26 Musculoskeletal Disorders

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Part I. Low Back Pain

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Work-related musculoskeletal disorders :ommonly involve the back, cervical spine, and upper extremities. Understanding of :hese problems has developed rapidly during :he past decade. The two sections of this :hapter provide an overview of these prob-ems and a framework for recognizing and preventing them.

Low back pain is one of the oldest occupa-ional health problems in history. In 1713, 3ernardino Ramazzini, the "founder" of oc-:upational medicine, referred to "certain vi-olent and irregular motions and unnatural postures of the body by which the internal tructure" is impaired. Ramazzini examined he harmful effects of unusual physical activ-ty on the spine, such as the sciatica caused y constantly turning the potter's wheel, umbago from sitting, and hernias among porters and bearers of heavy loads.

In addition to being one of the oldest occupational health problems, low back pain is one of the most common. Approximately 80% of workers experience low back pain sometime during their active working life. At any given moment, 10% to 15% of the adult U.S. population experiences low back pain (1,2). Back pain is the most frequent cause of activity limitation in people younger than 45 years of age, the second most frequent reason for physician visits, and the third ranking reason for surgical procedures. Approximately 11% of Americans report low back impairment or a reduced ability to function. Every year, about 2% of the employed population lose time from work because of low back pain, and approximately half of these people receive compensation for lost wages. Lost time from low back pain averages 4 hours per worker per year, and among medical reasons for work absence it is second only to upper respiratory tract infections.

Low back pain is clearly the most costly occupational health problem. Although 16% to 20% of all workers' compensation cases involve low back pain, these cases are responsible for 34% to 40% of the total costs. More than $16 billion (in direct costs) is spent each year on the treatment and compensation of low back pain in the United States (1). Including indirect costs, the total expenses for these back problems may be as

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Many different types of workers are prone to back problems. (Drawing by Nick Thorkelson.)

high as $50 to $80 billion (3). However, back pain expenses are not equally distributed; they are highly biased toward the more expensive cases—25% of low back pain cases account for more than 90% of the expenses. Most cases are relatively inexpensive. Psychological impairments accompany many of the more expensive cases, either preceding or in response to the physical disability. Therefore, in cases of chronic low back pain, both the medical and the psychological aspects must be addressed.

PATHOPHYSIOLOGY

Pain in the lumbosacral spine can result from inflammatory, degenerative, neoplastic, gynecologic, traumatic, metabolic, or other types of disorders. However, the great majority of low back pain is nonspecific and of unknown cause. Many theories regarding the origin of nonspecific low back pain have been proposed, but so far no one has been able to prove how and where the pain arises.

The intervertebral disc as a source of low back pain has attracted much attention, mainly for two reasons. Discs herniate and the herniated nucleus pulposus (HNP) is such an obvious, dramatic, and reputed cause of back pain and sciatica that most workers know, or know of, someone with this diagnosis. Furthermore, most workers know that a herniated disc may require surgical treatment and that the results vary. The second reason for attention to the disc is that it degenerates, and the degenerative process is readily visible on magnetic resonance images (MRI) and often on radiographs.

The significant focus on the disc as a source of back pain is unwarranted. In reality, herniated discs are responsible for only a minor share of back problems (1% to 5%). A herniated disc is a specific clinical entity characterized by pain radiating into one leg (sometimes both legs) and usually accompanied or preceded by low back pain. Physical examination often reveals the presence of one or more objective neurologic changes, such as reflex asymmetry, sensory change in the distribution of a nerve root, or muscle weakness. Additionally, the clinical diagnosis requires the presence of positive nerve root tension signs, for which the straight-leg raising test is most commonly used. Fewer than

1% of patients who have lumbar disc herniations have a massive extrusion of nuclear material sufficient to interfere with nerve control of bladder and bowel function (cauda equina syndrome). Although it is not common, the cauda equina syndrome is a true surgical emergency, because failure to decompress the lesion may result in permanent loss of bladder and bowel control. Most patients who meet the clinical criteria for HNP recover spontaneously from acute symptoms and have minimal residual functional or work capacity impairment.

Disc degeneration is not synonymous with back pain and, indeed, it is as common in those without as in those with low back pain. Disc degeneration, however, may predispose to herniations and to other clinical syndromes, such as "spinal instability" and spinal stenosis. All human spines degenerate with time. Most autopsy specimens show the onset of gross and microscopic evidence of intervertebral disc degeneration by the third decade of life. These pathologic changes are accompanied by alterations in the chemical composition of the disc, such as decrease in water content, increase in collagen, and decrease in proteoglycans. The onset of changes occurs earlier in life in men and occurs most commonly in the L4–5 and L5–S1 discs.

Radiographic changes indicative of disc degenerations, such as disc space narrowing and spinal osteophytes, lag behind the histologic and chemical events. The prevalence of these degenerative changes is the same in patients with and without low back pain. The presence of a narrowed intervertebral disc is not correlated with the risk for, or the presence of, a disc herniation. Nor does it provide an explanation of the patient's pain in most cases. This issue is of even greater importance in the interpretation of imaging studies such as computed tomographic (CT) scans and MRI studies. Disc degeneration is often present on MRI scans of workers in their 20s and 30s. As the disc degenerates, it usually bulges. The presence of disc bulging is equally common in those with and without a history of back pain. Furthermore, 20% to 30% of asymptomatic patients have evidence of disc herniation on these structural examinations, emphasizing the need to carefully correlate the patient's symptoms and signs with imaging studies. A positive image without appropriate clinical symptoms and signs is insufficient to make a clinical diagnosis.

Back sprains and strains are probably the most common causes of occupational low back pain. A strain is defined as a muscle disruption caused by indirect trauma, such as excessive stretch or tension. Sprains are actually specific to ligaments, but the terms *sprain* and *strain* are loosely interchanged. There is currently no available method to specifically diagnose a sprain or strain injury; these injuries usually are diagnosed by exclusion of other possible causes of pain. Animal studies have shown that strains heal rapidly (within weeks) and that the healing process, after the first few days, is positively influenced by controlled activation, defined as smooth movements within the normal range of the affected joint. The previously common recommendation of prolonged rest has been abandoned. Controlled activity leads to a more rapid recovery.

Other spinal diagnoses of relevance to occupational low back pain include spinal stenosis, spinal instability, facet syndrome, internal disc disruption, and spondylolysis/spondylolisthesis. A brief description of those entities is provided here; for detailed descriptions see references 3 and 4.

Spinal stenosis is defined as a narrowing of the spinal canal or nerve root foramina, or both. Diffuse narrowing of the spinal canal (central spinal stenosis) has many causes, but most commonly the stenosis results from degeneration with posterior osteophytes projecting into the spinal canal, hypertrophy of the articular facets, and buckling of the ligamentum flavum. Neurogenic claudication is a common symptom, as is pain on extension relieved by flexion. Reflex, motor, and sensory changes are often completely absent. Unlike lumbar disc herniations, nerve root tension signs (e.g., straight-leg raising test) are often negative.

A subgroup of patients with spinal stenosis have predominantly lateral recess or nerve root canal stenosis. This often is caused by a combination of facet hypertrophy and disc bulge, which reduces the exit space available at the affected disc level or levels and compromises the nerve root. These patients may present with disc hernia-like symptoms, particularly if only one level is affected. It is important to recognize the relation between spinal stenosis and disc herniations. When the spinal canal and lateral nerve root canals are narrowed, a relatively small disc herniation can produce clinically significant symptoms, such as radiculopathy, which would not have occurred if the canal had been of adequate dimensions. Therefore, preexistence of spinal stenosis can contribute to the development of symptoms caused by a disc herniation.

Spinal instability is an ill-defined entity characterized by recurrent episodes of low back pain and/or sciatica triggered by minor mechanical overloads. For definite diagnosis, a shift in the alignment of vertebrae observed on flexion-extension radiographs or other provocation radiographs is required. A special class of spinal instability comprises the gross instabilities caused by fractures, tumors, and infections. In these patients, flexion-extension radiographs usually are not necessary for diagnosis and can, in fact, be harmful, causing damage to the nerve structures.

Facet osteoarthritis can contribute to back pain. The role of the so-called facet syndrome has been deemphasized in recent years, because it appears not possible to classify it clinically with any certainty. Furthermore, specific treatment aimed at the facet joints has been largely unsuccessful.

Internal disc disruption is another syndrome for which the classification remains uncertain. Injections into the disc with contrast media (discography) should reproduce the patient's pain and also demonstrate disruption of the disc architecture. Although internal disc disruption probably exists, it should be considered a rare cause of occupational low back pain.

Spondylolysis (a defect in the neural arch) and *spondylolisthesis* (a forward displacement of one vertebra in relation to the underlying vertebra or sacrum), occurs most commonly at the L5–S1 level; it develops during adolescence, with little further risk of slippage in adulthood. It is generally believed to represent a fatigue fracture of the neural arch, occurring at a specific region (the pars interarticularis), that has failed to heal. Workers with spondylolysis are no more at risk for back pain than those without, whereas spondylolisthesis may render the worker somewhat more susceptible to low back pain. This is particularly the case when

TABLE 26-1. *Classification of Low Back Disorders*[a]

Classification	Symptoms
1	Pain without radiation
2	Pain + radiation to extremity, proximally
3	Pain + radiation to extremity, distally
4	Pain + radiation to upper/lower limb neurologic signs
5	Presumptive compression of a spinal nerve root on a simple roentgenogram (i.e., spinal instability or fracture)
6	Compression of a spinal nerve root confirmed by specific imaging techniques (i.e., computerized axial tomography, myelography, or magnetic resonance imaging) or other diagnostic techniques (e.g., electromyography, venography)
7	Spinal stenosis
8	Postsurgical status, 1–6 months after intervention
9	Postsurgical status, >6 months after intervention 9.1 Asymptomatic 9.2 Symptomatic
10	Chronic pain syndrome
11	Other diagnoses

[a] In addition to symptom classification, low back disorders are classified by duration of symptoms (<7 days, 7 days to 7 weeks, >7 weeks) and by working status at the time of the evaluation (W, working; I, idle).

From Spitzer WO, LeBlanc FE, Dupuis M, et al: Scientific approach to the assessment and management of activity-related spinal disorders: a monograph for clinicians. Report of the Quebec Task Force on Spinal Disorders Spine 1987;12(Suppl 7):S1–S59.

the olisthesis is grade 2 or greater—that is, the slip is more than 25% of the vertebra below.

A variety of classification systems have been developed for low back pain. The most comprehensive system is based on symptoms and was developed by the Quebec Study Group (5). Table 26-1 outlines the system, which is applicable to all anatomic regions of the human spine. Table 26-1 also notes two other important means for classifying low back disorders: duration of symptoms and working status. The Quebec Study Group states that acute symptoms are those that last 7 days or less; subacute symptoms last from 7 days to 7 weeks, and chronic symptoms last longer than 7 weeks. This is a convenient division that reflects the normal recovery period of patients with back pain. Work status is also important because of its influence on prognosis.

DIAGNOSIS

The cornerstones of diagnosis are the history and the physical examination (3,4). In most patients, this is the only evaluation necessary. Patients with recurrent or chronic symptoms, those with more severe back pain of an unrelenting nature, and those with neurologic deficits may require imaging, electrodiagnostics, or laboratory studies. The use of these tests should be based on specific indications derived from the history and physical examination, and the results must be correlated to the history and physical examination. Patients with chronic symptoms sometimes also need a psychological evaluation.

The history should contain information about present and previous symptoms, significant other medical diseases, and use of medications. The onset of the symptoms should be explored in detail, including recent trauma. Pain is the most important symptom. Its pattern, intensity, site, and distribution should be determined, as well as the factors that accentuate and relieve it. The time of day when pain is most severe should be ascertained. Worsening through the day suggests mechanical low back pain and is the most common pattern. Pain on arising in the morning, with improvement during the day, suggests an inflammatory condition. Pain that is most severe at night and awakens the patient is a sign of possible malignancy or infection. Pain distribution is critical for correct classification of patients, particularly when pain radiates down the leg. Dermatomal pain must be separated from referred or nonspecific leg pain.

Neurologic symptoms should be identified, including sensory changes such as numbness and tingling, subjective sense of lower extremity weakness, and changes in bladder and bowel control or sexual function. Loss of ability to initiate voiding and urinary or fecal incontinence are symptoms of a cauda equina syndrome that must be further evaluated with urgency. Progressive lower extremity weakness and "foot drop" are other symptoms requiring further evaluation.

Over time a series of symptoms and signs have been identified as "red flags" (Table 26-2). They are helpful in deciding which patients need emergency diagnostic tests or immediate referral.

The physical examination consists of inspection, palpation, range of motion measurements, and neurologic tests. Body movements, gait observations, and inspection of the patient's standing posture provide information on the severity of symptoms and allow an estimate of functional limitations. The range of motion, including flexion-extension, lateral bending, and axial rotation, are observed and measured. Examination of the lower extremities serves to determine the presence or absence of any significant joint deformities and to assess neurologic function. Hip motion should also be evaluated, because hip and spine problems are sometimes difficult to differentiate. Knee (quadriceps) and ankle (Achilles) reflexes should be obtained in the sitting or supine position. The knee reflex can be affected by an L4 root compression; the ankle reflex is medi-

TABLE 26-2. *The "Red Flags" of low back pain*

Possible condition	History	Physical examination
Fracture	Major trauma Minor trauma (older patient)	Intense tenderness
Tumor	Age <15 or >50 yr Known cancer Unexplained weight loss Night pain	
Infection	Recent fever or chills Recent bacterial infection (urinary tract infection) Intravenous drug use Immune suppression Unrelenting pain	Intense tenderness Fever
Cauda equina syndrome	Saddle numbness Urinary retention, incontinence Severe (progressive) neurologic deficit in legs	Weak anal sphincter Perianal sensory loss Major motor weakness

ated primarily by the S1 nerve root. Nonspecific loss of sensation must be differentiated from well-defined dermatomal loss. Motor function is also grossly evaluated. The strength of the extensor hallucis longus is typically affected by an L5 nerve root compression. Because more than 90% of all neurologic low back pathology involves the L4, L5, and S1 nerve roots, the two reflexes (knee and ankle), one strength test (extensor hallucis longus), and a sensory examination are sufficient for screening purposes.

The evaluation of nerve root tension signs is important. The straight-leg raising test is the test most commonly used. It is positive when sciatica (posterior leg pain) is reproduced. The degree of elevation at which the symptoms occur is recorded.

At the completion of the history and physical examination, decisions regarding the need for further diagnostic tests can be made and an initial therapeutic plan formulated. For most patients, further diagnostic studies are not required. Additional evaluation of the patient depends on symptom response to treatment and the severity of any remaining symptoms. The diagnostic tests under consideration fall into two categories: those performed to detect physiologic abnormalities and those performed to detect anatomic abnormality and provide anatomic definition. Tests of physiologic dysfunction include laboratory tests, bone scans, and electrodiagnostic studies (electromyography). Anatomic tests include radiology and other imaging studies (CT, MRI, and myelography). In selected cases a psychological evaluation may also be required.

Radiographs are commonly used, but as a screening tool they have limited value. Degenerative changes are nonspecific and often are unrelated to the patient's pain. A variety of other imaging techniques, as indicated previously, are now available to assess patients who fulfill criteria for their use. These tests allow assessment of the anatomy of the spinal canal and its contents. These tests should not be used routinely in patients with low back pain, but only when indicated, based on the patient's history and physical examination. In other words, these tests are used to confirm a clinical suspicion. The basic principle is that anatomic images are only as valid as their correlation with clinical signs and symptoms. This is important because imaging abnormalities are common in people who have never had low back symptoms or sciatica. Further, in addition to clinically significant abnormalities, a number of other findings of questionable or unknown importance are commonly observed. These include disc bulging and disc degeneration, which are both nonspecific. Other diagnostic tests are more rarely indicated (5). Laboratory tests are rarely helpful. A bone scan is an excellent screening test when there is clinical suspicion of tumor, fracture, or infection. Electrodiagnostic tests (electromyography, somatosensory evoked potential, and nerve conduction velocity) are indicated only when there is strong suspicion of neurologic involvement, but the neurologic examination and imaging studies are unclear.

RISK FACTORS—HIGH-RISK JOBS

It is difficult to determine the relation between occupational factors and low back pain because (a) low back pain is not easily defined and classified; (b) sickness absence and other disability data are influenced not only by pain but also by physical and psychological work factors, social factors, and insurance systems; (c) there is a poor relation between tissue injury and disability; (d) the "healthy worker effect" influences data; and (e) exposure is difficult to determine. The retrospective assessment of exposure in most studies limits casual interpretation.

The seven most frequently discussed factors are listed in Table 26-3 (2,6). The six physical work factors have been experimentally associated with the development of injuries in spinal tissues. The seventh, psychological and psychosocial work factors, is probably more related to back disability than to an actual back injury.

There is presently an enormous body of data implicating heavy work in increasing the risk of back pain, sciatica, and disc herniations. Most investigators are using sickness absence and injury reports as their sources; therefore, their studies reflect not only back pain but also disability caused by back pain. However, some studies are based on questionnaires, interviews, and even disc hernia operations. Several countries report similar data. One study of occupational safety and health data from the United States found significantly higher rates of back sprain or strain among workers in heavy industries and in physically demanding occupations (7). These data were confirmed in other populations (2,8). In another study, injury rates were related to predicted spine compression forces in 55 industrial jobs. Back pain was twice as common if the predicted disc compression was greater than 6,800 N (1,500 lb) (9).

TABLE 26-3. *Occupational factors associated with an increased risk of low back pain*

Heavy physical work
Static work postures
Frequent bending and twisting
Lifting, pushing, and pulling
Repetitive work
Vibration
Psychological and psychosocial stress

Static work postures include primarily long-term sitting, which appears to increase the risk of low back pain and which, in combination with driving, increases the risk of disc herniation (2,10-12) Frequent bending and twisting are usually associated with lifting when reported as causes of back injuries. However, one study found low back pain to be associated with asymmetric postures in a car assembly plant even when lifting was not performed (13).

Lifting is a well-known triggering event for back pain (2,14-17). One study compared workers who performed heavy manual lifting with sedentary workers; the odds ratio was 8 (18). Insurance company data indicate that a worker is three times more susceptible to compensable low back pain if he or she performs excessive manual handling tasks (19). Associations between prevalence of low back pain and lifting have also been established by others (15-17,20). Another study found that disc herniations were more frequent among subjects who had to lift, particularly when lifting was performed in a bent and twisted posture (odds ratio, 6) (21).

Low back pain is more frequent in vehicle drivers than in control subjects, implicating vibrations (perhaps in combination with the sitting posture) as a cause. One study found truck drivers to have a fourfold increased risk of disc herniations, whereas simple car commuting increased the risk by a factor of 2 (22). Other studies also indicate an increased risk of low back pain with vibration (2). Another study found that the risk of being hospitalized for HNP in Finland was particularly high for professional motor vehicle drivers (23). Studies of vehicle drivers have disclosed that radiographic changes occur over time (2).

Psychological and psychosocial work factors have received increasing attention because of their effect on low back disability. Monotony has been identified as a risk factor for back pain, (15) as has poor work satisfaction (14,15). Investigators concluded, based on the Boeing study, that psychological work factors were more important than physical factors as risk indicators of filing worker's compensation claims for low back pain (14,24).

MANAGEMENT

The management of patients with low back problems has undergone major changes over the last decade (3,4,25). In general, patients recover from an acute episode in days to a few weeks and require little treatment (Fig. 26-1) (5). If symptoms continue, physical activity is now recommended, whereas rest was often prescribed in the past.

Early treatment should include (a) information about back pain and its excellent prognosis; (b) help with control of symptoms, including medication and advice on activity; and (c) a reassessment plan. Many patients are concerned about a back problem when it first arises and have misconceptions about its natural history and effect on their future lives. This fear can be eliminated by appropriate information. Symptom control is typically achieved by medication, but manipulation can also have beneficial effects in the acute stages of the problem. Analgesics and nonsteroidal antiinflammatory drugs (NSAIDs) are the medications that are most frequently used. Muscle relaxants can cause drowsiness and appear to be no more effective than NSAIDs.

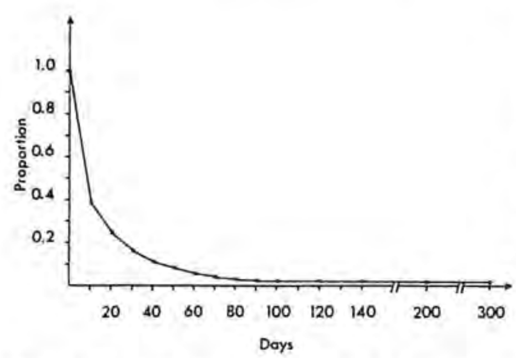

FIG. 26-1. The recovery rate after a back injury is rapid. The figure shows the proportion of people who were absent from work at different times after first reporting sick. (From: Andersson GB, Svensson HO, Oden A. The intensity of work recovery in low back pain. Spine 1983;8:880–884.)

Activity advice is critical. Some degree of activity restriction is often necessary to reduce symptom severity. This can often be accomplished by modifying work activities and work postures, while allowing the patient to continue working. Bed rest should be advised only in more severe cases, and then for no more than 2 to 3 days (26). Early return to work is critical to prevent prolonged disability and should be emphasized as being part of the recovery process. Activity recommendations (restrictions) may include limitations on lifting, twisting, and bending, and on the duration of sitting, standing, and walking (3). Restrictions should remain in place only for a short period. The beneficial natural history should allow unrestricted return to work after several weeks.

Many treatment alternatives have been and are being used in the treatment of acute low back pain, but few have been rigorously studied for treatment effect (5,25,27). There is no evidence that physical therapy modalities influence the natural history of recovery, although the patient many sometimes feel temporary relief. The medical literature also does not support benefits from the use of transcutaneous electrical nerve stimulation (TENS), corsets, traction, acupuncture, or biofeedback in the treatment of acute low back pain. Corset use may allow the patient to return to physical activities (e.g., lifting) earlier, but it does not affect long-term results. Back schools provide an efficient method of education but not an effective treatment method. Manipulation appears to hasten recovery in patients with acute low back pain without radiculopathy, when it is used in the first 4 weeks of symptoms. Manipulations should not be used in patients with neurologic deficits and should not be continued if a few attempts are unsuccessful.

Surgery is almost never indicated in the first 6 to 12 weeks, but it should then be considered for patients with severe persistent sciatica that has not responded to conservative treatment and when the findings on clinical examination and confirmatory diagnostic tests indicate nerve root compromise (28). The cauda equina syndrome remains the exception: it should be addressed surgically without unnecessary delay. Simple disc surgery does not prevent return to physically demanding jobs.

PROGNOSIS

Nonspecific low back pain is a self-limited disorder that resolves rapidly in more than 90% of cases (see Fig. 26-1). Approximately 40% of the patients recover within 1 week, 80% within 3 weeks, and 90% within 6 weeks, regardless of treatment. The rate of recurrence, however, is very high—estimates range up to 50% in the year following the first episode. A British study indicates that the probability of low back pain is almost four times greater in people who have had previous episodes of low back pain (29). A Swedish study found that industrial workers who have a first-time episode of low back pain have a 28% chance of a new episode during the next year (30).

At the onset of low back pain, it is difficult to predict which patients will require longer than 6 weeks to recover. Among factors that negatively influence recovery are the presence of leg pain, compensation, older age, a specific diagnosis, psychological factors, physical work factors, and socioeconomic factors. Because the interactions among these factors are complex, none of them is a particularly useful predictor of chronicity. If workers have been off the job for longer than 6 months, it is estimated that there is only a 50% possibility of their ever returning to productive employment; if disabled for longer than 1 year, only a 25% chance; and 2 years, almost none (31). The last decade has witnessed the development of comprehensive treatment programs that have improved on these data using various types of pain treatment and activation programs, but the prognosis after long work absence still remains poor (32).

Early return to work is now considered an important part of the therapy. However, there are many reasons why patients do not go back to work. The obstacles to early return to work include (a) lack of patient motivation, (b) illness behavior, (c) the problem of identifying and providing modified work, (d) unwillingness by employers to accept workers back unless they are fully recovered (despite evidence that accepting a partially recovered worker may be less costly and more effective in promoting recovery than continued disability), (e) difficulties imposed by rigid work rules, (f) inappropriate treatment by practitioners or prolonged use of ineffective treatment, and (g) legal advice to accept a "lump sum" settlement instead of a rehabilitation program designed to return the patient to work. The physician should be aware of these situations and recognize their relative importance in each case of low back pain.

PREVENTION AND CONTROL

Prevention of work-related low back pain is a complex challenge (33,34). Low back pain prevention in work settings is best accomplished by a combination of measures that are listed in Table 26-4. Low back pain can be controlled by reducing the probability of the initial episode, reducing the severity of the symptoms, reducing the length of disability, and reducing the chance of recurrence.

It is estimated that good ergonomic design can eliminate up to one-third of cases of compensable low back pain in industry (see Chapter 9) (20). Not only can good job design reduce the probability of initial and recurring episodes; it also allows the worker with moderate symptoms to stay on the job longer and permits the disabled worker to return to the job sooner. Good ergonomic design reduces the worker's exposure to the risk factors of low back pain through the following:

TABLE 26-4. *Prevention of low back pain*

Job design (ergonomics)
Mechanical aids
Optimum work level
Good workplace layout
Sit/stand work stations
Appropriate packaging
Job placement (selection)
Careful history
Thorough physical examination
No routine radiographs
Strength testing
Job-rating programs
Training and education
Training workers
Biomechanics of body movement (safe lifting)
Strength and fitness
Back schools
Training managers
Response to low back pain
Early return to work
Ergonomic principles of job design
Training labor union representatives
Early return to work
Flexible work rules
Reasonable referrals
Training health care providers
Appropriate medication
Prudent use of radiographs
Limited bed rest
Early return to work (with restrictions, if necessary)

FIG. 26-2. Automotive worker at risk of low back injury. (Photograph by Earl Dotter.)

1. Mechanical aids (powered or manual) to assist with heavy weights and forces (Figs. 26-2 and 26-3)
2. Optimum work level to reduce unnecessary bending and stretching (Fig. 26-4)
3. Good workplace layout to reduce unnecessary twisting and reaching (Fig. 26-5)
4. Sit/stand work stations to reduce prolonged sitting and standing
5. Appropriate packaging to match object weights with human capabilities
6. Good work organization to reduce repetitive high loading and fatigue
7. Good chairs to support the back properly.

The National Institute for Occupational Safety and Health (NIOSH) has provided guidelines for evaluating and designing manual lifting tasks (35,36). Guidelines for other manual-handling tasks, such as pushing, pulling, or carrying, have also been developed (37).

FIG. 26-3. Overhead hoists and lifting attachments. Overhead hoists with specially designed lifting attachments to fit the objects being handled eliminate the awkward manual handling tasks. This C-shaped attachment allows quick and easy placement of heavy rolls on a tire-building machine. (From Liberty Mutual Research Center, Hopkinton, Massachusetts.)

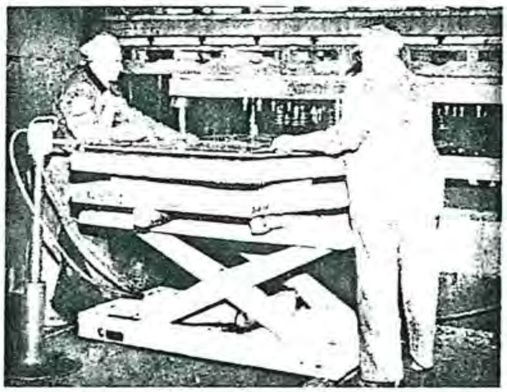

FIG. 26-4. Scissors lift. Hydraulic scissors lifts have a variety of uses in industry to position the workpiece so that a minimum of effort must be used to perform the operation. They can place the workpiece at the proper height to convert lifting and lowering tasks to carries or pushes. (From Liberty Mutual Research Center.)

Considerable attention and hope has been placed on the use of "lifting belts" as a means to reduce back injuries from lifting. Currently, there are insufficient data on the use of these belts to make recommendations on a scientific basis. The mechanical effect of the belts is unclear, but with respect to spinal loading it appears to be minor. Studies suggest that an initial beneficial effect on back injury reporting may occur, but the data remain preliminary and short-term. As we understand today, there are no direct negative effects of belt use, although long-term effects on trunk muscles have been discussed as a possible disadvantage (38–40).

Although job design may be applicable to many manufacturing operations, there are other jobs that are difficult to design and control, such as firefighting, police work, and certain construction and delivery operations. These jobs require greater dependence on preplacement testing and selection of workers (3,32,41). In the past the preemployment medical examination was used in many industries, especially since the enactment of workers' compensation laws. The introduction of the Americans with Disabilities Act changed this situation. Preemployment examinations are no longer acceptable, but preplacement examinations continue to be used to determine whether the worker, once hired, is capable of performing a specific job.

Many authorities believe that the medical history is the most important part of the medical examination for identifying workers who are susceptible to future low back pain (41). Use of this information to prevent back pain occurrence is difficult, however, because back pain is so common and its effect on an individual so variable.

Routine radiographs of the lumbar spine have often been part of the preplacement medical examination, but the preponderance of evidence indicates that the small yield does not justify the radiation exposure or increased cost. According to guidelines issued by the American College of Occupational and Environmental Medicine, lumbar spine radiologic examinations should not be used as a risk assessment procedure for back problems.

FIG. 26-5. Work dispensers are self-leveling devices designed to keep parts at a particular height, eliminating the need to bend over to pick up or release an item. Models are available that use trays or pans or provide for bulk-dispensing of small parts. The dispensers are portable and may be wheeled from station to station, eliminating the need to lift, carry, and lower trays and individual parts. (From Liberty Mutual Research Center.)

Several studies have demonstrated the relation between strength or fitness and the incidence of low back pain (9,32,42). Studies of isometric strength testing have shown that the probability of a musculoskeletal disorder is up to three times greater when job-lifting requirements approach or exceed the worker's isometric strength capability (9). A Danish study revealed that men who experienced low back pain for the first time had lower isometric endurance of the back muscles measured up to 1 year before the episode (42). In women, however, such lower endurance had no predictive value. Although isometric strength testing may be an effective selection technique, it should be used only for jobs that are difficult to design or control and for which a careful ergonomic evaluation has been made (3). Strength testing should never be used as a substitute for good job design. Furthermore, it should be used only when the job has been thoroughly analyzed so that the test truly reflects the demands of the work. Strength testing under a general protocol does not appear to be effective in preventing back injury reports (14).

Training and education are the oldest and most commonly used approaches for reducing low back pain in industry (3,32). Safety and personnel departments have typically used education and training to instruct employees in proper methods and work procedures. For example, training of workers in the biomechanics of safe lifting has been a part of safety programs in industry for more than 50 years. However, according to NIOSH, the value of training programs in safe lifting is open to question because there have been no controlled studies showing consequent decreases in rates of manual-handling accidents or back injuries (35). A major problem is compliance; even after training, most workers do not lift correctly because it is a more difficult way to lift. Greater compliance with training occurs with workers who have (or have had) low back pain. Exercises to increase strength and fitness have been a part of low back pain treatment programs for many years, but only recently have strength and fitness programs been advocated in industry to reduce or prevent the onset of low back pain.

The back school is an attempt to educate the worker in all aspects of back care; it represents a much more comprehensive approach to back care that includes the previous topics of safe lifting, strength, and physical fitness. The original concept of the back school was to educate patients who already had (or had recently had) low back pain—that is, it was a form of treatment. A more recent use of the back school has been to educate workers on how to prevent low back pain. However, no controlled study has shown the effectiveness of such a school as a preventive technique for workers (33,34).

Training of managers is as important as training of workers, both for primary and for tertiary prevention. Long-term disability is associated with adversary situations, litigation, hospitalization, and lack of follow-up and concern. Many of these situations can be alleviated by training foremen, supervisors, and upper-level managers in appropriate responses to worker complaints of low back pain. Also important is providing modified, alternative, or part-time work as a means of returning the worker to the job as quickly as possible.

A program in which management was trained in positive acceptance of reports of back pain has been described (43,44). An atmosphere was created in which workers were encouraged to report all episodes of low back pain—even minor episodes—to the company clinic. Immediate and conservative in-house treatment, including worker education, was provided by the company nurse. Attempts were made to keep the worker on the job—often with modified duties or a redesigned job. If necessary, referrals were made to the company physician, who closely monitored treatment and progress. Over a 3-year period, annual workers' compensation costs for low back pain claims were reduced from more than $200,000 to less than $20,000. Although this was not a controlled study, the results were impressive.

In addition to training for managers, efforts to incorporate union leaders into prevention efforts is important. Early return to work should be encouraged as an important part of the treatment of low back pain. Unions can often assist in the recovery of their members by allowing early return to work through flexible work rules and referrals to clinicians and lawyers who will not unnecessarily prolong the disability.

Company medical personnel should be trained in the benefits of early intervention, conservative treatment, patient follow-up, and job placement techniques. Both physicians and nurses should be familiar with recent literature that objectively evaluates various types of treatment for low back pain. Medical personnel should also become familiar with the physical demands of jobs performed in the company so that they can adequately place both injured workers and new employees.

The effectiveness of a standardized approach to the diagnosis and treatment of low back pain in industry has been demonstrated (32,45). This approach was used to monitor the course and treatment of low back pain. If there was any disagreement between the investigators (who were orthopedic surgeons) and the treating physician, they discussed the case together in detail. Usually, they reached an agreement; if they did not, another physician was consulted for an independent opinion. This program dramatically decreased the number of low back patients, the number of days lost, and the number of patients sent to surgery.

Although knowledge of low back pain is limited, enough is already known to adequately control the problem in industry. Instead of waiting for a major medical breakthrough to occur, emphasis should be placed on applying the knowledge that is already available. Low back pain control requires the combined efforts of workers, managers, unions, nurses, physicians, and others.

Part II. Work-Related Disorders of the Neck and Upper Extremity

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A 31-year-old, right-handed man had been employed in a variety of automobile manufacturing jobs for 13 years. Two years ago, he switched to a new plant and was assigned to a job that required him to manipulate a spot-welding machine beneath cars moving overhead. He had 1 minute to complete four welds on each car. The spot welder, which had metal handles, required substantial force for appropriate positioning, and it had to be repositioned four times for each car. The worker's wrists were in complete extension for a substantial portion of the job cycle.

When the worker started on this job, the weekday work shift was 9 hours long and Saturday work was required in most weeks. After 3 weeks on the job, he noted that he had pain in both wrists. He also noted numbness and tingling in the first four fingers of his left hand, at first only at night, a few nights each week, after he had fallen asleep. When he awoke at night with the numbness, he would get up and walk around shaking his hands; in about 10 minutes he would be able to go back to sleep. Gradually, over the next several months, the numbness and pain worsened in both frequency and intensity. His left hand would feel numb by the end of the workshift, and any time he was driving his hands would become numb. Because he liked his job and did not want to be placed on restriction, which would mean he could not work overtime, he decided to visit his private physician rather than the company physician. He also was not sure that the company physician would be very sympathetic to his complaints.

The physician found on physical examination that the worker had decreased sensitivity to light touch in the left index and middle fingers and a positive Phalen's test of the left hand. She suspected carpal tunnel syndrome (CTS) and believed that the disorder might be work-related because the patient was young, male, and had no other risk factors, such as diabetes, past history of wrist fracture, or recent trauma to the wrist. The physician discussed job changes with the patient. She also prescribed wrist splints to be used at night.

The splints relieved some of the nighttime numbness for a period. However, over the next 6 months, the patient's symptoms began to be present all of the time, and he thought that his left hand was becoming weaker. Similar symptoms also developed in his right hand.

The patient felt he could no longer do his job and returned to his physician. She referred him to a hand surgeon and ordered nerve conduction tests. The tests showed slowing of sensory nerve impulse conduction in the median nerve in the region of the carpal tunnel, more so on the right than the left.

One year after the problem was first noted, the worker had surgery, first on the left hand and then on the right. After surgery, the company placed him in a transitional work center for a 3-month period, where he worked at his own pace and had no symptoms. He then returned to the assembly line with the restriction that he not use welding guns or air-powered hand tools. When he worked on the line, he occasionally had symptoms, but they were substantially less intense and less frequent than before.

He later transferred to a warehouse, because he felt that he would have a better chance of avoiding long layoffs there. His job required use of a stapling gun to seal packages. Three weeks after beginning this job, his symptoms began to return with their former intensity. Through ordinary channels, he immediately sought and was given a transfer to a position driving a fork lift truck. This change reduced, but did not eliminate, his symptoms. Currently, he has numbness, tingling, and pain in the fingers of both hands about twice a month. Playing volleyball usually triggers a severe attack. With the use of nighttime splints, he can sleep through most nights without awakening. Although he believes that his hands are weaker than before the symptoms developed, he still is able to perform his job. He has decided that he will continue working as long as the symptoms remain at no more than the present level.

This case illustrates the intermittent and progressive nature of most work-related disorders of the upper extremity, and particularly of carpal tunnel syndrome (CTS) (46), the best known of the common work-related disorders of the upper extremity. Other examples of these disorders that may be related to work include de Quervain's disease (47), epicondylitis, shoulder supraspinatus tendinitis (48,49), and tension neck syndrome (50). This family of disorders may involve muscles (tension neck syndrome), tendons (supraspinatus), joints (degenerative joint disease), skin (calluses), nerves (CTS), or blood vessels (hand-arm vibration syndrome, or Raynaud's phenomenon of occupational origin). (See appendix to this chapter.) (51,52)

MAGNITUDE AND COST OF THE PROBLEM

The only national source of data about the magnitude of work-related musculoskeletal disorders is the Bureau of Labor Statistics (BLS) Annual Survey of Occupational Injuries and Illnesses (53). This is a federal/state program in which employer reports are collected from about 165,000 private industry establishments. The survey excludes the selfemployed, farms with fewer than 11 employees, private households, and employees in all governmental agencies. Each episode is classified as an illness or injury.

Illnesses or injuries that result in days away from work are classified on several bases, including (a) the associated events or exposures, such as a fall or overexertion; (b) the nature of the injury or illness, such as sprain, strain, or CTS; and (c) the source of injury or illness, such as machinery, worker motion, or worker position. Some of these categories probably represent illnesses and injuries caused by physical stressors at work, such as repetitive movements of the hands or lifting of objects. Decisions about the event or exposure that results in injury or illness are based on the validity of the employer's description of the associated events and decisions made by the coder and therefore should not be considered scientific causal inferences. Because the survey is confidential, which promotes accurate recording by employers, it is useful for identifying surveillance associations. A worker's or employer's ecision to report may be influenced by personal, cultural, administrative, peer pressure, r economic factors (54). The accuracy of the urvey depends on the interplay of complex ıctors, making it difficult to interpret time ends. The rate of illnesses or injuries that esult in days away from work has declined or 7 consecutive years. This trend has occurred among most types of injuries and illesses, including musculoskeletal disorders.

The BLS survey also tracks the number of ises of certain illnesses and injuries. Beeen 1992 and 1996, injuries and illnesses sulting in days away from work declined out 20%, and the number of CTS cases opped slightly more than 10% (to 29,900 ses) over the same period. The decrease ıs less for amputations and fractures. Some the decline in the overall trend for cases th days away from work may be explained a modest increase in the rate of cases volving work restrictions (e.g., shortened urs, no heavy lifting). There is little evince that underreporting has increased. No gle factor explains the reduction. However, increases in health and safety activities by private-sector firms, brought about after increases in workers' compensation costs and changes in Occupational Safety and Health Administration (OSHA) activities, may have contributed to these declines (54).

All disorders and injuries involving lost time identified in the annual BLS survey are classified based on the following question: What was the employee doing just before the incident occurred? Repetitive motion is one of the many narrowly-defined categories that trained survey coders record based on the employer's response to this question. Cases are classified as resulting from repetitive motion if a bodily motion such as typing or key entry, repetitive use of tools, or repeated grasping of objects other than tools is considered by the coder to be related to the illness or injury. Another event category that is relevant to estimating the number of work-related musculoskeletal disorders is overexertion, as in maneuvering especially heavy or bulky objects, such as cartons of soft drinks. In 1996, the BLS survey reported that about 74,000 (3.9%) of the almost 1,900,000 cases were coded as being associated with repetitive motion, most commonly in the upper extremities (shoulder, hand, and wrist) (53,55). In comparison, 311,900 cases (16.6%) were coded as being associated with overexertion in lifting, pulling, pushing, or other activities; approximately two-thirds of these were back injury cases. The survey also collects information on the duration of absences from work. For all cases, the median is 5 days; for CTS cases, it is 25 days. Although these numbers do suggest that back injuries caused by lifting and other manual-handling activities are a larger problem, upper-extremity disorders and injuries are clearly major problems. In 1994, there were about 48,000 cases of shoulder injury associated with overexertion from lifting, carrying, pulling, or pushing objects, and about 51,000 wrist cases were associated with repetitive motion (55).

The BLS data not only provide information on the magnitude of the work-related musculoskeletal problem, but they also can be useful in identifying industries that contain many jobs with higher levels of exposure to repetitive tasks and manual-handling activities (55). In 1994, several industries had rates of overexertion disorders that were significantly higher—more than three times higher than the average rate for private industry (7.6 cases per 1,000 workers). These include nursing and personal care facilities; scheduled air transportation; manufacturers of travel trailers and campers, food products machinery, soft drinks, and mattresses; wholesaling of alcoholic beverages; and coal mining. Similarly, several industries had significantly increased rates of injuries and disorders associated with repetitive motion—more than seven times higher than the average rate for all private industry (1.2 cases per 1,000 workers). These industries include a number of clothing manufacturing sectors (e.g., knit underwear mills, male workclothes) and other manufacturing industries, including potato chips, motor vehicles, and meat-packing plants. More than 3.5 million workers were employed in these high-risk industries, but not all of them were in high-exposure jobs. However, other industries, such as trucking and courier services, with more than 1.6 million workers, had rates of overexertion disorders that were almost three times higher than the average rate for all private industries.

The BLS survey, like most surveillance data systems, has some degree of misclassification or error in the information on exposure and health outcomes. Nevertheless, industries with consistently increased rates are likely to contain a substantial number of high-risk jobs. Overexertion in lifting, other types of overexertion, and repetitive motion were associated in 1996 with about 600,000 illnesses and injuries, most involving the back or upper limbs.

More information about the prevalence of some specific disorders of the upper extremity and the costs of these disorders is provided by workers' compensation data from Washington State (56). Workers' compensation data for 1989 to 1996 were used to identify all the accepted musculoskeletal claims; these claims were categorized specifically (rotator cuff syndrome, epicondylitis, CTS, and sciatica), based on physician diagnoses. Other, less specific musculoskeletal disorders of the upper extremity and back were also identified. An effort was made to determine whether the onset was acute (e.g., after a fall) or gradual. Gradual-onset disorders represented 67% of the back claims, and 36% of the upper-extremity claims. The claims incidence rate for gradual-onset back disorders was 16 per 1,000 workers, and for gradual-onset upper-extremity problems it was 9 per 1,000. The claims incidence rates for the specific disorders of the upper limb were approximately 2 per 1,000 workers for rotator cuff syndrome, 1 per 1,000 for epicondylitis, and 3 per 1,000 for CTS. The percentage of all claims that were for musculoskeletal disorders remained constant over the 8-year period. The rates from these data are higher than those from the BLS data, suggesting some degree of underreporting in the latter program. Workers in industries with widespread manual-handling tasks, such as nursing homes, several construction activities, and garbage collection, had the highest incidence rates for back and shoulder disorders. Workers in industries with highly repetitive work, such as wood product manufacturing or fruit and vegetable packing, were at highest risk for CTS and epicondylitis. One group of workers who appeared to be at increased risk were those in the rapidly growing temporary-help industry. The data suggest that these workers are being placed in high-risk jobs.

Overall, the three specific diagnoses for upper limb disorders accounted for about one-third of upper-extremity injuries and illnesses. The Washington State data suggest that, in addition to CTS, both epicondylitis and particularly rotator cuff injuries are also common disorders that deserve more study and greater efforts at prevention. This finding underlines the conclusion that, although back disorders are more common than upper limb disorders, work-related upper limb disorders are often serious enough to result in workers' compensation claims—in about 1 of every 100 workers per year.

The Washington State data also allow the development of a national estimate of the cost of gradual-onset disorders of the back and upper extremity. For the 96 million workers in the United States covered by OSHA, the estimated direct cost for gradual-onset back disorders ranges from $1 to $17 billion, depending on whether one uses the average or the median cost for each Washington State claim. For upper-extremity disorders, the range is from $291 million to $6.7 billion (56). These figures do not consider the indirect costs to employers for lost productivity or training of replacement workers—nor do they consider the costs to workers and their families that are not covered by workers' compensation.

Although the precise cost and prevalence of work-related musculoskeletal disorders of the upper extremity is unknown, they are among the most common occupational disorders. Typical annual incidence rates for CTS, epicondylitis, and rotator cuff syndrome in workplaces with an average level of risk should be less than 1 per 100 workers. Both the Washington State and BLS data show an overall decline for all illnesses and injuries and a trend toward a higher proportion of workers with injuries and disorders remaining on the job. The overall decline results from the interplay of several factors, such as changes in the nature of work and more effective prevention efforts. The trend for more affected workers to be able to remain on the job may have resulted from either changes in treatment or greater use of work restrictions and alternative work placements (54).

Pathophysiology

Clinical, laboratory, and epidemiologic studies all have contributed to the current understanding of the pathophysiology of work-related musculoskeletal disorders of the upper extremity and neck.

Although the current level of knowledge is incomplete, it nevertheless guides both treatment and preventive strategies. Five workplace physical factors are important in the etiology of these disorders: repetitive motions, forceful motions, mechanical stresses, static or awkward postures, and local vibration (Fig. 26-6). The effects of these physical load factors probably can be exacerbated by workplace psychosocial factors, such as the perception of intense workloads, monotonous work, and low levels of social support at work (55). In assessing the role of workplace factors, it is important to consider the duration, frequency, and intensity of the individual and combined factors.

Repetition and Force

Repetitive motions of the hands, wrists, shoulders, and neck commonly occur in the workplace. A data-entry operator may perform 20,000 keystrokes per hour; a worker in a meat-processing plant may perform 12,000 knife-cuts per day; and a worker on an assembly line may elevate the right shoulder above the level of the acromion 7,500 times per day. Such repetitive motions may eventually exceed the ability of the individual to recover from the stress, especially if forceful contractions of muscles are involved in the repetitive motions.

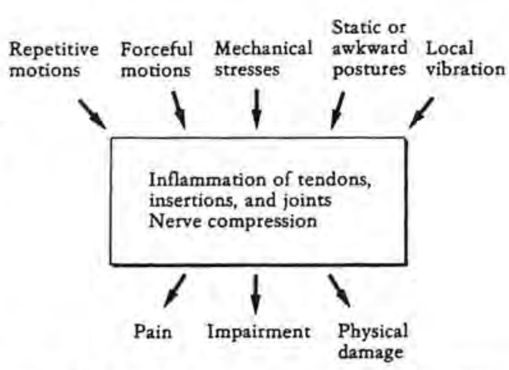

FIG. 26-6. Schematic representation of pathophysiology of work-related disorders of the upper extremity and neck.

Failure to recover usually implies some type of tissue damage or dysfunction ("tissue reaction to injury"), which may represent acute inflammation and may be totally reversible. Tissue damage may even lead, over time, to improved function—a "training effect." Acute damage to muscle from overexertion often leads to muscle hypertrophy. In work-related musculoskeletal disorders, the sites of likely tissue damage are most commonly tendons, tendon sheaths, and tendon attachments to bones, bursae, and joints. It is probable that, over time, these tissue changes can in some cases lead to nerve compression (CTS), chronic fibrous reaction in the tendon, tendon rupture (rotator cuff injury), calcium deposits, or fibrous nodule formations in a tendon, leading to a trigger finger (57).

Abrupt increases in the number of repetitive motions performed by a worker each day are well recognized clinically as a cause of tendinitis (58). Too many forceful contractions of muscles can cause corresponding tendons to stretch, compressing the microstructures of the tendons and leading to ischemia, microscopic tears in tendons, progressive lengthening, and sliding of tendon fibers through the ground substance matrix. All of these events can cause acute inflammation of tendons. The process by which these acute changes evolve over time to the more common chronic picture of damage, such as that observed during carpal tunnel surgery (59), is not well understood. Both laboratory and epidemiologic studies have provided substantial evidence that high levels of exposure to the combination of repetitive and forceful movements is strongly associated with several musculoskeletal disorders of the upper extremity (55,60).

An important but inadequately investigated question is whether the repetitive stresses to the joints of upper limbs that occur in some occupations lead to accelerated development of localized osteoarthrosis. Because localized osteoarthrosis is not a specific disease but the final common pathway of biomechanical and pathologic changes in cartilage, subchondral bone, and bone surrounding joints, it is reasonable to assume that repetitive stresses accelerate its development (51).

Repetitiveness has a number of components to be considered, including the velocity and acceleration of movement and the amount of recovery time within any repetitive cycle or task.

Posture, Stress, and Vibration

In addition to repetitive and forceful motions, three other exposure variables that influence the development of work-related musculoskeletal disorders are external mechanical stress, work performed in awkward or static postures, and segmental (localized) vibration.

Mechanical stress in tendons results from muscle contractions or from compression of a tendon or other tissues by contact between the body and another object. One of the major determinants of the level of the mechanical stress is the force of the muscle contractions. For example, a pinch that is very forceful is more stressful than one that is not very forceful. Another source of mechanical stress results from work surfaces or hand-held tools with hard, sharp edges or the ends of short handles that press on soft tissues. The tool exerts just as much force on the hand as the hand does on the tool. These stresses can lead, for example, to neuritis associated with the forceful contact between the edge of scissors handles or bowling ball holes with the sides of the fingers or thumb, and to cubital tunnel syndrome in microscopists who must position their elbows on a hard surface for long periods. Short-handled tools (e.g., needle-nosed pliers) that dig into the base of the palm exert as much force on the hand, particularly on the superficial branches of the median nerve, as the hand does on the tool.

Work performed in awkward or static postures is another important influence on the development of work-related musculoskeletal disorders. The level of mechanical stress produced by a muscle contraction varies with the posture of a joint. For example, the amount of force that can be exerted in a power grip is greatly reduced as the wrist moves from a neutral to a flexed position. Work with the arm elevated more than 60 degrees from the trunk is more stressful for the rotator cuff tendons than work performed with the arm at the trunk. Work performed in static postures that requires prolonged, low-level muscle contractions of the upper limb or trapezius muscle may also trigger chronic localized pain by an unknown mechanism (perhaps decreased blood flow to the muscle).

Segmental vibration is transmitted to the upper extremity from impact tools, power tools, and bench-mounted buffers and grinders. The mechanism by which localized vibration from power tools contributes to the development of work-related Raynaud's phenomenon is not clear. Nevertheless, this syndrome has been associated with several types of power tools, including chain saws, rock drillers, chipping hammers, and grinding tools.

Most of the effects thus far described center on the tendon structures. The chronic effects of repetition and other risk factors on muscles are not as well understood as the effects on tendons. Chronic or intermittent pain originating in muscles may be important in understanding several disorders, including tension neck syndrome (costoscapular syndrome) and overuse injuries in musicians (61). Two types of muscle activity may be important in work-related disorders: low force with prolonged muscle contractions (e.g., moderate neck flexion while working on a video display terminal for several hours without rest breaks) and infrequent or frequent high-force muscle contractions (e.g., intermittent use of heavy tools in overhead work). Sustained static contractions can lead to increases in intramuscular pressure, which in turn may impair blood flow to cells within the muscle.

Motor nerve control of the working muscle may be important in sustained static contractions, because even if the relative load on the muscle as a whole is low, the active part of the muscle can be working close to its maximal capacity. Therefore, small areas of large muscles, such as the trapezius, may have disturbances in microcirculation that contribute to or cause the development of muscle damage (red ragged fibers), reduction of strength, higher levels of fatigue, and sensitization of pain receptors in the muscle leading to pain at rest (62). High levels of tension (strong contractions) can lead to muscle fiber Z-line rupture, muscle pain, and large delayed increases in serum creatine kinase. If not prolonged, these changes are reversible and completely repaired, often making the muscle stronger.

It is hypothesized that if damage occurs daily from work activity, the muscle may not be able to repair the damage as fast as it occurs, leading to chronic muscle damage or dysfunction. The mechanism of this damage at the cellular level is not fully understood. Work activities that lead to sustained relatively low-level muscle activity or higher-level muscular contractions may be a causal factor in some work-related musculoskeletal disorders.

Nonoccupational Factors

In addition to occupational risk factors or exposures such as repetitive work, personal risk factors may influence the risk of developing these work-related disorders. For example, forceful repetitive activities, such as wrist extension, can occur in some recreational activities and contribute to the development of work-related disorders; however, factors related to some specific disorders, such as rotator cuff tendinitis, have not been adequately studied.

The nonoccupational factors for CTS that have been most thoroughly studied include coexisting medical conditions such as rheumatoid arthritis, diabetes mellitus, pregnancy, and acute trauma, especially after a Colles' fracture of the wrist. Additional possible nonoccupational risk factors are age, gender, obesity, and carpal tunnel size or shape. Carpal canal size, either small or large, has been proposed as a risk factor based on limited evidence (63). For nonoccupational CTS, men have increasing risk with age; in women, the risk peaks at approximately 50 years of age (64). Both men and women may experience occupationally-related CTS at an earlier age (65). Although most clinic- or community-based studies report three times as many CTS cases among women as among men, studies from workplaces have not tended to observe so large a gender difference. In a study of occupational CTS in Washington State, based on workers' compensation data, the female-male ratio was 1.2:1 (65). Several studies have identified obesity as an independent risk factor (66,67). Both pregnancy and cigarette smoking have been also identified as risk factors (68,69). Few, if any, personal factors are useful and strong predictors of susceptibility to work-related disorders of the upper extremity.

Psychosocial Factors

In addition to the physical factors described, psychosocial factors may be important in both the initial development of these disorders and the subsequent long-term disability that sometimes occurs (see Chapter 21). Few studies have rigorously investigated both psychosocial and physical factors or their combined effects (56,60,70). In the future, this type of study is likely to become more common. At least one such study has been done on low back pain; it found that specific aspects of the physical and psychosocial demands of work were strong and independent predictors of low back pain, after adjusting for individual factors (71). In a study of aluminum smelter workers, both forearm rotation and low degree of latitude in decision making were associated with shoulder and elbow disorders in carbonsetters (72).

Psychosocial factors relate to the way in which work is organized. The effects of psychosocial factors may operate indirectly by altering muscle tension or other physiologic processes and, through the latter, may also influence the perception of pain (73). Psychological factors may be particularly important in determining whether specific musculoskeletal disorders evolve into chronic pain syndromes. Overall, psychosocial factors appear to be more important in disorders of the neck and shoulder muscles than in tendon-related disorders of the forearm and the hand (55). Epidemiologic studies of upper-extremity disorders suggest that the perception of an intense or stressful workload, monotonous work, and low levels of social support at work increase the risk of upper limb disorders (55). Different studies use a variety of measures to define intense or stressful workloads, such as lack of control over how work is done, perceived time pressure, deadlines, work pressure, or workload variability (55). The causal role of psychosocial factors probably is not limited to particular jobs, such as the use of computers in the office setting.

Studies that have addressed psychosocial factors have often used the demand-control-support model originally introduced by Karasek and Theorell (73). In this model, high levels of psychological job demands may contribute to the development of work-related musculoskeletal disorders when they occur in an occupational setting in which the worker has little ability to decide what to do or how to do a particular job task and little opportunity to use or develop job skills. Further, these adverse effects are hypothesized to occur more frequently in a work environment in which there is little social support from coworkers or supervisors. Nonoccupational psychosocial factors could also be important. Further studies are needed to better understand the complex interactions among physical occupational factors and occupational psychosocial factors.

A model has been developed to incorporate both physical and psychosocial factors in the development of work-related musculoskeletal disorders (Fig. 26-7) (74). Exposures may be either to physical work factors or to psychosocial factors. Dose also may be either

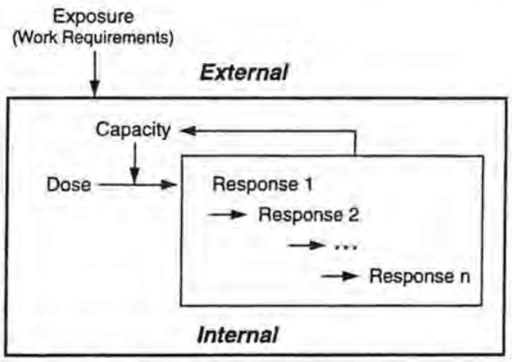

FIG. 26-7. The proposed model contain sets of cascading exposure, dose, capacity, and response variables, such that the response at one level can act as a dose at the next level. In addition, the response to one or more doses can diminish (impairment) or increase (adaptation) the capacity for responding to successive doses.

physiologically or psychologically defined. Capacity may physiologically defined (e.g., strength of a specific tendon) or psychologically defined (e.g., level of self-esteem). The internal processes resulting from a specific dose could occur in the spinal neural circuits or in the muscles of the forearm.

In summary, excessive repetitive or forceful motions, high levels of mechanical stress, work in static or awkward postures, and the use of vibrating power tools can—either singularly or, more often, in combination—increase the risk of upper-extremity disorders and cause inflammation and chronic localized pain in the upper limb and neck. Precise dose-response relations have not been developed for these risk factors, and the precise role of the psychosocial factors needs to be further elucidated. At present, it appears that when the exposure to several physical factors is high, then the risk of these disorders is substantially increased. When the level of exposure to physical factors is more moderate, then the overall level of risk may appear to depend more on the combination of personal attributes, physical factors, and psychosocial factors. As with many occupational exposures, the risk is influenced also by nonoccupational factors (55,60).

DIAGNOSIS

This broad group of work-related disorders of the neck and upper extremity has a diverse set of symptoms and physical findings. The evaluation of a patient for a suspected work-related disorder should have three major components: obtaining a history of present illness from the worker, performing a physical examination of the upper extremity and the neck, and assessing the work setting and tasks (75,76).

The *history* of the present illness should fully characterize the symptoms by determining the location, radiation, duration, evolution, time patterns, and exacerbating factors. The worker's description of work activities is useful. The worker should describe the nature of specific work tasks by risk factors (forceful exertions, repetitive activities, and other adverse exposures). For example, a worker who for 8 hours a day uses a vibrating hand tool to perform a task that is repeated every 30 seconds may be at high risk for wrist tendonitis or CTS. Similarly, a repetitive job that requires the arms to be held overhead during most of the work shift may increase the risk of a rotator cuff shoulder tendinitis. Because specific job tasks can vary within even a high-risk occupation, a careful history of specific job tasks is important.

When a worker who has been performing the same job for a considerable period develops a disorder, the history should be directed not only at the chronic stable exposures, but also at acute factors. For example, if the worker uses a power screwdriver, perhaps the symptoms started when screws from a "bad" batch were used, requiring more force for proper insertion. Other common acute risk factors are changes in work pace or length (longer or more frequent overtime, either by lengthening of the normal workday or by decreasing the number of days off); such changes may reduce the opportunity for recovery from fatigue and occult injury.

Despite the conscientious efforts of the employee and careful interviewing by the physician, description of work tasks may not be sufficient. In general, direct observation of the work process provides the most accurate view of the risk factors associated with specific job tasks. In addition to visiting the workplace, review of representative videotapes of job tasks, written descriptions of job tasks based on industrial engineering data, and results of ergonomic job analyses can all provide helpful information. Although direct observation of the work is often required to determine more precisely the level of risk factor exposure in specific job tasks, descriptions by workers may identify many high-risk exposures with sufficient accuracy for a correct diagnosis.

Determining whether the patient has a predisposing medical condition (e.g., previous injury to the symptomatic area) is also important. In a study of all cases of CTS in Rochester, Minnesota, from 1961 through 1980, the following conditions were associated with CTS in more than 4% of the cases: Colles' fracture, other acute trauma, collagen vascular disease, arthritis of the wrist including rheumatoid arthritis, hormonal agents or oophorectomy, diabetes mellitus, and pregnancy (68). Nonoccupational exposure to risk factors can be a potential confounding influence and should be elicited during the worker interview. For these nonoccupational exposures to be significant as causal factors, they must be similar in intensity and frequency to the known occupational exposures.

Surveillance and epidemiologic studies have identified several industries and occupations associated with risks of CTS or other upper-extremity disorders. Awareness of these findings can alert physicians to the industries and occupations in which adverse exposures are more common. A few illustrative examples are listed in Table 26-5.

Finally, clinical experience, surveillance, and epidemiologic research suggest that many jobs with substantial exposure may adversely affect closely related muscles, tendons, or joints at the same time. As a result, workers in these high-risk jobs may present with any of several disorders, such as CTS and de Quervain's disease or epicondylitis.

The *physical examination* is an important part of evaluation of the patient with work-related musculoskeletal disorders. An examination of the upper extremity typically involves inspection, palpation, assessment of the range of motion, and evaluation of peripheral nerve function.

One of the main objectives of the physical examination is to determine the precise structure or structures in the upper extremity that are the anatomic source of the symptoms. Numbness and paresthesias often result from peripheral nerve compression, but there are many other reasons why there might be numbness and tingling in the fingers. Increased pain on resisted movements (e.g., resisted wrist extension) often results from lesions in a tendon or at the insertion of a tendon. In some cases, it is not possible to determine the precise source of the pain in the upper extremity; in others it is possible to determine the specific disorder that is present (e.g., CTS, de Quervain's stenosing tenosynovitis). The severity of these disorders ranges from very mild, with no significant impairment of the ability to work, to very severe. The symptoms and physical signs of several of these disorders are described in the appendix to this chapter (77–80).

In addition to the disorders with specific findings on physical examination, workers in certain occupations (e.g., keyboard operators, musicians, newspaper reporters) often have an increased rate of complaints of pain in the upper extremity or neck. These symptoms are similar to those of low back pain because a specific anatomic source of the pain often cannot readily be identified on clinical evaluation. As with low back pain, these pains are common, often intermittent in nature, and sometimes lead to substantial disability and impairment (61).

The diagnosis of a work-related musculoskeletal disorder is based on a three-step process. First is the determination of whether the patient has a specific disorder, such as flexor tendinitis of the forearm. This is usually based on the history and physical examination.

TABLE 26-5. *Illustrative examples of industries and occupations with high-risk job tasks*

Occupations and industries	Disorders (Ref)
Occupations	
Seafood packers	Carpal tunnel syndrome (21)
Carpenters	" " "
Invasive cardiologists (removal of intraaortic balloons)	Carpal tunnel syndrome (32, 77)
Metal platers	Carpal tunnel syndrome (19)
Sausage makers	Epicondylitis (3)
Rock blasters	Shoulder tendinitis (4)
Dentists	Cervical spondylosis (5)
Data-entry operators	Tension neck syndrome (5)
Instrumental musicians	Focal dystonias (16)
Industries	
Manufacture of knit underwear, hats, bras, girdles, house slippers, men's and boys' workclothes	Disorders associated with repetitive motion (11)
Manufacture of potato chips	" " "
Automobile manufacturing	" " "
Meatpacking plants	" " "
Temporary help, assembly	Hand/wrist disorders, gradual-onset (12)
Seafood canneries	" " "
Meat and poultry dealer, wholesale	" " "
Wallboard installation	Elbow disorders, gradual-onset (12)
Roofing	" " "
Temp help assembly	" " "
Wallboard installation	Shoulder disorders, gradual-onset (12)
Fence erection	" " "
Temporary help, assembly	" " "
Glass installation	" " "
Garbage installation	" " "

Second, there should be evidence from a detailed occupational history, or, better yet, from direct observation of the workplace, of substantial exposure to specific occupational risk factors. Analysis of health surveillance data, such as OSHA logs or workers' compensation records from the specific workplace, may be particularly helpful in confirming that a particular job is associated with an increased risk of a work-related musculoskeletal disorder. Some employers, to facilitate return-to-work evaluations, now provide physicians with a videotape of the job that the worker normally performs. This may be useful in determining the approximate level of exposure.

Third, nonoccupational causes should be considered as possible primary causal factors or as extenuating factors based on the history and physical examination. Review and analycsis of surveillance and epidemiologic data of similar work may provide information on the relative contributions of occupational and nonoccupational factors in the causation of a specific work-related musculoskeletal disorder in the patient's selected occupation and industry (see Table 26-5). With the exception of tests for abnormalities in nerve conduction, elaborate diagnostic or laboratory studies often are not necessary unless the patient has a history of trauma or symptoms suggestive of underlying systemic disease or fails to improve with conservative treatment.

The most difficult part of the diagnosis of work-related musculoskeletal disorder is determination of the relative contribution of occupational factors in the etiology of the disorder. As with other diagnostic evaluations of work-relatedness, the critical question is: Was the exposure of sufficient intensity, frequency, and duration to have caused the injury or illness? Because intense periods of high exposure as short as weeks in duration can cause lateral epicondylitis or other work-related musculoskeletal disorders, attention should be directed to estimating the intensity and frequency of exposure. It is not uncommon for there to be exposure to multiple risk factors at the same time—for example, repetitive and forceful exertions of the hands, shoulder abduction, and exposure to vibration from hand tools. There are no simple rules for assessing whether exposures has been of sufficient intensity and frequency to cause a disorder.

One study of CTS was based on patients referred for an independent medical examination for both diagnostic evaluation and determination of work-relatedness. The investigators used typical workers' compensation criteria and a standardized approach to assess exposure (frequently based on plant visits or reviews of videotapes). Approximately 60% of the confirmed cases of CTS were found to be work-related (80). Fifteen percent of the patients were found to have not CTS but rather a different work-related disorder of the upper limb, such as localized muscle "fatigue/myalgias." An additional 21% had non–work-related disorders. This study emphasizes the need for thorough diagnostic evaluation to identify the specific disorder and to assess exposure as carefully as possible.

TREATMENT AND PROGNOSIS

The goals of treatment are elimination or reduction in symptoms and impairment and return of the employee to work under conditions that will protect his or her health. These goals can be most easily achieved by early and conservative treatment. Treatment of work-related musculoskeletal disorders early in the course has several advantages: such treatment is less difficult and less costly, surgical procedures can be avoided, periods of absence from work or stressful exposures are shorter, and the effectiveness of treatment is greater (50,81).

The initial goals of treatment are to limit further tissue damage, dysfunction, and inflammation (if present) and to assist the repair of any tissue damage. Symptomatic relief is provided by the use of antiinflammatory medications, rest (sometimes facilitated by splints), and application of heat or cold. Physical therapy techniques are used to assist in symptom relief, to ensure normal joint motion (stretching), and to recondition muscles after periods of rest or reduced use. If these more conservative measures fail to reduce symptoms and impairment for some conditions such as CTS, steroid injections or surgical treatments can be helpful (75,82,83). Surgery, even in CTS, may be ineffective if the worker is returned to the old job without an effort to reduce the occupational exposures that were present. Because few scientifically valid studies have evaluated the long-term effectiveness of the treatment of work-related musculoskeletal disorders of the limb and neck, an empiric approach is indicated (83).

Resting of the symptomatic part of the upper extremity is the most important part of the treatment program. Reducing or eliminating worker exposure to the known risk factors can achieve this. In addition to engineering changes, restricted duty, job rotation, or temporary transfer may be effective. In order for job transfer or rotation to be effective, the new job duties must result in a net reduction in the level of exposure. It is often necessary to conduct an evaluation of the new duties to determine whether a reduction in exposure will occur. The magnitude of reduction required to facilitate recovery often is not known. In general, the more severe the disorder, the greater the reduction in magnitude and duration that will be required. Because of the adverse consequences of complete removal from the work environment, this step should be taken only in severe cases or after less drastic measures have failed.

Splints and other immobilization devices may provide rest to the symptomatic region. However, they may increase the level of exposure if the worker must resist the device in order to carry out regular job tasks (e.g., frequent wrist flexion while wearing neutral-position wrist splints for CTS). Workers may also adapt to wearing a splint by altering their work activities in a way that leads to substantial stress on another region of the upper extremity, such as the elbow or shoulder. Immobilization or prolonged rest may have direct adverse effects if either leads to muscle atrophy. As a result, careful monitoring of the worker who is on restricted duty or job transfer or is wearing an immobilization device is indicated. In addition, because it is difficult to predict the clinical course of these conditions and because the empiric basis of many of the treatments is poorly understood, frequent follow-up is desirable. Failure of the treatment plan to produce improvement over several weeks should lead to thorough re-evaluation of the plan and its underlying assumptions. Many of these conditions resolve within a few weeks with early treatment. The prognosis is generally good with early treatment and reduction in exposure.

Sometimes CTS and other conditions of he upper extremity follow a course similar o that of chronic severe low back pain. With onservative treatment and appropriate adustments in the work setting, most cases hould improve enough so that the patient an successfully return to work, but a small ninority become chronic and very difficult o treat successfully with conventional ap'roaches. In these cases of work-related dis'rders of the back and upper limb, the physial capabilities of the worker, the work emands, and the psychosocial factors reıted both to the worker and the employer re all-important in determining whether the 'orker successfully returns to work (84). The 'ays in which these factors interact are comlex. The recognition that psychosocial fac'rs—such as job satisfaction or negative :lf-fulfilling beliefs on the part of the paent, the employer, or the health care proder—are important should not lead to ignoring the role of occupational physical exposures or to "blaming the victim" (85). When the latter occurs, delayed recovery is often attributed to personal weakness, low job satisfaction, or desire for secondary gain (86). Critical to prevention of these persistent cases is early intervention—an important reason to eliminate barriers to early reporting of symptoms.

It is increasingly recognized that comprehensive approaches that directly address all facets of the patient's situation may prove to be most effective in returning the patient to work and reducing future impairment. As a consequence, there has been a rapid development of comprehensive programs that ideally address the physical reconditioning of the worker, psychosocial factors, and workplace factors such as ongoing exposure (84,86). A contract between the patient and the health care provider should be established early in the treatment process, with the explicit aim of returning the worker safely to work. The diagnosis and treatment of severe or chronic work-related musculoskeletal disorders is sometimes challenging. Identification of the level of exposure by patient history is difficult, and usually direct observation of work is the preferred approach. There is substantial uncertainty about how to best measure exposure in some occupational settings, especially in the office. There is a danger of both overdiagnosis and underdiagnosis—for example, assuming either that every case of CTS is work-related or that no case of CTS is work-related. Not only is the assessment of exposure difficult, but scientific understanding of the relation between exposure and disease is still limited and imprecise. The danger exists of not recognizing when a case is becoming chronic and severe and when a multidisciplinary approach should be considered. Several observations are helpful when one is faced with challenges of diagnosing and treating these work-related conditions. A careful history and physical examination are important. An extensive objective assessment of the work environment may be required. In most cases, conservative treatment that preserves normal physical conditioning, that relies on a reduction of the level of occupational exposure while the patient remains at work, and that incorporates careful monitoring of the patient is a reasonable initial approach and is effective.

Prevention of these disorders requires the successful identification and remediation of adverse exposures.

PREVENTION

Preventive strategies are largely experience-based and have not been comprehensively evaluated by scientific studies. The principles outlined here must be adapted to fit the specific characteristics of each working environment. They should be viewed as a guide rather than a blueprint, and they require ongoing scientific evaluation (87,88). Three standard preventive strategies can be considered: (a) a reduction of the exposure to suspected occupational risk factors, such as vibrating hand tools; (b) a conditioning process that increases the tolerance of workers to the suspected occupational risk factors; and (c) development of a replacement process that is highly predictive and reliable to identify those persons who are at unusually high risk for development of an upper-extremity disorder. The remainder of this chapter discusses the first strategy in detail. Before this discussion, however, brief comment is in order for the other two strategies.

Development of a replacement process is the least desirable of these strategies because there are no scientifically valid screening procedures to identify which persons are at high risk, and because this shifts the cost of reducing the incidence of symptoms onto the workers (who are denied employment or placement) and increases the costs of the hiring and replacement processes. A prospective study comparing workers who were without symptoms of CTS but had abnormally slow sensory median nerve conduction with workers from the same industries with normal conduction concluded that workers with asymptomatic slowed conduction did not have an increased risk of developing CTS over an 18-month period (89).

The second approach, a conditioning process that provides a period of time during which workers can gradually adapt their muscles and tendons to the new demands, could be a useful approach for workers in forceful- or repetitive-action jobs. Training of new workers in the most efficient and least stressful ways of performing their jobs may also be useful, provided that the work tasks can be done in alternative ways that are both less stressful and at least as fast. Similarly, workers with symptoms may, with training, be able to adapt an equally efficient, but less stressful, work method. Training activities have not been evaluated specifically. Several employers, perceiving long-term benefits from a "phasing-in period," have established transitional or training areas where employees may work at a reduced pace for a limited time. In a survey of 5,000 employers in Washington State, among those who took prevention steps, a larger percentage reported decreased number and severity of musculoskeletal disorders with engineering and administrative measures (e.g., task variety, reduced overtime) than with strictly personal controls (e.g., exercise programs, personal protective equipment) (90).

Reduction in exposures, the standard preventive approach that directs attention to control of occupational factors, has the most promise. This approach often requires changes in the workstation, work process, or use of tools. Sometimes administrative changes, such as work restrictions, use of personal protective equipment (e.g., palm pads), or job rotation are useful alternatives, either as preventive or as therapeutic interventions.

In order for work restrictions to be effective in the treatment of injured workers, the health care provider must be specific about the type of work activity that should be avoided or reduced. For example, it is better to limit repetitive hand activities to "fewer than 10 movements per minute for more than 2 hours per day" than to prescribe "no repetitive hand movements during the work shift." Developing specific recommendations for work restrictions is facilitated by viewing videotapes of the usual job of the worker or by obtaining detailed job descriptions from the employer. As a preventive intervention, job rotation of workers among jobs that require different types of motions of the upper extremity may simply expose an even greater number of workers to a considerable degree of risk.

To reduce exposure, the first step required for instituting changes in workstations or work processes is to analyze the specific characteristics of suspected high-risk jobs. Although the job review can be conducted by an industrial engineer or occupational health professional with training in ergonomics, the involvement of those persons who are most knowledgeable about the job is important. Experience has shown that operators and supervisors with limited technical training can successfully identify many of the hazardous aspects of a specific job, and that specific solutions may not be effective or accepted without the involvement of such persons in the job review and development of solutions.

REDUCING EXPOSURE TO RISK FACTORS

A job analysis performed for the patient with the spot-welding job in the case at the start ɔf this section would have identified several ɜxposure factors. The job was repetitive and ·equired forceful gripping of the handles of he welding gun. The wrists were extended hrough most of the job cycle.

After a job analysis has identified the po-ɜntially hazardous exposures associated ʼith a particular job, specific solutions hould be solicited from those who are nowledgeable about the job. With limited ·aining in the control principles (discussed ı the next section), engineers, production nployees, and front-line supervisors often ·opose the most useful methods for elimi-ɪting hazardous risk factors. If several fac-rs are present, it can be difficult to deter-ine which is the most detrimental. Where possible, integrated solutions should be developed that reduce multiple risk factors at the same time.

Control of repetitiveness, forcefulness, awkward posture, mechanical stress, vibration, and cold are often possible, as illustrated in the following examples.

Control of Repetitiveness

1. Use mechanical assists and other types of automation. For example, in packing operations, use a device, rather than the hands, to transfer parts.
2. Rotate workers among jobs that require different types of motions. Rotation must be viewed as a temporary administrative control, one used only until a more permanent solution can be found.
3. Implement horizontal work enlargement by adding different elements or steps to a job, particularly steps that do not require the same motions as the current work cycle.
4. Increase work allowances or decrease production standards. This control strategy is rarely looked on favorably by management.
5. Design a tool for use in either hand and also so that fingers are not used for triggering motions.

Control of Forcefulness

1. Decrease the weight held in the hand by providing adjustable fixtures to hold parts being worked on. Many conventional balancers are available to neutralize tool weight. Articulating arms are used in many plants to hold and manipulate heavy tools into awkward positions.
2. Control torque reaction force in power handtools by using torque reaction bars, torque-absorbing overhead balancers, and mounted nut-holding devices. Control the time that a worker is exposed to torque reaction by using shut-off rather than stall power tools. Avoid jerky motions by hand-held tools.

3. Design jobs so that a power grip rather than a pinch can be used whenever possible. (Maximum voluntary contraction in a power grip is approximately three times greater than in a pinch).
4. Increase the coefficient of friction on hand tools to reduce slipperiness, for example, by use of plastic sleeves that can be slipped over metal handles of tools.
5. Design jobs so that slides or hoists are used to move parts, to reduce the amount of handling or carrying of parts by the worker.

Control of Awkward Posture

The primary method for reducing awkward postures is to design adjustability of position into the job. Wrist, elbow, and shoulder postures required on a job often are determined by the height of the work surface with respect to the location of the worker. A tall worker may use less wrist flexion or ulnar deviation than a shorter worker. Additionally, awkward postures can be reduced by the following procedures.

1. Alter the location or method of the work. For example, in automotive assembly operations, changing the line location at which a particular part is installed may result in easier access.
2. Redesign tools or change the type of tool used. For example, when wrist flexion occurs with a piston-shaped tool that is used on a horizontal surface, correction may involve use of an in-line type tool or lowering of the workstation.
3. Alter the orientation of the work.
4. Avoid job tasks that require shoulder abduction or forward flexion greater than 30 to 45 degrees, elbow flexion greater than 110 degrees, wrist flexion or extension greater than 20 degrees, or frequent neck rotation.
5. Provide support for the forearm when precise finger motions are required, to reduce static muscle loading in the arm and shoulder girdle.

Control of Vibration

1. Do not use impact wrenches or piercing hammers.
2. Use balancers, isolators, and damping materials.
3. Use handle coatings that attenuate vibrations and increase the coefficient of friction to reduce strength requirements.

Control of Mechanical Stress

1. Round or flare the edges of sharp objects, such as guards and container edges.
2. Use different types of palm button guards, which allow room for the operator to use the button without contact with the guard.
3. Use palm pads, which may provide some protection until tools can be developed to eliminate hand hammering.
4. Use compliant cushioning material on handles or increase the length of the handles to cause the force to dissipate over a greater surface of the hand.
5. Use different-sized tools for different-sized hands.
6. Avoid narrow tool handles that concentrate large forces onto small areas of the hand.

Control of Cold and Use of Gloves

1. Properly maintain power tool air hoses to eliminate cold exhaust air leaks onto the workers' hands or arms.
2. Provide a variety of styles and sizes of gloves to ensure proper fit of gloves. Although gloves may protect the hands from cold exposures, they often decrease grip strength (requiring more forceful exertion), decrease tactile sensitivity, decrease manipulative ability, increase space requirements, and increase the risk of becoming caught in moving parts.
3. Cover only that part of the hand that is necessary for protection. Examples include use of safety tape for the fingertips with fingerless gloves and use of palm pads for the palm.

Conclusion

In summary, work-related low back pain and disorders of the upper extremity are together among the most common occupational health problems. Although scientific knowledge often limits our ability to determine precisely the role of occupational and nonoccupational factors in the diagnosis of these conditions, substantial progress can be made in reducing their severity by applying existing knowledge about the role of physical factors in these disorders, including forceful repetitive hand work and frequent lifting of heavy objects. Work should be designed to reduce exposure to the known physical risk factors. Encouragement of prompt and appropriately conservative medical evaluation of workers with such disorders can contribute to secondary prevention. Finally, for the minority of workers with disorders that do not respond to conservative treatment, including reduction in the level of exposure, treatment programs that address all aspects of the problem, both the psychosocial and the physical, probably have the greatest chance of preventing permanent disability from these disorders.

REFERENCES

1. American Academy of Orthopaedic Surgeons. Musculoskeletal conditions in the United States. Park Ridge, IL: AAOS, 1992.
2. Andersson GBJ. The epidemiology of spinal disorders. In: Frymoyer JW, ed. The adult spine: principles and practice, 2nd ed. Philadelphia: Lippincott-Raven Press, 1997:93–141.
3. Pope MH, Andersson GBJ, Frymoyer JW, Chaffin DB. Occupational low back pain: assessment, treatment and prevention. St. Louis: Mosby -Year Book, 1991:1–325.
4. Frymoyer J. The adult spine: principles and practice. Philadelphia: Lippincott-Raven, 1997.
5. Spitzer WO, LeBlanc FE, Dupuis M, et al. Scientific approach to the assessment and management of activity-related spinal disorders: a monograph for clinicians. Report of the Quebec Task Force on Spinal Disorders. Spine 1987;12:S1–S59.
6. Andersson GBJ. Epidemiologic aspects on low back pain in industry. Spine 1981;6:53–60.
7. Klein BP, Jensen RC, Sanderson LM. Assessment of workers' compensation claims for back strains/sprains. J Occup Med 1984;26:443–448.
8. Frymoyer JW, Pope MH. Epidemiologic insight into the relationship between usage and back disorder. In: Hadler NH, ed. Current concepts in regional musculoskeletal illness. Orlando, FL: Grune & Stratton, 1987:263–279.
9. Chaffin DB, Herrin GD, Keyserling WM. Preemployment strength testing: an updated position. J Occup Med 1978;20:403–408.
10. Kelsey JL. An epidemiological study of acute herniated lumbar intervertebral discs. Rheumatol Rehab 1975:14:144–159.
11. Kelsey JL, Githens PB, O'Connor T, et al. Acute prolonged lumbar intervertebral disc: an epidemiologic study with special reference to driving automobiles and cigarette smoking. Spine 1984;9:608–613.
12. Magora A. Investigation of the relation between low back pain and occupation. Ind Med Surg 1972;41:5–9.
13. Keyserling WM. Postural analysis of the trunk and shoulders in simulated real time. Ergonomics. 1986;29(4):569–583.
14. Bigos SJ, Battie MC. Risk factors for industrial back problems. Seminars in Spine Surgery 1992;4:2–11.
15. Svensson H-O, Andersson GBJ. Low back pain in forty to forty-seven year old men: work history and work environment factors. Spine 1983;8:272.
16. Svensson H-O, Andersson GBJ. The relationship of low-back pain, work history, work environment, and stress: a retrospective cross-sectional study of 38 to 64 year old women. Spine 1989;14:517–522.
17. Frymoyer JW, Pope MH, Costanza MC, Rosen JC, Goggin JE, Wilder DG. Epidemiologic studies of low back pain. Spine 1980;5:419–423.
18. Chaffin DB, Park KS. A longitudinal study of low-back pain as associated with occupational weight lifting factors. Ind Hyg Assoc J 1973;34:513–525.
19. Snook SH, Campanelli RA, Hart JW. A study of three preventive approaches to low back injury. J Occup Med 1978;20:478–481.
20. Snook SH. Low back pain in industry. In: White AA, Gordon SL, eds. Symposium on idiopathic low back pain. St. Louis: Mosby, 1982:23–28.
21. Kelsey JL, Githens PB, White AA, et al. An epidemiologic study of lifting and twisting on the job and risk for acute prolapsed lumbar intervertebral disc. J Orthop Res 1984;2:61–66.
22. Kelsey JL, Hardy RJ. Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc. Am J Epidemiol 1975;102:63.
23. Heliovaara M. Occupation and risk of herniated lumbar intervertebral disc or sciatica leading to hospitalization. J Chronic Dis 1987;3:259–264.
24. Bigos SJ, Spengler DM, Martin NA, Zeh J, Fisher L, Nachemson A. Back injuries in industry: a retrospective study. III: Employee-related factors. Spine 1986;11:252–256.
25. Bigos S. Acute low back problems in adults. Clinical Practice Guidelines No. 14. Agency for Health Care Policy and Research Publ. No 95-0642, Washington, DC: U.S. Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research, 1994:1–160.
26. Deyo RA, Diehl AK, Rosenthal M. How many days of bed rest for acute low back pain? A randomized clinical trial. N Engl J Med 1986;315:1064–1070.
27. Deyo RA. Conservative therapy for low back pain:

distinguishing useful from useless therapy. JAMA 1983;25:1057.
28. Weber H. Lumbar disk herniation: a controlled, perspective study with ten years of observation. Spine 1983;8:131–140.
29. Dillane JB, Fry J, Kalton G. Acute back syndrome: a study from general practice. Br Med J 1966;2:82–84.
30. Bergquist-Ullman M, Larsson U. Acute low back pain in industry. Acta Orthop Scand 1977;48 (Suppl. 170): 1–117.
31. McGill CM. Industrial back problems: a control program. J Occup Med 1968;10:174–178.
32. Battie MC. Minimizing the impact of back pain: workplace strategies. Seminars in Spine Surgery 1992;4:20–28.
33. King PM. Back injury prevention programs: a critical review of the literature. J Occup Rehabil 1993;3:145–157.
34. Lahad A, Maller AD, Berg AO, Deyo RA. The effectiveness of four interventions for the prevention of low back pain. JAMA 1994;272:1286–1291.
35. US Department of Health and Human Services. Work practices guide for manual lifting. NIOSH publication no. 81-122. Washington, DC: DHHS, 1981.
36. Waters TR, Putz-Anderson V, Garg A, Fine LJ. Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics 1993; 26:749–776.
37. Snook SH. The design of manual handling tasks. Ergonomics 1978:21:963–985.
38. Lavender SA, Thomas JS, Chang D, Andersson GBJ. Effect of lifting belts, foot movement, and lift asymmetry on trunk motions. Hum Factors 1995;37:844–853.
39. Reddell C, Congleton J, Huchingson D, Montgomery J. An evaluation of weight lifting belt and back injury prevention training class for airline baggage handlers. Appl Ergon 1992;25:319–329.
40. Walsh NE, Schwartz RK. The influence of prophylactic orthoses on abdominal strength and low back injury in the workplace. Am J Phys Med Rehabil 1990;69:245–250.
41. Himmelstein JS, Andersson GBJ. Low back pain: risk evaluation and preplacement screening. Occup Med 1988;3:255–269.
42. Biering-Sorensen F. Physical measurements as risk indicators for low-back trouble over a one-year period. Spine 1984;9:106–119.
43. Fitzler SL, Berger RA. Attitudinal change: the Chelsea back program. Occup Health Saf 1982:51:24–26.
44. Fitzler SL, Berger RA. Chelsea back program: one year later. Occup Health Saf 1983;52:52–54.
45. Wiesel SW, Feffer HL, Rothman RH. Industrial low back pain: a prospective evaluation of a standardized diagnostic and treatment protocol. Spine 1984;9:199.
46. Phalen G. The carpal tunnel syndrome: clinical evaluation of 598 hands. Clin Orthop 1972;83:29.
47. Moore JS. De Quervain's tenosynovitis. Stenosing tenosynovitis of the first dorsal compartment. J Occup Environ Med 1997;39:990–1002.
48. Kurppa K, Viikari-Junta E, Kuosma E, Huuskonen M, Kivi P. Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. Scand J Work Environ Health 1991;17:32–37.
49. Stenlund B, Goldie IN, Hagberg M, Hogstedt C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scand J Work Environ Health 1993;19:43–49.
50. Hagberg M, Wegman DH. Prevalence rates and odds ratios of shoulder-neck disease in different occupational groups. Br J Ind Med 1987;44:602–610.
51. Hadler NM, Gillings DB, Imbus HR, et al. Hand structure and function in an industrial setting. Arthritis Rheum 1978;21:210–220.
52. Taylor W, Pelmar PL. The hand-arm vibration syndrome: an update. Br J Ind Med 1990;47:577–579.
53. Bureau of Labor Statistics. Lost-worktime injuries and illnesses: characteristics and resulting time away from work, 1996. Washington, DC: Bureau of Labor Statistics, US Department of Labor, April 23, 1998.
54. Conway H, Svenson J. Occupational injury and illness rates, 1992–1996: why they fell. Monthly Labor Review, November 1988:36–58.
55. National Institute for Occupational Safety and Health. Musculoskeletal disorders and workplace factors: a critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. DHHS (NIOSH) Publication No. 97-141. Cincinnati: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, NIOSH, 1997.
56. Silverstein B, Kalat J. Work-related disorders of the back and upper extremity in Washington State, 1989–1996. Technical Report 40-1-1997. Olympia: Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, January 1998.
57. Gorsche R, Wiley JP, Renger R, Brant R, Gemer TY, Sasyniuk TM. Prevalence and incidence of stenosing tenosynovitis (trigger finger) in a meat-packing plant. J Occup Environ Med 1998;40:556–560.
58. Thompson AR, Plewes LW, Shaw EG. Peritendinitis crepitans and simple tenosynovitis: a clinical study of 544 cases in industry. Br J Ind Med 1951;8:150–160, 1951.
59. Gross AS, Louis DS, Carr KA, Weiss SA. Carpal tunnel syndrome: a clinicopathologic study. J Occup Med 1995;37:437–441.
60. Steering Committee for the Workshop on Work-Related Musculoskeletal Injuries. Work-related musculoskeletal disorders: the research base. Workshop summary and papers. Washington, DC: National Academy Press, 1999.
61. Lacewood AH. Medical problems of musicians. N Engl J Med 1989;320:221–227.
62. Armstrong TJ, Buckle P, Fine LJ. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health 1993:19:73–84.
63. Hagg GM. Static work load and occupational myalgia: a new explanation model. In: Anderson P, Hobart D, Danoff J, eds. Electromyographical kinesiology. Amsterdam: Elsevier Science Publishers, 1991:141–144.
64. Hagberg M, Morgenstern H, Kelsh M. Impact of occupations and job tasks on the prevalence of car-

pal tunnel syndrome. Scand J Work Environ Health 1992:18:337–345.
65. Stevens JC, Sun S, Beard CM, O'Fallon WM, Kurland LT. Carpal tunnel syndrome in Rochester, Minnesota, 1961 to 1980. Neurology 1988; 38:134–138.
66. Franklin GM, Haug J, Heyer N, Checkoway H. Occupational carpal tunnel syndrome in Washington State, 1984–1988. Am J Public Health 1991:81: 741–746.
67. Werner S, Albers JW, Franzblau A, Armstrong TJ. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. Muscle Nerve 1994:17:1492.
68. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry: a cross-sectional and longitudinal study involving 429 workers. J Occup Med 1992;34:379–383.
69. Stevens JC, Beard CM, O'Fallon WM, Kurland LT. Conditions associated with carpal tunnel syndrome. Mayo Clin Proc 1992;67:541–548.
70. Tanaka S, Wild DK, Cameron LL, Freund E. Association of occupational and nonoccupational risk factors with the prevalence of self-reported carpal tunnel syndrome in a national survey of the working population. Am J Ind Med 1997;32:550–556.
71. Theorell T, Harms-Ringdahl K, Ahlberg-Hulten G, Westin B. Psychosocial job factors and symptoms from the locomotor system: a multi-causal analysis. Scand J Rehabil Med 1991;23:165–173.
72. Kerr MS, Frank JW, Shannon HS, et al. Independent biomechanical and psychosocial risk factors for low back pain at work. Personal communication.
73. Hughes RE, Silverstein BA, Evanoff BA. Risk factor for work-related musculoskeletal disorders in an aluminum smelter. Am J Ind Med 1997;32:66–75.
74. Theorell T, Nordemar R, Michelsen H, Stockholm Music Study Group. Pain thresholds during standardized psychological stress: relation to perceived psychosocial work situation. J Psychosom Res 1993; 37:299–305.
75. Rempel DM, Harrison RJ, Barnhardt S. Work-related cumulative trauma disorders of the upper extremity. JAMA 1992;267:838–842.
76. Rempel D, Eranoff B, Amadio PC, et al. Consensus for the classification of carpal tunnel syndrome in epidemiologic studies. Am J Public Health 1998;88:1447–1451.
77. Stevens K. The carpal tunnel syndrome in cardiologists [Letter]. Ann Intern Med 1990;112:796.
78. Dawson DM, Hallet M, Millender LH. Entrapment neuropathies, 2nd ed. Boston: Little Brown, 1990.
79. Herington TN, Morse LH, eds. Occupational injuries: evaluation, management, prevention. St. Louis: Mosby, 1995.
80. Moore JS. Clinical determination of work-relatedness in carpal tunnel syndrome. J Occup Rehab 1991;1:145–158.
81. Hales TR, Bertsche PK. Management of upper extremity cumulative trauma disorders. AAOHN J 1992;40:118–128.
82. American Academy of Orthopaedic Surgeons. Clinical policies: carpal tunnel syndrome. Park Ridge, IL: American Academy of Orthopaedic Surgeons, 1991.
83. Katz JN, Keller RB, Simmons BP, et al. Maine carpal tunnel study: outcome of operative and nonoperative therapy for carpal tunnel syndrome in a community-based cohort. J Hand Surg [Am] 1998; 23:697–710.
84. Feurstein M. A multi-disciplinary approach to the prevention, evaluation and management of work disability. J Occup Rehab 1991;1:5–12.
85. Niemeyer LO. Social labeling, stereotyping, and observer-patient interaction on outcome. J Occup Rehab 1991;1:251–267.
86. Parenmark G, Malmkvist AK. The effect of an outpatient rehabilitation program on occupational cervicobrachial disorders. J Occup Rehab 1992; 2:67–72.
87. Silverstein B, Fine LJ, Armstrong SJ. Carpal tunnel syndrome: causes and a preventive strategy. Semin Occup Med 1986;1:213–221.
88. National Institute for Occupational Safety and Health. Elements of ergonomics programs. DHHS (NIOSH) Publication No. 97-117. Cincinnati, OH: US Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, NIOSH, 1997.
89. Werner RA, Fransblau A, Albers JW, Buchele H, Armstrong TJ. Use of screening nerve conduction studies for predicting future carpal tunnel syndrome. Occup Environ Health 1997;54:96–100.
90. Foley M, Silverstein B. Musculoskeletal disorders, risk factors and prevention steps: a survey of employers in Washington State. Technical Report 53-1-1999. Olympia: Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, January 1999.

BIBLIOGRAPHY

Cailliet R. Hand pain and impairment, 2nd ed. Philadelphia: Davis, 1981.
A good but old introductory text with excellent illustrations. (Look at the Seminars in Occupational Medicine for a better example.)

Deyo RA. Conservative therapy for low back pain: distinguishing useful from useless therapy. JAMA 1983;250:1057.
Reviews the evidence supporting commonly used conservative therapies for low back pain.

Nachemson A. Advances in low back pain. Clin Orthop 1985;200:266.
An objective and thorough review of current knowledge about low back pain. Topics include epidemiology, etiology, biomechanics, and treatment. Emphasis is placed on the benefits of patient education and motion and the disadvantages of prolonged bed rest (inactivity) and repeat surgery.

National Institute for Occupational Safety and Health. Musculoskeletal disorders and workplace factors: a critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. DHHS (NIOSH) Publication No. 97-141. Cincinnati: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, NIOSH, 1997.

Reviews epidemiologic studies and discusses the clearest delineation of the association of upper-extremity disorders with work exposures.

Nordin M, Andersson GBJ, Pope MH, eds. Musculoskeletal disorders in the workplace: principles and practice. St. Louis: Mosby, 1997.
Covers basic concepts of pain, biomechanics, psychosocial factors, clinical evaluation, and patient care as well as workplace modifications.

Quinet RJ, Hadler NM. Diagnosis and treatment of backache. Semin Arthritis Rheum 1979;8:261.
A comprehensive, objective, and well-written review of the etiology, diagnosis, and treatment of low back pain. The authors discuss traction, drugs, diathermy, heat, cold, manipulation, corsets, braces, injection therapy, exercises, chemonucleolysis, and surgery.

Rempel DM, Harrison RJ, Barnhardt S. Work-related cumulative trauma disorders of the upper extremity. JAMA 1992;267:838–842.
A concise summary of the causes, diagnosis, and principles of treatment for common work-related disorders of the upper extremity.

Rowe ML. Backache at work. Fairport, NY: Perinton, 1983.
Describes the results of a 20-year clinical study of low back pain at a large company. Included in the study are 1,500 cases. The effectiveness of current selection techniques in preventing low back pain is discussed. Emphasis also is placed on preventing the disability.

Wiesel SW, Feffer HL, Rothman RH. Industrial low-back pain: a prospective evaluation of a standardized diagnostic and treatment protocol. Spine 1984;9:199.
Describes a standardized approach to the diagnosis and treatment of low back pain in employees at a large company. Two orthopedic surgeons monitored the course and treatment of employee low back pain and intervened when they believed it necessary. The program dramatically decreased the number of patients sent to surgery.

APPENDIX

WORK-RELATED DISORDERS OF THE UPPER EXTREMITIES

Disorder	History	Physical examination
Wrist		
Carpal tunnel syndrome	Pain, tingling, or numbness in medial sensory distribution of the hand; nocturnal exacerbation; problems with dropping things	Positive Phalen's test; positive Tinel's test; thenar atrophy in severe cases; rule out pronator teres syndrome, cervical root syndrome
De Quervain's disease	Pain in anatomic snuffbox; may radiate up forearm; no history of radial or wrist fracture	Positive Finkelstein's test with sharp pain rather than just pulling sensation; rule out radial nerve entrapment
Trigger finger	Finger locks in extension or flexion; requires assistance in unlocking; nodule or tendon	Nodule at base of digit palpable; locking on flexion or extension of digits
Ulnar nerve compression (Guyon canal syndrome)	Burning, tingling, or numbness in fourth and fifth digits; clumsiness in fine movements	Positive Tinel's sign at Guyon canal; positive Phalen's test in ulnar distribution; decreased pinch strength; weakness on resisted abduction and adduction of digits; rule out cervical root disorder, thoracic outlet syndrome, cubital tunnel syndrome
Tendinitis, tenosynovitis	Localized pain and swelling over muscle-tendon structure	Pain exacerbated by resisted motions; fine crepitus on passive range of motion (ROM) possible; no pain on passive ROM; pronounced asymmetric grip strength
Elbow/Forearm		
Lateral epicondylitis (tennis elbow)	Pain at lateral epicondyle during rest or active motion of wrists and fingers	Pain on resisted extension of wrist with fingers flexed; no pain or limitation on full passive ROM; pain at epicondyle on palpation; pain on resisted radial deviation; rule out radial nerve entrapment
Medial epicondylitis (golfer's elbow)	Pain at medial epicondyle during rest or active motion of wrist and fingers	No pain on passive ROM; pain on resisted wrist flexion and resisted forearm pronation; pain at medial epicondyle on palpation
Olecranon bursitis	Pain and swelling at olecranon	No pain on passive or resisted ROM; swelling around olecranon on palpation; rule out rheumatoid arthritis
Pronator teres syndrome	Burning pain in first three digits of hand and forearm	Increased pain in forearm by resisted pronation with clenched fist and flexed wrist (Mill's test); sensory impairment of thenar eminence; rule out carpal tunnel syndrome

WORK-RELATED DISORDERS OF THE UPPER EXTREMITIES (Continued)

Disorder	History	Physical examination
Shoulder		
Rotator cuff tendinitis (mainly supraspinatus)	Dull ache generally localized to deltoid area without neck or arm radiation; no symptoms of distal paresthesia; nocturnal exacerbation; subject may not "catch" on movement.	Diffuse tenderness over shoulder, especially over humeral head and lateral to acromion; if tenderness is localized, it is most often over supraspinatus insertion; weakness uncommon *Supraspinatus:* shrugs shoulder on abduction, painful arc at 70–90 degrees; passive ROM normal; pain on resisted abduction *Infraspinatus:* pain on resisted external rotation; painful arc; rule out rheumatoid arthritis
Bicipital tenosynovitis	Pain localized to bicipital groove area that may radiate to anterior aspect of arm; no distal paresthesia; nocturnal exacerbation; subject able to use forearm when upper arm held against chest; subject notes pain on abduction and rotation	Positive Yergason's test (resisted supination), or positive Speed's test (resisted wrist flexion); normal passive and active ROM
Degenerative joint disease—acromioclavicular joint	Generalized aching shoulder pain exacerbated by motion; least difficulty in morning but worse as day progresses	Limitation is similar on active and passive ROM; most discomfort is with mild abduction; crepitus common; tenderness on palpation directly over acromioclavicular articulation; pain reproduced as arm is abducted more than 90 degrees; pain on shoulder shrug
Degenerative joint disease—glenohumeral joint	Pain is very diffuse and nocturnal	Tenderness to palpation along joint line; no deltoid or suprespinatus pain; passive ROM full but painful; active ROM retarded on flexion and extension (normal is 240 degrees in youth, 190 degrees at age 70; normal abduction in youth is 166 degrees, 116 degrees at age 70)
Neck/Scapula		
Tension neck syndrome (costal-scapular syndrome)	Neck pain or stiffness; no history of herniated cervical disc, injury, or ankylosing spondylitis	Muscle tightness, palpable hardening and tender spots; pain on resisted neck lateral flexion and rotation
Cervical root syndrome	Pain radiating from neck to one or both arms with numbness in one or both hands; exacerbated by cough	Limited passive or active ROM; radiating pain on passive motions; positive foreminal test; decreased pinprick in dermatome; absence of joint findings

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Fourth Edition

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