Musculoskeletal injuries, biomechanical risk factors

OHS information for employers and workers

Musculoskeletal injuries, or MSIs, are referred to by a variety of different names. They include repetitive strain injuries (RSIs), repetitive motion injuries, cumulative trauma disorders (CTDs), work-related upper limb disorders (WRULDs), and others. In each case, the name is used to describe injuries of the bones, joints, ligaments, tendons, muscles, and other soft tissues.

Key information

As muscles, tendons, and ligaments move away from the middle of their range of motion, they become stretched and vulnerable to injury.

Although the causes of MSIs are difficult or sometimes impossible to determine, a number of risk factors have been shown to contribute to them. This Safety Bulletin discusses the factors that involve how the worker's body functions during work, the biomechanical risk factors. The remaining factors involve the workplace and the nature of the work being performed.

Biomechanical risk factors

Three major factors that involve how a worker's body functions during work contribute to injuries. They are awkward body positions, excessive force (forceful exertions), and repetition. These factors often work in combination to affect and bring about injury in susceptible workers.

Awkward body positions

The problem

The key to reducing or eliminating the use of awkward body positions and work postures is to understand why they are being used in the first place. Awkward positions are often the result of the location and orientation of the object being worked on, poor workstation design, product design, tool design, or poor work habits. Several of these causes can be engineered out, eliminating the problem altogether. For example, a worker who bends over to lift objects out of large bins or cardboard boxes must assume an awkward body position. Raising and tilting the bins can easily eliminate the awkward position. As muscles, tendons, and ligaments move away from the central portion of their range of motion, they become stretched and vulnerable to injury. As they approach the end of their range of motion, they become fully stretched and further motion due to sudden movements or unexpected loads may cause tissue injury. As the angle of a joint increases or decreases past the middle of it's range of motion, the amount of force that muscles acting on that joint can easily produce is reduced because they are no longer in their most favourable positions. To compensate for this mechanically-caused strength reduction, muscles try to develop more force and their tendons are placed in even greater tension. This is added stress that can lead to injury. Less-than-optimal postures such as leaning forward from the waist for extended periods of time, or bending the neck downwards at an exaggerated angle, can load muscles with 'static work'. Static work involves muscles being tensed in fixed positions and over time, becoming tired, uncomfortable, and even painful. Production line

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workers who have to bend their necks and hold them in one position often experience strain in their neck and shoulder muscles. Sedentary work involving sitting or standing for long periods of time without movement can lead to pain and discomfort.

Potential solutions

Awkward body positions and their effects can be reduced by:

- encouraging frequent changes of position. This avoids becoming “locked” into one position for extended periods of time.
- avoiding forward and downward bending of the head and upper body. This commonly occurs when tasks, work surfaces, or controls are too low relative to the worker’s standing or sitting position.
- avoiding having the arms held in a raised position, either in front of the body or out to the sides with the elbows bent. Such positions are often the result of work surfaces or controls being too high relative to the worker’s standing or sitting position.
- avoiding twisted body positions. Arrange the work and workstation so that twisting is avoided.
- avoiding positions that require a joint to be used for extended periods of time at the limit of its range of motion e.g. constant reaching behind the back can place considerable strain on the shoulder joint.
- providing adequate back support in all chairs or seats. Back supports, preferably adjustable ones, improve posture, lessen fatigue, and make sitting for long periods of time more comfortable.
- optimizing the position of arms and legs. Ensure that the arms and legs are positioned within their middle range of motion when muscular force needs to be exerted.

Forceful exertions

The problem

Forceful exertions may overload muscles, tendons, and ligaments. Forceful exertions are commonly used when lifting, pushing, pulling, and reaching. A packer on an assembly line for example, may often use a highly forceful grip to assemble a lightweight item or lift a box or carton, especially if it is slippery or difficult to grasp. Workers who use tools such as handheld grinders for extended periods of time may be at risk of developing MSIs of the hand because of the amount of force needed to use, hold, and trigger the tools. Awkward wrist and arm positions may also contribute to the problem.

Potential solutions

High muscular forces can be reduced by:

- reducing the forces required to perform the task e.g. using mechanical aids when lifting and handling materials, using jigs, vices, and clamps rather than hands to grip parts, keeping sharp edges of tools and equipment sharp, reducing contact forces on switches and controls, lubricating and maintaining tools and equipment.
- distributing forces e.g. using a larger body part, such as an arm rather than a finger, to deliver the force.
- establishing better mechanical advantage e.g. with larger, better positioned tools, with levers, or by involving larger muscle groups.

Repetition

The problem

Repetitive movements eventually wear the body down. Without sufficient time to recover between repetitions, muscles become tired and may cramp. Other muscles try to help but they may also become tired, cramp, and become injured. How quickly this happens depends on how often a repetitive motion

is performed, how quickly it is performed, and for how long the repetitive work continues. Repetitive work is more of a problem when it is combined with awkward body positions and forceful exertions. A worker who packages a small product day after day or who uses a stapler or power nailer to assemble wooden frames are examples of workers performing repetitive work.

Potential solutions

Worker exposure to repetitive work and its effects can be reduced through:

- automation of the task or portions of the task. Machines are particularly effective at performing repetitive tasks.
- job rotation. This breaks up a worker's exposure to a particular repetitive movement. It is extremely important that the new task involve different movements and muscle groups.
- job diversity. Training workers to perform a series of properly selected jobs rather than the same, simple one repetitively reduces monotony, boredom, and the potential for injury. Jobs with greater diversity often provide workers with a sense of accomplishment.
- job enrichment. Workers are given responsibility for a wider range of duties that require a variety of skills and qualifications. As examples, these duties may include work planning, inspection activities, or customer contacts.
- frequent breaks. Frequent, short breaks from work activities provide workers an opportunity to recover from their activities by stretching, changing body positions, or relaxing hard-working muscles.

Other biomechanical risk factors

Compression and impact stress

Tissues can become compressed when they come into contact with the edges of workbenches, tool handles, machine corners, and poorly designed seating. Forces are concentrated on small areas of tissue, resulting in high localized pressure. This pressure can compress nerves, blood vessels, tendons, and other soft tissues, resulting in damage and injury. Using the hand or knee as a hammer is a form of external tissue compression known as impact stress.

Vibration

Hand-arm vibration is vibration transmitted to the arms through the hands. It can damage both the small blood vessels and small nerves of the fingers, resulting in two specific injuries: vibration-induced white finger and vibratory neuropathy. Together, these injuries are known as the hand-arm vibration syndrome (HAVS) and result in numbness, loss of finger coordination and dexterity, clumsiness, and an inability to perform fine motor tasks. Blanching or loss of colour in the skin usually starts at the tips of the fingers but progresses as exposure time increases. The most important sources of vibration due to tools include grinders, sanders, drills, impact wrenches, jackhammers, riveting and chipping hammers, and chain saws.

While there is substantial evidence that whole body vibration is associated with lower back and neck injuries, identifying practical ways for employers to determine whether vehicles or other equipment produce hazardous exposures is difficult. Operators of off-road vehicles are likely to have the most hazardous exposures, depending on how long they work and the quality of the vehicle's suspension system, shock absorbers, seats, and tires.

In closing, a real world example

Repetitive motions and the forces exerted can add up rapidly over the course of a workday. What at first appears to be a simple job with little potential for

injury results in some startling numbers. This example comes from a real production line in operation in Alberta: Standing at their workstation, a worker fills a medium-sized plastic bag with fluid weighing 4 kg. Each bag is raised with the right arm and placed into a box that is held in the left hand. The worker performs 8 lifts/minute and because of staffing levels, only 2 workers share this job during the entire workday. On a normal day, 15 pallets of product are produced, the equivalent of 2,880 boxes/day for a total weight of 11,520 kg (25,344 lbs)! Workers can only perform their work from one side of the production line, meaning that they cannot switch arms for a break. Issues of importance in this example are the weight of the bag, the fact that the bag has an unsteady, moving centre of gravity, a pinch grip is required to hold the bag, only the right arm can be used to perform the lift, the left hand is used as a vice to hold the box, and the worker must often reach excessively.

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