagnosis and treatment of non-occupational injury and disease in emerging situations when local resources are not available (Levy & Wegman, 2000). In a Vivarium setting, occupational physicians must be aware of the work processes, zoonoses, and laboratory animal allergies, in addition to the musculoskeletal and general health and safety concerns.

Industrial Hygienists

The role of industrial hygienists is to anticipate, recognize, evaluate, and control workplace hazards. This is accomplished by performing walk-through evaluations of the worksite, measuring workplace exposures, and recommending interventions and control strategies. Industrial hygienists understand job demands and worker capabilities and are instrumental in addressing enviromechanical hazards that can lead to WMSDs. In a Vivarium setting they monitor decibel levels as part of the hearing protection program, inspect and certify biosafety cabinets, and monitor air quality for dander as part of the respirator program.

Safety Committee

A team approach to employee health and safety brings expertise from all parts of the organization. Safety committees are comprised of people from all levels of the company. Included are representatives from groups such as facilities support (engineering, maintenance, shipping); industrial hygienists; risk management; staff who work with radiation, chemicals, biologics, or animals; occupational and environmental health nurses; human resource staff; and line workers. The committee identifies and addresses safety and health issues before problems arise and write and enforce safety policy. The safety committee also encourages safe work practices, performs inspections and audits, conducts accident investigations, performs ergonomic assessments, provides education and training, addresses emergency evacuation procedures such as terrorism, spills or releases, fire or disaster, and addresses housekeeping issues. This is important in a Vivarium setting where the health and safety of the staff and the animals has to be considered in an emergency situation. Employee input is valued and solicited proactively and reactively, such as when accidents are investigated.

The safety committee will evaluate and investigate all work related injuries and illnesses, including WMSDs. Injury trends will be evaluated, equipment and processes reviewed, and ergonomic concerns will be forwarded to the ergonomics team for further evaluation.

Ergonomics Team

The ergonomics team is made up of employees from all parts and levels of the organization, as is the safety committee. The ergonomics team provides ergonomic assessments, addresses ergonomic concerns, and conducts training. A basic ergonomics awareness program can be as simple as articles in the company newsletter and bulletin board displays. Advanced interventions can include periodic "time outs" for performing relaxation techniques, such as rolling the shoulders. The ergonomics team works together in applying problem-solving techniques to best address the ergonomic problems.

Veterinarians

Veterinarians may be either on-site or on-call. They bring expertise on the health and safety concerns in a Vivarium, including specific biologic/zoonotic exposures, as well as the chemical, enviromechanical, physical, and psychosocial hazards one may not encounter outside an animal facility. The veterinarians are not only concerned about the health and safety of the animals, but also the animal caretakers who report to them, as well as the scientific staff who work periodically in the Vivarium.

Most laboratory animal veterinarians, by the nature of their work, stay abreast of the latest scientific developments. They tend to be active members of AALAS and network regularly. There is an active Internet exchange program called CompMed where ideas, questions, concerns, and evaluation results of equipment, etc. are regularly exchanged. The veterinarians know the work processes intimately and can be strong advocates for safety measures for the staff.

Animal Caretakers

The animal caretakers are similar to line workers in a manufacturing plant. They are at greater risk to hazards by virtue of tasks performed. In a well run Vivarium, animal caretakers meet regularly with supervisors (usually weekly) to discuss animal care, procedures, and hazards encountered in their daily tasks. They provide input and share concerns which are discussed and addressed, and supervisors share concerns about staff safety and health issues. This sharing makes the animal caretakers feel valued and bring to the table the hands-on perspective that the other members lack.

Management

Management is where it all begins. The CEO is ultimately responsible for the health and safety of the staff. Management is involved in planning, providing financial support, organizing, staffing, providing direction, and evaluating overall program effectiveness. OSHA recommends that management support be visible to all employees. This can be accomplished by:

- Consistently communicating the importance of employee safety and health;

- Assigning and communicating responsibility for the various aspects of the ergonomics process to appropriate managers, supervisors, and other employees;
- Committing adequate resources to the ergonomics process;
- Integrating production processes and production improvements with safety and health concerns; and
- Ensuring that all managers and employees are accountable for carrying out their responsibilities under the ergonomics process (OSHA, 2004b, p. 7).

An important job of management is training those below them, keeping communication open, and providing feedback (Rogers, 2003).

Summary

To effectively prevent and control workplace ergonomic deficiencies, there must be top management commitment and cooperation on the interdisciplinary teams. The goals of WMSD reduction and improved worker health and safety are attainable as long as the program is regularly evaluated and revised to incorporate this new input.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

Musculoskeletal disorders account for a significant number of the injuries and illnesses sustained by the U. S. workforce each year. Due to the research published over the last 10 years, there is a lot known about the cause and control of musculoskeletal disorders. These data provide a base for researchers to offer advice and recommendations on the control and treatment of WMSDs. Proactive ergonomic approaches are necessary to prevent these WMSDs from developing. With proper process, workstation, and tool design, as well as proactive workplace and administrative practices, the risk factors leading to WMSDs can be decreased.

More research is needed to fully examine the relationship between the risk factors and the workers to ensure a safe and healthy workplace while protecting and promoting the physical and mental well being of the employee.

Policy Implications

Although there are currently no regulations directly addressing ergonomic issues, guidelines are available in the Ergonomics Program Management Guidelines for Meatpacking Plants (OSHA, 1991), Elements of Ergonomics Programs (NIOSH, 1997), Guidelines for Nursing Homes (OSHA, 2003), Guidelines for Poultry Processing (OSHA, 2004b), and Guidelines for Retail Grocery Stores (OSHA, 2004a).

Small animal research laboratories, therefore, need to have a comprehensive program in place to address ergonomic issues. This includes a company commitment for the costs associated with implementing engineering and administrative controls, preferably when new processes or job tasks are planned. Although companies may be hesitant to commit additional funds for major engineering changes, management can be aware of the costs of OSHA fines (under the OSHA General Duty Clause), the direct and indirect costs of worker disabilities, and the costs of low morale and job dissatisfaction.

OEHNs are in a critical position to recognize injury and illness trends, conduct worksite assessments, work with the safety committee and the ergonomics team, identify injury trends, perform root cause analyses of injuries, perform job task analyses to identify problem areas, and evaluate interventions. If the company does not employ OEHNs, a consultant can be hired to assist in developing an ergonomics program. OEHNs are familiar with OSHA regulations and guidelines, and are able to provide management with data to support the need for an ergonomics program.

Recommendations for Practice

It is imperative that OEHNs remain current in the field of occupational and environmental health and safety. This requires coordinating and collaborating with professionals in other health and safety disciplines as well as frequent interaction with all employees, including animal care workers.

There is a good deal of information addressing ergonomic issues in a small-animal research laboratory facility. "Animal Lab News" and "ILAR" are published bimonthly and monthly respectively, and are full of information addressing laboratory animal issues. Occupational and environmental health nurses who have employees working in animal research should read these journals to become aware of current trends and issues, available equipment, and research studies on pertinent areas of occupational safety and health.

Occupational and environmental health nurses are in a position to recognize work related musculoskeletal disorder trends through employee visits to the heath unit, OSHA 300 log, employee complaints, observations during walk-throughs, checklists and surveys, and periodic evaluations of interventions. Once trends are identified, the ergonomics team can evaluate the risk factors and suggest interventions to prevent or minimize employee risk for injury or illness. OEHNs can coordinate employee ergonomics training. Once trained to recognize early symptoms of WMSDs, employees can be treated and the risk factors addressed before they become a problem.

OEHNs serve as active participants on both the interdisciplinary safety and ergonomics committees. Frequently the only licensed professional on either committee, they can stress proactive approaches in reducing the risk of WMSDs and assure that ergonomics strategies are considered prior to new processes or tasks being implemented. OEHNs work with occupational physicians in developing an early return to work program and identifying alternate work or modified duty that will allow the employee to work and not exacerbate a current musculoskeletal symptom.

Occupational and environmental health nurses and other members of the ergonomics team must constantly re-evaluate the processes, making adjustments as needed. Training must be updated as new procedures are introduced.

Future Research

Over the last twelve years, there has been a wealth of articles written about WMSDs. The findings from many publications have been summarized by NORA (2001). They have identified a simple framework of factors that contribute to an MSD.

> Initial loads are applied to the musculoskeletal system either by external forces or by internal forces resulting from dynamic and gravitational effects on the mass of the body segments. These applied loads create internal tissue responses in the muscles, ligaments, and at the joint surfaces. Depending upon the magnitude of the load and other individual, organizational, or societal factors, one or more outcomes may result. These may include adaptation effects (such as increases in strength, fitness, or conditioning) or potentially harmful outcomes (such as pain or other symptoms, and structural damage to tendons, nerves, muscles, joints, or supporting tissues) that may result in symptoms, impairment, or disability. Whether the exposure leads to an MSD depends on the physical demands of the job, the adaptation response of the worker, and other individual physical and psychological factors. These in turn may modulate the effects of the external load (NORA, 2001, p. 2).

The research has promoted many prevention efforts at the worksite. However, more research is needed. Health care professionals need reliable clinical methods to diagnose WMSDs. Researchers need a clear definition of WMSDs so that data can be compared and appropriately compiled. Employees need to have a safe and healthy work environment. Employers want to reduce costs of equipment, injuries, claims, litigation, and fines, while positively impacting the mission and vision of the organization. Manufacturers need to constantly adapt the equipment designs to further minimize ergonomic risks.

The results of the research must be made available to all, and occupational and environmental health nurses need to share it with their peers. Ways to disseminate research results are to publish an article or a continuing education unit in the *AAOHN Journal*, present information at local and state chapter meetings, or conduct a program on ergonomics in a small-animal laboratory facility at the national AAOHN meeting. The research process can be improved by strengthening communication between those who conduct the research and those who apply the research findings.

The National Occupational Research Agenda (NORA) on Work Related Musculoskeletal Disorders brought together an interdisciplinary team representing industry, labor, and government interests to evaluate the status and define future research needs in the area of WMSDs. They developed an agenda that will serve as a model for building a national research program by identifying high priority problems and influencing the allocation of resources (NORA, 2001). After three focus groups met, the team summarized the information and developed "Academic Input on What is Possible in the Next Five Years" (NORA, 2001), and is Appendix B. Areas of interest that they look forward to addressing include:

- Study workers in understudied industries,
- Address the question of why workers respond differently to interventions; focus should be on the workers who do well,
- Develop a "gold standard" for measuring biomechanical factors,
- Develop simple, validated assessment tools for hazard surveillance and intervention,
- Develop a gold standard for diagnosis of WMSD,
- Conduct basic research into injury mechanisms and models,
- Develop a mechanism to support multi-disciplinary research efforts, and
- Create a common ergonomics language that is used by engineers, health professionals, and industry. Ergonomics is interdisciplinary, yet currently the different disciplines cannot talk to each other.

Ergonomic issues in a small animal laboratory setting are no different than ergonomic issues in any other setting. While engineering controls are different, administrative and workplace controls are very similar. The factors of force, repetition, frequency, duration, awkward postures, contact stresses and vibration are known to contribute to work related musculoskeletal disorders. By recognizing these stressors, occupational and environmental health nurses can effectively work with the safety committee and the ergonomics team to implement interventions to reduce the risk of work related musculoskeletal disorders.

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APPENDICES

APPENDIX A

Ergonomics Risk Analysis

Job title: Animal Handler Job Description: Clean cages, change cages, load/unload autoclave, receive supplies Evaluators: Melanie Alexandre, Ronnie Balan, Cheryl Bennett Supervisor/Contacts: Patsy Gilbert, Paul Borenstein, Patti Kluck			
Awkward Postures			
Neck	☐ No problems observed ■ Twisted (rotated) ■ Tilted back ■ Tilted Forward ☐ Lateral (bend side to side) ☐ Other	Description: Reaching into sinks, handling cages (clean and dirty), reaching into bedding and food containers	Solutions: Provide education/training Change depth of sink and storage containers (food and bedding) Minimize use of top shelves in labs and cleaning rack
Wrist/ Hand	☐ No problem observed or reported ■ Flexion ■ Ulnar deviation ■ Extension ■ Radial Deviation ☐ Other	Description: Handling cages (clean and dirty) Sustained pinch during handling of cages, pistol handle of hose while cleaning cages, opening bedding bags, bottle handling	Solutions: Provide education/training Explore equipment options (storage containers, scoops, hose handles, bottle brushes, utility knives)
Elbows/ Forearm	☐ No problem observed or reported ■ Flexed (arm bent up) ■ Extended (arm straight) ■ Winged (away from body) ■ Supination (palm up) ■ Pronation (palm down) ☐ Sustained extension/flexion ☐ Other	Description: Reaching on racks, autoclave, sink	Solutions: Provide education/training Explore equipment options (storage containers, scoops, hose handles, bottle brushes, utility knives)

APPENDIX A (continued)

Ergonomics Risk Analysis

Back	☐ No problem observed or reported ☐ Slouched ☐ Inadequate lumbar support ■ Twisted ■ Standing on hard surfaces and lifting	Description: Standing for all work tasks, Lifting shavings, feed and water	Solutions: Provide education/training
Shoulders	☐ No problem observed or reported ■ Forward reach ☐ Reaching behind ■ Raided/above shoulder height ☐ Other	Description: Reaching into sink, racks, handling cages, autoclave	Solutions: Explore equipment options Minimize use of top shelves in labs and cleaning racks
Legs	☐ Insufficient leg clearance ■ Stance ☐ Other	Description: Standing continuously Dirty area has slippery surface	Solutions: Explore equipment options (safety shoes, anti-fatigue mats, and non-slip strips)
Other	■ Work surface height	Description: Various heights from overhead to floor level Deep sink Deep bedding storage	Solution: Change depth of sink and storage containers (food and bedding)

APPENDIX A (continued)

Ergonomics Risk Analysis

Repetitive Activities	Description: Most tasks require same muscles and positions Heavy objects: rack, autoclave, bedding, feeding, garbage Noted pulling versus pushing Noted bending and twisting	Solutions: Provide education and training
Static Postures	Description: Continuous standing, reaching, and hand use	Solutions: Provide education and training
Contact Stress /Pressure	Description: Pushing and pulling autoclave rack and door	Solutions: Explore equipment options (well padded gloves) Perform maintenance on autoclave doors
Work Style/ Flow	Description: Employees report fast pace	Solutions: Encourage teamwork with heavy and awkward tasks including carrying supplies, emptying bottles, loading/unloading autoclave and dirty rack
Environment	Description: Dirty side-wet and slippery floor when hosing cages 180 degree water used Clean side-slippery with shoe coverings	Solutions: Explore equipment options (safety shoes, shoe coverings, non-skid strips and/or paint)
Force	Description: Lifting, pushing, pulling, reaching, grasping	Solutions: Provide education and training
Tools & Equipment	Description: Gloves, lab coats/shoe coverings, autoclave gloves, bottle brushes	Solutions: Explore equipment options

APPENDIX A (continued)

Ergonomics Risk Analysis

Summary of ergonomic risk analysis:

1. Provide education and training including: stretching, reaching, lifting, bending, standing, team lifting and carrying
2. Explore equipment options including: storage containers, scoops, hose handles, bottle brushes, utility knives, safety shoes, casters on carts, shoe coverings, padded gloves, non-skid strips and/or paint
3. Environment options: Perform maintenance on autoclave doors, change depth of sink and storage containers (food and bedding)

Source: Alexandre, M., Balan, R., and Bennett, C. (nd). Ergonomics risk analysis for small animal handlers. Retrieved August 20, 2004 from www.llnl.gov/ergo/source/animal_handler.pdf.

APPENDIX B

Academic Input On What Is Possible In The Next Five Years

These six topics are consolidated from those identified by the five academic workgroups that met in Houston, where attendees were asked to identify the research topics from Appendix A or other topics where progress seems most feasible in the next five years. They did not discuss the surveillance topics listed in Appendix A [*sic*].

Risk Factor Identification

- Initiate a new prospective ergonomics study. Although the length of the study may be longer than a few years, the initial cross-sectional and longitudinal data would be valuable.
- Develop accurate risk assessment models. Develop a comprehensive, multi-factorial model of the predominant causes of repetitive motion disorders. For example, for wrist disorders, address all the contributing causes, including personal variables, like demographics and medical history, work factors, off-the-job factors, and physical and psychosocial factors. Develop job simulation models to predict stress on the job.
- Study workers in understudied industries, such as agriculture and construction. Investigate task performance, capabilities, tolerances, and limitations among special worker populations, such as older workers, pregnant women, and those exposed to lead as children. Address the question of why workers respond differently to interventions; focus should be on the workers who do well.
- Acquire more information by age and gender on grip strength norms for the industrial population or the adaptations that occur in repetitive work as reflected in grip strength. Include different postures, not just one regular grip strength posture.
- Study the relationship between acute trauma and chronic disorders, particularly whether an acute injury of the back, hand, shoulder, or neck predisposes a person to a chronic disorder. Study how self-reported symptoms relate to acute and chronic disorders.
- Retain a balance between controlled laboratory studies and field studies; both have their place. Conduct research on participatory versus nonparticipatory ergonomics research to evaluate the value of participatory research.

Improvement of Exposure Assessment Tools and Methods

- Develop a "gold standard" for measuring biomechanical factors.

APPENDIX B (continued)

Academic Input On What Is Possible In The Next Five Years

- Improve the scientific basis for predictive tools, like the NIOSH lifting equation, and evaluate their effectiveness.
- Develop simple, validated assessment tools for hazard surveillance and intervention.
- Initiate effort to develop an upper extremity equation similar to the NIOSH lift equation.
- Acquire more data on human capacities.
- Developing methods to identify .[*sic*]
- Quantify physical stress.
- Use state-of-the-art technology to develop better exposure assessment tools, using dynamic biomechanical models.
- Develop good tools to assess exposure/effect relationships at the target tissue level. Develop better quantitative tools for tissue load assessment, especially for field studies.

Medical Research

- Develop standardized and validated definitions for the gamut of adverse health effects (ranging from biochemical markers to preclinical effects, symptoms, and permanent disability) and better health effect assessment methods.
- Develop a gold standard for diagnosis of MSD.
- Conduct basic research into injury mechanisms and models. Define effective return-to-work strategies, and define what causes "bad" outcomes.

Intervention

- Conduct intervention studies.
- Identify and replicate effective ergonomic programs in specific businesses or industries.
- Institute intervention activities on lower extremity problems.
- Conduct research on back belts.
- Evaluate whether shoe inserts work.

Dissemination of Information about Ergonomics

- Create a publication database and a detailed solutions database.
- Develop guidelines or a handbook for process and product engineers and designers to incorporate ergonomic principles into their work.

APENDIX B (continued)

Academic Input On What Is Possible In The Next Five Years

- Improve training and education tools and methods, including those for children.
- Develop a public awareness campaign to explain ergonomics to the general public.

Removal of Barriers to Research

- Develop a task force to facilitate research by linking researchers and industry and by encouraging industry to participate in ergonomic research efforts.
- Identify means of "immunizing" industry for participation. Provide anonymity for corporations with industry-wide studies and surveillance and other methods.
- Develop a mechanism to support multi-disciplinary research efforts. Create ergonomic research centers. Foster collaborative associations (researchers, clinicians, industry). Create a common ergonomics language that is used by engineers, health professionals, and industry. Ergonomics is interdisciplinary, yet currently the different disciplines cannot talk to each other.
- Piggyback ergonomic medical tests onto large, pre-existing prospective studies like those of NHANES or the Institute of Aging. While these would never be comprehensive in scope, they could provide valuable benchmarks or reference values on a variety of basic physiological functions and human capacity profiles. For example, include a few hand function maneuvers, like grip strength measures.

Source: National Occupational Research Agenda for Musculoskeletal Disorders: Appendix C. (2001). Retrieved August 20, 2004 from http://www.cdc.gov/niosh/2001-117f.html