

Bullock, M., ed.: *ERGONOMICS: THE PHYSIOTHERAPIST IN THE WORKPLACE*, Churchill-Livingstone, 1991.

This landmark text describes the role of the physical therapist as the most qualified industry resource for ergonomics. The physical therapist is described as providing a valuable mix of musculoskeletal medical training with human biomechanics and physics of movement and posture as the basic science foundation of this profession. Most large industry settings in Europe employ on-site physical therapists as their ergonomics resource (in contrast with US industry which relies primarily on engineers.) In Scandinavian countries ergonomics is chiefly the domain of physical therapists. See pages 214-215 and 228-229.

pp52-53: Posture work load is described as a primary risk for CTD. Static muscle contraction reduces circulatory irrigation to muscle, decreasing oxygen and creating metabolic wastes accumulation in the tissues, leading to pain and hardening. Muscle posture work should not tolerate more than 5-6% of MVC in work conditions exceeding one hour. Rapid repetitive motion and high accuracy demands create increased background tensions in working muscles and tendons, as do noise and cold, creating similar stresses as seen in excessive posture load demands and high MVC. Similar stresses are seen when repetitive loading exceeds 50% of MVC and peak loading exceeds 75% of MVC. Similar stresses are seen in extreme positions and sudden jerky motions.

pp108-115: Posture load is described as a severe risk particularly in the presence of short rest breaks. Static posture loads with short rests is a strong risk. Posture load is a risk especially when posture is awkward or needed to manipulate tools distally. Speed of repetition increases static posture loads (Waersted 1986). Forward head posture is seen as a pain source in many static posture jobs according to one study, suggesting pain is a result of mechanical deformation of passive tissues (Harms-Ringdahl 1986).

...Static loading is identified as stress causing fatigue and reduction in blood flow at a time when wastes are increasing and oxygen demands are increasing (IBID). VDT work is discussed in this context, with up to 95% demonstrating symptoms (Bjorksten 1984). Management of this risk calls for improving posture habits, early symptom reporting, redeployment of work, and task alternation.

...Fatigue is the precursor to musculoskeletal pain problems. Repetitive light tasks produced significant changes in EMG and serum creatine kinase (SCK) in local muscles. These changes were not seen in heavy aerobic tasks (Hagberg and Jonsson 1982, 1984). The quality and frequency of rest affects the ability of muscles to recover (Rhomert).

pp134-143: Forward head posture produces stress through muscles posture load and passive tissue loads at ROM extremes, where EMG may be quiet. Posture loads at neck and shoulder are affected by motions, postures and loads in the arms and hands. Precision, speed, psychological stresses all increased muscle posture loads.

...Neutral upright head posture uses approximately 2% of MVC; slightly flexed uses 10%; much flexed posture uses 17% of MVC. Trapezius fatigue is reached where MVC is at 2-5% for more than an hour. This load is greatly increased with arm flexion or abduction. Flexion was defined as lower cervical flexion with some compensatory extension at upper cervical, a protracted head posture over the shoulders (Harms-Ringdahl and Schuldt 1988).

...Work with arms unsupported greatly accelerates fatigue. The more they are elevated, the more fatigue changes are seen spreading from the upper traps to the lower traps, thoracic erector spinae, rhomboids and glenohumeral muscles. Symptoms are related to time spent in forward postures, shoulder elevation, and total duration of arm activity. Endurance also depended upon the worker's physical condition.

...Continuous arm activity entails no return to zero activity, so there is no relaxation of neck and shoulder muscles. Rather, movement is superimposed on static contractions. This is in light of the obstruction in perfusion of these working tissues (Schuldt, Jonsson, Christensen). The use of micro-pause loading breaks for only a few seconds are important to preserve comfort and work performance through the work day. When the hands and arms are supported during work activity, there is less pain in the neck and shoulder region (Hunting, 1981). Elbow support, properly designed, reduced activity in the traps, rhomboids, and erector spinae in both erect and flexed head positions among assembly workers (Schuldt, 1987).

pp310+ : Abstracts the papers used in the text. Extensive, highly pertinent information.

Hertling and Kessler: MGT OF COMMON MUSCULOSKELETAL DISORDERS, pp138-140, Lippincott, 1990.

Pages 138-140: These three pages from this landmark textbook offer a remarkably clear and detailed description of the pathogenesis of tendinitis and CTD at the cellular and molecular level. Authors discuss the metabolic and nutrient pathways for tendons under work stress. It describes tendon breakdown in response stresses as a nutrient pathway problem, resulting in acute inflammation, fibrosis and eventual chronic inflammation. It describes the physical properties of tendon versus scar tissue and its ability to tolerate physical stresses. Vascularity and nutrient pathway is described as part of pathomechanics. Balance between rest and activity are discussed relative to work recovery. EXCELLENT!

Kelley, M., and Clark, William: ORTHOPEDIC THERAPY OF THE SHOULDER; Lippincott, 1995; Chapter 3, pp144-149.

These pages provide the very best available description of the various entities that comprise "thoracic outlet-inlet syndrome." This is a highly controversial topic within the medical community, due to varying definitions of what really is thoracic outlet-inlet syndrome. These pages describe the varied entities that fall into this category, clarifying the various categories of disorders that may fall into this diagnosis. This is essential for the prevention specialist to understand in their work on workplace injury prevention and the role of the thoracic outlet-inlet.

Ellis, J.: "Balancing the Upper Quarter Through Awareness of RTTPB" CLINICAL MGT, Vol. 7, No. 6

Describes sources of posture dysfunctions for upper quarter problems. These include TMJ dysfunction, thoracic outlet syndrome, cervical strain, shoulder problems and headache. Implies a postural relationship among TMJ, neck pain and upper extremity problems. Describes restoration of erect upper body posture, correction of breathing mechanics and unloading TMJ stresses posturally as an essential treatment objective in upper quarter problems.

Jackson, P.: "Thoracic Outlet Syndrome: Evaluation and Treatment" CLINICAL MGT, Vol. 7, No. 6.

This paper describes TOS pathomechanics in details. Prior neck trauma and abnormal posture habits are identified as risk factors. Correction of posture habits and body mechanics are identified as foremost in treatment objectives. Correction of round shoulders slumped postures, scaleni stretching and relaxed diaphragmatic breathing are recommended.

Joyce, M.: "Ergonomics Will Take Center Stage in the 90's and Next Century" JOR OCC HLTH AND SAFETY, Jan 1991.

The American Academy of Orthopedic Surgeons estimates repetitive motion injuries costs the US \$27 billion annually for medical and lost salary costs. One risk is the young people entering the work force are less physically fit. This is combined with the increasing age of the worker population, bringing degenerative and disease risks with age.

Hansford, P.; et al: "Blood Flow Changes at the Wrist in Manual Workers After Preventive Interventions": J HAND SURG: 1968: 11A: 503-508

Manual workers performing repetitive motion tasks were provided a five minute exercise program. Another group of workers were provided a five minute rest period. These interventions were performed after 1.5 hours of repetitive motion work tasks. Radial and ulnar artery blood flow were assessed with the Doppler method, as was Systolic blood pressure on the dominant extremity. Radial and ulnar blood flow velocity decreased while Systolic blood pressure remained stable after the 1.5 hours of manual work. Both the rest and exercise groups demonstrated increased blood flow velocity, unchanged radial blood pressure and decreased ulnar blood pressure. The five minute exercise group demonstrated greater increases in radial blood flow velocity than did the five minute rest group. Sustained, repetitive motion manual work can produce a decrease in blood flow through the wrists. Brief exercise programs have been shown to improve circulation at the wrist after circulation was compromised by the performance of manual work. Such programs may offer one practical method of preventing soft tissue injuries related to sustained compromise of blood flow at the wrist.

Allers, V.: "Workplace Preventive Programs Cut Costs of Illness and Injuries"; J OCCUP HEALTH & SAFETY: October 1989: 26-29.

Pre-work flexibility stretching exercises have demonstrated significant reductions in employee musculoskeletal injury and company health care costs. Warm-up stretching exercises were designed for employees in various work settings. These exercises emphasized flexibility throughout the spine, lower extremities and upper extremities. The objective of the exercises was to restore flexibility through passive stretching, improve blood flow to on-demand tissues and enhance fitness and self-care attitudes among employees.

Renco Forest Products in Central Point, Oregon, demonstrated a 91% reduction in injuries after one year of pre-work stretching exercises on the job. Roseburg Forest Products of Roseburg, Oregon, reduced lost-time injuries by 80% in one year with this program. Smurfit Newsprint Corporation in Oregon City, Oregon, reduced lost-time injuries by 95% in three years since starting the program. Tigrad Care Center in Portland, Oregon, has reduced lost-time injuries by 78% and lost work days by 96%. J.M. Smucker's Company of Woodburn, Oregon, reduced accidents during its six-month seasonal employment period by 56% and at cost savings of 95%.

HEBERT, L : "OSHA Ergonomic Guidelines and the PT Consultant," PT MAGAZINE, Jul.95

This paper describes how stronger OSHA enforcement efforts against Worker Compensation claims for CTD and back injury represents a tremendous opportunity to physical and occupational therapists to offer their services to industry as injury prevention consultants. The OSHA Ergonomic Guidelines 3123 is described as a format for the consulting therapist to design and present a comprehensive prevention and ergonomics plan to client workplaces. The paper discusses in detail the complicating attitude and sociopolitical issues surrounding the controversy that often accompanies a CTD claims problem in the workplace. This is described as a primary avenue to follow in evaluating and designing a comprehensive prevention program. A specific ergonomic risk analysis checklist and recommendations report is presented as an example of the approach therapists may take.

HEBERT, L: "Cumulative Trauma Prevention" CLINICAL MGT, Vol 10, No 5, Sept-Oct 1990

Discusses in detail the format, content and rationale behind the IMPACC CTD School. Discusses the procedure of marketing and providing this service to industry. Describes protocol of Work Risk Analysis, management training, employee worksmart training, preventive exercises, task rotations.

HEBERT, L: "A Change of Place" CLIN MGT, VOL. 8, NO. 6

Discusses the role physical therapist may play as consultants to industry to help them learn how to understand and resolve their injury risk issues pertaining to low back and CTD claims. Describes the Back School and CTD School formats of prevention training in the workplace.

HEBERT, L: "Stretching Exercises in the Workplace" ORTHOP PT PRACTICE, Vol.11, no.4, 1999

Describes IMPACC stretching program for the workplace; strategies, specifics, outcomes.

HEBERT, L: "Becoming a Consultant to Industry" ORTHOP PT PRACTICE, vol.12, no.2, summer 2000

Profiles the services PTs may offer to industry as a consultant: prevention and treatment services. ergonomics, CTD School, Back School, on-site services, preferred PT provider arrangements, early intervention-primary care PT strategies.

HEBERT, L: "Analytic Focus to Preventing CTD" J OCCUP HLTH & SAFETY, Apr 1993.

Describes a comprehensive approach to identifying and correcting hazards for CTD. Describes a methods of Risks Analysis, Management Education, Employee Motivation Training and other tactics. Injuries, claims and costs are described as separate issues, each with its own prevention strategy. Describes the IMPACC CTD SCHOOL approach to implementing an effective program, particularly to overcome attitudes and workplace politics that make claims expensive.

HEBERT, L: "Body At Work; Preventive Stretching on the Job" J OCC HLTH SAFETY, pp48-58, Oct 1992.

This paper describes mechanisms of CTD, strategies for prevention, limitations of a strictly engineering approach to CTD prevention, and discusses design and rationale of a preventive stretching program for the workplace. Employers report significant successes with the plan developed by IMPACC physical therapists. Table illustrates several successful preventive exercise outcomes with reductions in CTD lost time days ranging from 60 to 98 percent in the year following, some with measured increases in productivity. Major feature of the described exercises is the consideration of proximal structures to be stretched, i.e. scaleni and other thoracic outlet-inlet tissues. One key feature of these exercises is stretching of the scaleni to open the thoracic outlet-inlet. Exercises and CTD prevention training program described in this paper have a ten-year experience history at nearly 300 companies throughout the US.

HEBERT, L. "A Cumulative Trauma School for Industry" INDUSTRIAL REHAB QUARTERLY, fall 1992

This article describes the format and strategy of the IMPACC CTD SCHOOL. Rationales, pathophysiology, and prevention strategies are explained. This article offers a table summarizing the successful outcomes of eleven companies that implemented the IMPACC CTD SCHOOL program.

HEBERT, L "Preventive Stretching Exercises" IND SAFETY & HYGIENE NEWS April 1992.

Preventive stretching exercises for the workplace are described. Outcomes and rationale are presented, describing successful programs.

HEBERT, L: "The Politics of Work Injury Prevention" IND SAFETY AND HYGIENE NEWS, May 1992.

Discusses preventing CTD to be more of a political issue than a safety issue, requiring management training and attitude adjustment prerequisite to ergonomic efforts and employee behavior changes. Proposes that while it is the responsibility of management to provide a safe workplace, it is the responsibility of workers to properly use and care for the working body. Describes socio-political issues IMPACC addresses in its training program, The CTD School

HEBERT, L: "New Opportunities for Physical Therapists in Industry" PHYS THER TODAY, Spring 1991

Describes the opportunities available to physical therapists to present themselves to industry as consultants on work injury prevention. Describes Work Risk Analysis services, Back School, CTD School programs for managers, supervisors and workers. Discusses marketing strategies.

Lutz, G.; et al: "Cumulative Trauma Disorder Controls: The Ergonomics Program at Ethicon, Inc.": J HAND SURG: 1987: 12A (2,part 2): 863-866.

A ten-year experience history of an ergonomics task force for Ethicon, Inc. is described. The program is based on multiple strategies, including ergonomics, policy management, training and preventive exercise programs. Medical management procedures were developed for effective treatment and rehabilitation. Ergonomic design criteria for new and existing equipment were established. Employee orientation and education programs were provided to build acceptance of ergonomics and exercise strategies.

A preventive exercise program was established and studied. Exercises were performed twice per day per shift for approximately seven minutes each session. Participation level was voluntary, averaging between 80% - 90%. Prior to the exercise program, the medical department reported an average of 76 work-related visits for CTD problems per month. Following the exercise program, three months later, the medical department reported an average of 28 work-related visits per month for CTD problems. This is nearly 63% reduction in medical department visits for CTD-related complaints following initiation of a preventive exercise program.

Sawyer, K.: "An On-Site Exercise Program to Prevent Carpal Tunnel Syndrome": PROFESSIONAL SAFETY: May 1987: 17-20.

Workers at a racquetball racquet manufacturing facility were experiencing a high frequency of carpal tunnel syndrome-related problems. From September 1983 until May 1984, 11 workers were referred for medical attention, two requiring carpal tunnel relief surgery. A preventive exercise program was initiated in July 1984. These exercises included stretching of various muscle groups in the neck, shoulders, arms and hands. Contract-relax exercises were provided for the fingers and thumb.

From July 1984 through May 1987, there had been only one case of carpal tunnel syndrome reporting for medical attention. This was successfully corrected with conservative treatment. It was noted that in May 1986, ergonomic modifications were made to some tools in an attempt to reduce forearm muscle work demand. Nearly two years of the exercise program had passed to that point.

Silverstein, B.; et al: "Can In-Plant Exercise Control Musculoskeletal Symptoms?": J OF OCCUP MED": Vol. 30, No. 12, Dec. 1988: 922-927.

After one year of an on-the-job exercise program to control musculoskeletal subjective symptoms in the neck and

upper extremity, there were no statistically significant differences in localized posture discomfort. 67% of respondents who participated in the exercise program reported that the program made them feel better.

The exercises employed in this study included shoulder joint stretching and hand squeeze-relax to a bean bag. The author stated that any gain that might have been made with the exercise program may have been over shadowed by increasing productivity demands. The authors also pointed out on-going ergonomic problems with the jobs being studied.

{{ LAUREN'S RESPONSE: Exercise design was questionable. This did not demonstrate that exercises are useless; this demonstrates that improper exercises are useless! Ergonomic stresses persisted uncorrected. Production demand increased. Confusing and contradictory conclusion statement stated there was no difference in discomfort, yet 67% felt better? }}

De Vera Barredo R, Mahon K: The effects of exercise and rest breaks on musculoskeletal discomfort during computer tasks: an evidence based perspective. J Phys Ther Sci, 2007, vol 19, no 2: 151-163.

A review of research evidence on effects of exercise and rest breaks on musculoskeletal discomfort during computer work found that evidence supports use of rest breaks and exercise breaks to reduce discomfort. The evidence, in aggregate, suggests no additional benefits of exercises over rest breaks. This review identified widespread problems with research design, internal validity, statistical analyses, dropout rates and poor subject compliance. This serves to illustrate the potential value of rest breaks and exercise breaks but identifies problems with the research in allowing us to reach valid conclusions. This article is also an excellent demonstration of how to assess the value of research according to levels of evidence and internal validity.

Fenety A, Walker JM: Short-term effects of workstation exercises on musculoskeletal discomfort and postural changes in seated video display unit workers. Phys Ther, 2002, 82: 578-589.

Authors examined short term effects of an exercise program on eleven subjects, involving an exercise break every 30 minutes. Exercises done by video display unit operators resulted in short-term decrease in both musculoskeletal discomfort and postural immobility. This is a non-randomized trial where participants acted as their own controls, resulting in evidence level IV with moderate internal validity.

Saltzman A: Computer user perception of the effectiveness of exercise mini-breaks. In: Proceedings of the Silicon Valley Ergonomics Conference and Exposition. Silicon Valley, CA, 1998, 147-151.

Authors examined effects of an ergonomics exercise software program of frequent short stretch breaks. Participants reported stretch breaks were effective in reducing workplace discomfort. 23 percent of participants reported increased productivity. 34 percent of participants dropped out of the study. This study is level V evidence with weak internal validity.

Thompson D: Effects of exercise breaks on musculoskeletal strain among data entry operators: a case study. In: Promoting Health and Productivity in the Computerized Office: Models of Successful Ergonomics Intervention. Taylor and Francis, 1990, 118-127.

Employees were asked to perform five-minute exercise sessions during their two regular break periods. Operators reported reduced discomfort and generally improved physical condition. There were no Worker Compensation claims for one year into the program. Productivity had increased by 25 percent during the first four months of the program. Level of evidence is V, with weak internal validity.

Karas B, Conrad K: Back injury prevention in the workplace: an integrative review. AAOHN J, 1996; 44(4): 189-96.

Review of 15 experimental and quasi-experimental studies showed some positive evidence for back belts,

back schools, stretching programs, and educational classes. Back schools and stretching programs were studied more frequently and showed the greater proportion of positive results.

Moore T: A workplace stretching program. Physiologic and perception measurements before and after participation. AAOHN J, 1998, 46(12): 563-8.

Participants who completed a structured stretching program had zero occurrences of MSD during the two-month period. There was statistically significant improvements in flexibility and the Fox Self Perception Profile, suggesting that flexibility exercises may reduce workplace MSD.

Hess J, Hecker S: Workplace stretching programs: the rest of the story. Appl Occup Envir Hyg, 2003; 18(5): 331-8.

Several studies are examined and analyzed in detail, describing positive and negative findings among a variety of studies and exercise approaches. One study review included flexibility program for firefighters. Showing no significant reduction in incidence of LBI, but injury costs significantly reduced (\$85,372 for stretch group versus \$235,131 for control group) from Hilyer 1990.

Hilyer J, et al: A flexibility intervention to reduce the incidence and severity of joint injuries among municipal firefighters. J Occup Med 1990, 32(7): 631-637.

A flexibility program for firefighters showed no significant reduction in incidence of musculoskeletal injury, but total injury costs significantly reduced (\$85,372 for stretch group versus \$235,131 for control group)

Rosta, P.: "Industrial Workers Excel With Work Hardening" REHAB MGT, April-May 1991.

Half of all workers injured on the job never return to work after six months of absence. 90% recover after 12 weeks. The remaining 10% account for 80% of costs. Companies rely on ergonomic redesign of work stations. This inadequate since there is no direct link between ergonomic design and high Worker Comp claims. A company's Worker Comp problem is a complex set of economic, political, medical and legal issues. These must all be considered. Limiting attention to job design issues is putting a simple band-aid on a very large wound.

Melnik, M.: "Enlisting Participation in an Injury Prevention and Management Program" WORK, Fall, 1990.

...Various prevention approaches have been promoted in industry: ergonomic re-design, employee training, incentive programs, fitness and exercise plans, supervisor training, and psychosocial strategies. Most claim at least modest success. There appear to be several common themes that account for success: genuine management commitment, ongoing efforts to keep programs alive, employee willingness to participate. Prevention programs are doomed to failure without the participation of all parties.

...Therapist consultants to industry must consider existing industry conditions that may affect outcomes: an existing medical management program, an effective return to work policy, official employee education system, equipment problem reporting system, official lines of communication, a physician who understands the job demands, relations between managers and supervisors, relations between supervisors and employees, and employee job satisfaction.

...Injury causes fall into two categories: conditions versus behaviors. Programs that focus just on job design will be helpful when such conditions are at risk, but industry must be aware that this addresses only one aspect of the problem. Buying ergonomic chairs does not reduce stress for an employee who does not use it correctly. Safe work is often a choice. Safe choices require education. Industry would be naive to believe they can eliminate all risk factors through design changes.

...The first step is to define unsafe conditions and unsafe behaviors. Unsafe behaviors are the result of: communication deficits, negative attitudes, poor physical condition, insufficient knowledge, stress, and lack of proper supervision. A truly effective program must address behaviors, attitudes, knowledge and physical condition

along with the physical work environment.

...Essential components include: orientation of top managers, work site evaluation, a task force, employee education, supervisor education, address strength and flexibility, review sessions, an on-site stretching program, task force updates, and an incentive program.

Nag P, et al: Influence of arm and wrist support on forearm and back muscle activity in computer keyboard operation. *Appl Ergo*. 2009; 40(2): 286-291,

Study examined muscle activity while using a wrist rest, forearm support and floating (unsupported) upper extremity work posture during keyboard work. Wrist rest showed mixed reductions in muscle activity, while forearm support showed widespread reduction in muscle activity compared to forearms unsupported.

Conlon C, Krause N, Rempel D: A randomized controlled trial evaluating an alternative mouse and forearm support on upper body discomfort and musculoskeletal disorders among engineers. *Occup Environ Med*. 2008 May; 65(5): 311-8.

In engineers using computers more than 20 hours per week, a forearm support board may reduce right upper extremity computer use.

Remple D, et al: A randomized controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. *Occup Environ Med*. 2006 May; 63(5): 300-6.

Comparing ergonomics training only with training plus computer trackball with training plus forearm support revealed that training plus forearm support was effective in preventing upper body MSD among call center employees.

Sheley, Elizabeth: "Preventing Repetitive Motion Injuries," *HRM MAGAZINE*, Oct. 95.

This article comes from the non-refereed professional journal of human resource managers in industry. It discusses the introduction of the IMPACC program of CTD prevention to several workplaces. It describes a three-step approach: work risk analysis to identify CTD risks, management training to build company and supervisor commitment and knowledge for identifying and correction risks, and employee self-protection training. The IMPACC program is specifically highlighted as being particularly effective in reversing CTD claims. Several companies using the IMPACC program revealed dramatic reductions in injury claims. Mike Strakal, PT, of Elkhart, Indiana and Lauren Hebert, PT, of Portland, Maine, were profiled as IMPACC providers, describing their techniques and success with the IMPACC program.

P.T. BULLETIN, June 29, 1994: "CTS, Tendon Ailments on the Increase"

UNUM Corp. findings demonstrate CTS increased 308% and tendon disorders 289% from 1989 to 1993. For men CTS increased 386%, tendon disorders 453% and back problems by 180%. For women CTS increased 379%, tendon disorders by 239% in the five year period. Claims for all disabilities increased 78% during that period.

Spinner, R.; et al: "The Many Faces of Carpal Tunnel Syndrome": *MAYO CLINIC PROCEEDINGS*: 64: 829-836, 1989.

This medical paper describes typical and atypical symptom presentations for carpal tunnel syndrome. The paper discusses differential diagnosis, electro-diagnostic studies and treatment strategies. The paper describes secondary or contributory diagnoses, such as "double crush" lesions and pronator syndrome. It discusses various neuropathies, autonomic reflex contributors and other disease processes.



Jenkins, B: "Differential Diagnosis and Management of Neck Pain": PHYSIOTHERAPY: August 1982: Vol. 68, No. 8: 253-255.

This paper describes various neurophysiological and biomechanical processes of neck and upper extremity pain and dysfunction. It discusses various treatment strategies. It provides a detailed description of pathology of various neck conditions.

Of particular note on CTD, this paper describes a central summation phenomenon whereby nociception originating from various neck tissues due to inflammation or mechanical irritation can lead to a background of subliminal sensory stimuli which can increase the central excitatory state. This can lower the threshold of pain for other peripheral lesions throughout the upper extremity and explain the apparent correlation between painful shoulder problems, tennis elbow and carpal tunnel problems in cervical problems. The contribution of the cervical spine must be considered carefully when presented with one or more of these symptom complexes.

This paper, therefore, presents one neurological explanation as to how various and multiple CTD problems throughout the upper quarter may be related to neck problems. This offers an explanation of the apparent strong relationship between neck pain problems and carpal tunnel syndrome and tendinitis distally in the arm.

Zacharkow, Dennis, "Sitting Posture: The Overlooked Factor in C.T.S." ADVANCE FOR P.T., May 16, 1994

This paper describes in great detail and extensive literature references the role of sitting posture stress in the etiology of Carpal Tunnel Syndrome, primarily via thoracic outlet compression caused by forward head posture during sitting work tasks. Numerous studies are quoted citing the strong relationship between CTS and TOC and forward head posture. 64% of thoracic outlet patients had clinical evidence of CTS in one study (Novak, 1993); another showed virtually 100%. Another study (Glick, 1994) of 500 CTS patients showed 93% had minor to moderate underlying cervical radiculopathies.

Barrer, S.: "Gaining the Upper Hand on Carpal Tunnel Syndrome" JOURNAL OCC HLTH AND SAFETY, Jan 1991.

CTD accounts for 48% of claims, up from only 18% less than a decade ago. This is a function of the shift to automation, requiring more repetitive motion in sustained postures. Repetition without adequate recovery leads to inflammation. NIOSH found that 8-9 repetitions per minute did not allow enough recovery time between repetitions to produce adequate lubrication of moving tissues.

The average high risk workplace will spend \$250,000 on these claims per 100 employees per year (1988 dollars). The hidden costs are likely much greater: damage to morale, for one. Worker who feel the company is not responding adequately to the problem feel trapped and demoralized, possibly adding to the problem.

The first step is not to deal with at-risk workers. Rather, one must first educate management. It is imperative that top management become committed experts on the issues. The attitude of management will dictate the effectiveness of any prevention efforts. Only then should one proceed with employee training. Employee training is essential to ensure their working future. They must conform to company risk reduction policies, including on-the-job exercises.

Seater, S.: "Physical Therapy Emerging As a Partner in the Corporate Fight To Contain Costs" P.T. FORUM, Vol. 5, No. 13

Several examples of successful injury prevention and cost reductions following physical therapy consulting for injury prevention are cited. Westmoreland Coal reduced back injury lost days by 330, saving \$53,130 in employee pay and benefits alone. Black and Decker reduced medical department visits by 50% with work station modifications and posture education from a P.T. Adolph Coors Beer used a P.T. to create a wellness and prevention program that saved them \$663,677 in health costs alone. Lockheed Missile reduced back injuries

dramatically with a back injury prevention training program. Public Service of New Hampshire reduced back injuries by 60% following a similar training process, as did Texas Instruments. Physical therapists are described as leading authorities on injury prevention due to their mix of training on musculoskeletal function, making them ideally suited to prevention programs emphasizing ergonomics.

Will, Robert: "How to Control Worker Comp Costs" NATION'S BUSINESS, March, 1990.

Statistics indicate that people, not workplace conditions, cause 80% of all injuries. Work habits, attitudes, stress, physical ailments all contribute. Keep people happy. Injuries and job satisfaction are related. Those with bad attitudes are far more likely to be injured. Modified duty is vital to reducing costs. The sooner the return to work, then lower the cost.

Armstrong, T.: "Ergonomics and Cumulative Trauma Disorders": HAND CLINICS: Vol. 2, No. 3: Aug. 1986: 553-565.

This paper discusses the chronic effects of repetitive work on tendons and nerves of the upper extremity as it relates to CTD. The author identifies the list of frequently reported causes or contributors. He discusses various preventive strategies for re-design of work equipment and procedures. This paper is a rather exhaustive summary of ergonomic principles and strategies. Various repetitive motion and posture stresses are described in detail. Tool modifications are described. An extensive bibliography is also provided.

Schuck, L.: "Handling Carpal Tunnel Syndrome": ASSEMBLY ENGINEERING: Nov. 1988: 30-33.

This non-medical paper describes carpal tunnel syndrome, its risk factors and contributory stresses, and various strategies for treatment and prevention. The paper discusses the role of vibration and other ergonomic contributors. It discusses the use of a vibrometer as a diagnostic or screening tool. The paper also discusses splints, vitamin B6, and other treatment strategies. The paper describes various basic ergonomic modifications in the workplace.

Cannon, L.; et al: "Personal & Occupational Factors Associated With Carpal Tunnel Synd": J OCC MED: Vol. 23, No. 4: April 1981: 255-258.

This paper describes case studies of personal and environmental factors associated with the onset of carpal tunnel syndrome in manufacturing workers. Particular attention is paid to vibratory hand tools in a history of gynecological conditions. There are statistical studies regarding years on job, job type, vibration, diabetes, gynecological conditions, and sex discussed in the paper

Silverstein, B.; et al: "Carpal Tunnel Syndrome: Causes & a Preventive Strategy": SEM IN OCC MED: Vol. 1, No. 3: Sept. 1986: 213-219.

This paper provides an extensive description of occupational risk factors, non-occupational risk factors and CTS prevention strategies. It identifies reducing exposure to risk factors such as vibration, worker conditioning and training to improve work tolerance and modification of work postures. The paper states a lack of scientifically valid or socially acceptable screening procedures to identify those at high risk. The paper discusses the value of a "phasing-in" for training workers new to the job. The paper provides an excellent basic understanding of injury mechanisms.

Mallory, M.; Bradford, H.: "An Invisible Workplace Hazard Gets Harder to Ignore": BUSINESS WEEK: January 30, 1989: 92-95.

Business article describes extent of the epidemic. Gives a detailed statistical report on frequency, costs and growth. It provides a layman's description of the problem and its sources. It also discusses simplified personal ergonomics.

Bleecker, M.: "Recent Developments in the Diagnosis of Carpal Tunnel Syndrome and Other Common Nerve Entrapment Disorders": SEMINARS IN OCCUPATIONAL MEDICINE: Vol. 1, No. 3, Sept. 1986: 205-212.

This paper provides a detailed summary of carpal tunnel syndrome, ulnar nerve compression, radial nerve compression, peroneal nerve problems, tibial nerve compression (tarsal tunnel syndrome). The paper discusses various occupational and non-occupational risk factors. It describes symptomatology, diagnosis, treatment and prevention.

Erdreich, J.: "VFWS Threatens Your Most Valuable Tool: Employee Hands": J OF OCCUP HEALTH & SAFETY: June 1989: 26-28.

This paper described Vibration White Finger Syndrome, particularly differentiating it from carpal tunnel syndrome. The paper discusses the similarities and differences between carpal tunnel syndrome and vibration white finger syndrome. Discusses diagnosis, treatment and prevention.

Strakal, Michael: "The Magic in Minutes of Exercise," J. OCC. HLTH. & SAFETY, Aug 1996.

This article comes from the non-refereed professional journal of corporate safety managers and safety professionals. It is written by a physical therapist specializing in workplace injury prevention, specifically targeting back and neck-arm CTD claims. It describes the rationale and experience of specifically-designed intermittent exercise breaks in the workplace to reverse the fatigue and potential damage of CTD. Strakal specifically profiles the IMPACC program and its approach to exercise. It must be pointed out that the author emphasizes that simply imposing stretching exercises is not effective. Certain management attitudes, commitment, policies must be first put in place through effective training. Employees must be taught the rationale behind exercises and that other steps must also be taken to manage ergonomic risks. Several companies were described as having experienced dramatic reductions in CTD claims and costs as a result of the IMPACC program.

Morris, A.: "Program Compliance Key to Preventing Low Back Injuries" JOURNAL OCCUP HLTH AND SAFETY, Mar 1984.

80% of population will experience back pain. 8% of total worker population will be disabled during each year. Repeat incidents are the result of incomplete rehabilitation or inadequate re-entry to work. Employees must be made aware of the problem and their roles and involvement in it. Employees must understand the basic structure, function and degenerative processes of the spine to motivate their compliance with prevention. Using slide of the employees doing at-risk behaviors will motivate their compliance also.

The frequent and thoughtless use of stressful movements and postures is the primary risk. Back injury should be identified as a cumulative process. Training should teach why and how to change at-risk behaviors. Techniques should include reaching, lifting, posture correction, rest strategies, and simple steps to restore flexibility and strength. Actual practice of techniques is needed, customized to the actual jobs, with peer group critique and comment.

Follow-up and vigorous reinforcement is essential to success. Peer support is essential. Management and supervisors must provide ongoing feedback. The impact of management attitudes cannot be underestimated!

Nordin, M., et al: "Prevention and Treatment of Low Back Disorders" THE ADULT SPINE, Frymoyer, J., ed., 1991.

...This paper offers various information of back injury prevention training. Various studies show some prevention training programs have been very effective while others have not. The conflicting results appear to be due to varying company support, teacher qualifications and employee involvement.

...Movements and postures associated with back injury are frequent lifting (>25x per day), twisting while lifting,

heavy lifting (>11.3 Kg), static postures, forward bending, twisting, and muscle fatigue. The worse appears to be simultaneous twisting and forward bending, resulting in a six-fold increase in risk.

...Training workers in materials handling techniques is ineffective. Inconsistent results appear due to lack of control over materials handling demands among many workers. Avoiding twisting and keeping the load close appears to be the most important materials handling methods. Studies have failed to assess the acquisition of new motor skills as a result of the training. These skills can be effectively taught. Workers will retain new skills for three months. Long term retention is seen with on-site feedback and enforcement. 60% of back injuries can be prevented with safer lifting techniques.

...The firefighters study showed that the unfit are more likely to sustain back injury. Isometric strength is a poor predictor, as was flexibility. Nevertheless, fitness programs have shown overall reductions in absenteeism and costs. Smoking has a positive risk relationship, particularly with disc herniation. Dissatisfaction with one's job is a very high risk for injury claims and costs. One study showed that job dissatisfaction was the number one predictor for back pain. Management programs have been effective in decreasing accidents.

...Training should be mandatory to assure those most at risk attend. Groups should be small, between 3 and 12. Audiovisual aids are important. Actual demonstrations and practice are important. Lifestyle changes is an objective. Training must fit real life for the students. Development of skills must be foremost over simple acquisition of knowledge.

Twomey, L. "A rational Approach to the Treatment of Back Pain by Manual Therapy" *PHYS THER*, Vol. 72, No. 12, Dec 1992

This author provides an excellent description of the pathophysiology of lower back degeneration and injury, describing the loss of nutrient pathway and physical changes due to sustained loading/strain stresses to articular cartilage and discs and ligament structures. The author discusses flexion loading, particularly sustained, as a mechanisms of injury and degeneration due to nutrient pathway changes, fluid dynamics, collagen and cartilage effects. End-range loading, creep and crimp effects are discussed. The role of passive extension and pause stretching to prevent injury and reverse many of these processes is described. Excellent discussion of prevention rationales.

McKenzie, R.: *THE LUMBAR SPINE, MECHANICAL DIAGNOSIS AND THERAPY*, Spinal Publications, 1981.

The McKenzie low back care manual. The standard reference on McKenzie protocol, lordosis lifting methods and mechanisms of disc injury. Extensive description of mechanisms of disc failure pp16-21.

Hart, D. et al: "Effect of Lumbar Posture on Lifting" *SPINE*, Dec. 1986.

This LANDMARK research dissertation compares various methods of lifting techniques and implications for avoiding back injury on materials handling tasks. Strictly controlled study shows the best method to be one of maintaining lumbar lordosis during squat lifting. This method is demonstrated to be favored over the traditional "pelvic tilt" method.

Lumbar flexion moments were least in this lifting posture. Protective muscle recruitment of erector spinae and obliques was highest with this lifting posture, particularly during the critical early stage of the lift. An extensive and valuable bibliography is provided.

Delitto, R., et al: "EMG Analysis of Two Techniques for Squat Lifting" *PHYSICAL THERAPY*, Vol. 67, No. 9. Sept 1987.

This study describes the effects on the spine for two different methods of squat lifting: pelvic tilt versus maintaining lordosis. The researchers discovered that for pelvic tilt, flexion moment loads were at maximum at the beginning of

the lift while protective contractions of erector spinae and abdominal obliques were at minimum. During lordosis lifting, protective activity of the erector spinae and abdominal obliques was highest at the critical early stage of lifting. It was concluded that lordosis lifting method offered the best potential muscle protection, particularly during the critical early phase of the lift.

One of the best papers re motor activity of ES during flexion and lifting in various postures. Reveals near shutdown of erector spinae and abdom obliques (needed to stabilize and protect LB structures during lifting) when lifting done with LB flexion, but high activity during lifting with lordosis preserved. A landmark paper validating maintaining lordosis during squat lifts (per McKenzie) to recruit active muscle protection of passive tissues during loading.

Jackson, C. and Brown, M.: "Analysis of Current Approaches and a Practical Guide to Exercise Prescription" and "Is There a Role for Exercise in Treatment " CLINICAL ORTHOP AND REL RESEARCH, No. 179.

Extensive discussion of the design and rationales of various exercise methods. Notable discussions are offered on the role of obliques, hamstrings, erector spinae. Excellent critique of otherwise accepted protocols for exercises. Challenges various traditional assumptions about spine function and exercise, offering sound research data foundations for challenging traditional assumptions. Excellent.

Lepore, B. et al: "The Dollars and Sense of Occupational Back Injury Prevention Training" CLINICAL MGT, Vol. 4, No. 2

1000 Lockheed Missile and Space Co. employees participated in a back injury prevention training program that resulted in a 67.5% reduction in total back injury liability costs, a 71% reduction in lost time cases for back injury, a 76% reduction in costs per case, and a 57% reduction in injury cost reserves.

Gatty C, et al: The effectiveness of back pain and injury prevention programs in the workplace. Work 2003; 20(3): 257-66.

Review of nine studies showed that positive outcomes were associated with studies reporting high compliance that used job-specific and individualized/small group education and training approaches.

Schenk R, Doran R, Stachura J: Learning effects of a back education program. Spine 1996; Oct 1; 21(19): 2183-2189.

The American Back School was compared to a video education group and a control group. Learning effect was assessed by examining gains in post-test results. No differences in post-test comparisons were seen in control and video groups. Significant differences were seen in the back school group at the .001 level, indicating that back school is an effective intervention for influencing lifting posture and conveying information on spinal mechanics and lifting technique. Additionally, video training may not be an effective prevention intervention.

Heymans M, van Tulder M, et al: Back schools for nonspecific low back pain: a systematic review within the framework of the Cochran Collaboration Back Review Group. Spine. 2005; 30(19): 2153-63.

There is moderate evidence suggesting back schools in an occupational setting reduce pain and improve function and return-to-work status.

Karas B, Conrad K: Back injury prevention in the workplace: an integrative review. AAOHN J, 1996; 44(4): 189-96.

Review of 15 experimental and quasi-experimental studies showed some positive evidence for back belts, back schools, stretching programs, and educational classes. Back schools and stretching programs were studied more frequently and showed the greater proportion of positive results.

Hickey, D., et al: "Relation Between the Structure of Annulus Fibrosus and Function and Failure of Intervertebral Disc" SPINE, Vol. 5, No. 2

Annulus fibers have the same mechanical properties as tendon fibers, per tolerance to stretch and strain. Failure of the annulus is most likely to fail during forward bending loads and during torsion loads. Compression is more likely to cause end-plate failure. {This paper is often cited as one basis for not advocating pelvic tilt lifting methods.}

Versloot, et al: "Cost-Effectiveness of a Back School Program in Industry" SPINE; Vol 17, No 1, 1992; pp22-27.

A controlled longitudinal study of cost-effectiveness of a Back School for a Dutch bus company over a six-year period. Results showed a customized Back School reduced absenteeism by at least 5 days per year per employee, making Back School cost-effective.

McKenzie, R: "Spinal Assessment & Therapy Based on Pain Behavior" Lecture handout for BACK PAIN '92 symposium, Boston, Ma. Dec 1992.

Describes McKenzie method of back pain evaluation and treatment in a concise and organized manner. Of note: the Quebec Task Force reviewed over 7000 scientific studies from 1975 to 1985 to identify acceptable methods of categorizing mechanical back problems. The QTF concluded that a specific diagnosis in LBP is not possible in 90% of cases. The paper goes on to describe the McKenzie system of mechanical diagnosis and corrective exercise design.

Daltroy, et al: "A Controlled Clinical Trial of an Educational Program to Prevent Low Back Injuries" N ENGL J MED 337: 322-328, 1997.

2500 US Postal Service workers underwent back injury prevention training programs. A similar number were assigned to a control group. a 5.5 year follow-up revealed no difference between the two groups relative to incidence, lost days, injury costs, re-injury rates. This study appears to demonstrate for this group of workers Back School training is ineffective. Authors considered the possibility management did not take the employee prevention efforts seriously and employee job dissatisfaction and a negative perception of management's attempts to impose prevention efforts. {{Lauren's note: IMPACC has had Back School failures at similar postal service settings, apparently due to hostile employer-employee relations issues. Employee-management relations MUST be addressed before Back School can be expected to succeed !!}}

Donelson, M. et al: "A Prospective Study of Centralization of Lumbar and Referred Pain" SPINE, Vol 22, No 10.

This compared the McKenzie method of identifying disc derangements to findings produced by discographic pain provocation and annular competency. The study concluded the McKenzie method was actually better than MRI in differentiating painful versus non-painful discs.

Fritz, Erhard, Hagen: "Segmental Instability of the Spine", PHYS THER, Vol 78, No 8

This is a clear, scientific, practical, clinical description of "spinal segment instability," probably the best description available anywhere. Excellent!

APTA: "Guidelines for Evaluating Functional Capacity" 1998.

Official guidelines from the American Physical Therapy Association. Describes pertinent definitions, therapist knowledge base, FCE admissions criteria, testing methods, outcomes data generation. This is a summary outline, not instructions on how to do an FCE.

King, et al: "Critical Review of Functional Capacity Evaluations" PHYS THER, Vol. 78, No. 8, Aug 1998 pp 852-866. This is the most complete comparative analysis of the top 10 FCE systems performed to date. Issues of evaluator qualifications, test protocols, validity, reliability, safety, standards are discussed at length. Important comparative analyses are illustrated on easy-to-follow tables. This is an excellent analysis that allows more informed therapist decisions on selecting an FCE system.

Lechner, et al: "Detecting Sincerity of Effort: A Summary of Methods and Approaches" PHYS THER, Vol. 78, No. 8, Aug 1998. pp 867-888.

Waddell's nonorganic signs, grip dynamometer validity testing and other sincerity-of-effort test methods are critically analyzed by way of medical literature relative to their validity and reliability. Literature review reveals therapists may be overstepping the bounds of defensible assessment when assigning a label of invalid or symptom magnification or malingering based on these tests. Such labels are just not supported by peer reviewed literature research reports.

McGill, SM: "Low Back Exercises: Evidence for Improving Exercise Regimens" PHYS THER, Vol. 78, No. 8, Aug 1998. pp 754-765.

An exceptional laboratory analysis of various exercise methods, lifting techniques, injury mechanisms, including a rare incident that produced a video fluoroscopy of an instability injury as it occurred. A wealth of valuable information on lumbar injury and care is provided in this article. Well-supported suggestions for exercises.

Byl, et al: "A Primate Model for Studying Focal Dystonia and Repetitive Strain Injury: Effects on the Primary Somatosensory Cortex," PHYSICAL THERAPY, Vol 77, No 3, Mar 1997

This study illustrates changes in the brain as a result of repetitive motion demands at the hand. Repetitive hand motion degrades hand representation in the sensorymotor cortex of the brain and interferes with motor control. Restoring hand representation may be a critical part of treatment for patients with RSI.

Solomonow, M, et al "Increased Exposure to Lumbar Injury due to Cyclic Loading," Volvo Award, presentation at Intl Soc for Study of Lumbar Spine, as yet unpublished, 1999.

Repetitive mechanical loading progressively desensitizes mechanoreceptors in soft tissues of the spine. This results in exponential decrease in protective reflex muscle activity, increasing risk of injury. Discs, ligaments and other viscoelastic structures progressively deform (creep) under such repetitive loads, as muscles lose their ability to stabilize the spine from fatigue, mechanoreceptor desensitization and neurological habituation. Rest periods required hours to recover lost tension in experimental tissues (feline model)...

Moffett, J, et al "Benefits of Exercise for patients with Low Back Pain" BRITISH MEDICAL JOURNAL, July 31, 1999.

Patients were assigned to either a PT-designed exercise program, versus no exercises beyond general practitioner care. 64% of the exercise group had improved at least three points on a 24-point disability questionnaire, compared with 35% of the non-exercise group.

Zigenfus GC, Yin J, Giang GM, Fogarty WT. Effectiveness of early physical therapy in the treatment of acute low back musculoskeletal disorders. J Occup Environ Med. 2000;42:35-39.

Patients referred to physical therapy at day one or day two of back pain onset needed fewer treatment visits and had fewer lost work days than those referred later than day two.

Landsmann, M.: "Music Above All," ADVANCE FOR DIRECTORS OF REHAB, May, 2000.

An excellent review of specific CTD problems common to musicians. Clear parallels to industry. Professional musicians are workers, too, after all.

Gross, m., et al: "Relationship Between Lifting Capacity and Anthropometric Measures", JOSPT, vol 30, no 5, May, 2000

Various anthropometric measures were taken among men and women of various ages and related to maximum lifting capacity, using lordotic spine technique. Higher lifting capacities were discovered among men (vs. women), older subjects (vs. younger), larger thigh girth (vs. smaller), narrower pelvis girth (vs. wider pelvis). See next two abstracts for perspectives).

Chaloupka, E., et al: "Metabolic and Cardiorespiratory Responses to Continuous Box Lifting and Lowering in Nonimpaired Subjects," JOSPT, vol 30, no 5, May, 2000

Much higher energy expenditure and related cardiopulmonary responses were seen during squat lifting versus leg-torso coupled flexion lift method. The squat method employed was a full squat with torso upright, while the leg-torso lift shared partial knee flexion with forward inclination of the torso (appears to combine hip flexion with some lumbar flexion. See next abstract for perspective.

McGill, Stuart, "Invited Commentary" , JOSPT, vol 30, no 5, May, 2000

Exceptionally enlightening commentary on the above two articles, in perspective with several other related studies, noting how all these fit the realities of the workplace (prevention) and clinic (rehabilitation). Excellent bibliography. Summary findings include: Continuous lifting is the more valid function to examine; Experienced lifting workers will use a variety of lifting postures throughout the work day; Curvature of lordosis important to control lines of action along many lumbar stabilizer muscles, more beneficial mechanically than lumbar flexion positions; Spine ROM and strength have little correlation with future injury; Use of screening measures legally risky and very limited; Patients should be classified functionally and by specific injured tissues to determine lifting technique.

Byng J: Overuse syndromes of the upper limb and the upper limb tension test: a comparison between patients, asymptomatic keyboard workers and asymptomatic non-keyboard workers. Man Ther 1997, 2: 157-164

The ULTT was positive in 100 percent of the patient group, supporting the hypothesis that the pathology of occupational upper limb overuse is neurogenic in origin. Furthermore, the asymptomatic keyboard users (intended to be a control subgroup) also had a significantly higher positive ULTT compared to asymptomatic non-keyboard users (the other control subgroup).

Lundborg G, Dahlin L: Anatomy, function, and pathophysiology of peripheral nerves and nerve compression. Hand Clin 1996; 12(2):185-93.

The clinical stages of nerve compression lesions can be related to changes in intraneural microcirculation and nerve fiber structure, alterations in vascular permeability and subsequent formation of edema. The double crush and reverse double crush syndromes are related to disturbances in axonal transport induced by compression, followed by morphological and functional changes in nerve cell bodies.

Edgelow P: Ch.6; Neurovascular consequences of cumulative trauma disorders affecting the thoracic outlet: a patient-centered approach. In Donatelli R (ed): Physical Therapy of the Shoulder; 1997; Churchill-Livingstone.



Comprehensive description of pathomechanics and pathophysiology of thoracic outlet compression.

Federal Register, 11-14-00, Vol. 65, No. 220, Pages 68261-68870, issued Nov 14, 2000

This is the final OSHA Ergonomics Program Rule (cancelled by Congress in Feb 2001). Book Two details the debate and rationale for how and why the Ergonomics Rule was constructed. Pages 68442 to 68486 discusses injury pathomechanics, biomechanics, pathophysiology, epidemiology of these MSD's. Pages 68487 to 68582 details a debate from various parties challenging studies on occupational risks versus non-occupational risks, offered by various opinionated parties with their own parochial interests in these rules. An excellent research review and debate.

Reuters News abstract: Radiography Discouraged for Patients With Low Back Pain, BMJ 2001;322:400-405:

Feb 15, 01 - Radiography is not advisable for patients with low back pain in the absence of indications of serious spinal disease, even if pain is present for more than 6 weeks, according to British researchers. Dr. Mike Pringle, of the School of Community Health Sciences in Nottingham recruited 394 patients with low back pain of at least 6 weeks' duration. The patients were randomized to receive a radiograph of the lumbar spine or to receive usual care from their doctor. The findings appear in the British Medical Journal for February 17. Patients who underwent radiography were more likely to report longer duration and greater severity of pain, reduced functioning, and poorer health status than those who had no X-rays taken. The investigators surmise that "radiography encourages or reinforces the patient's belief that they are unwell and may lead to greater reporting of pain and greater limitation of activities." Approximately two thirds of patient X-rays showed abnormal results, although no significant differences in outcome were noted between patients with normal versus abnormal X-rays. In an interview with Reuters Health, Dr. Pringle pointed out, "Often X-rays show minor abnormalities such as 'wear and tear.' These cannot be treated, as such, and do not affect care." However, patients who received X-rays were more satisfied with their care. Even after 9 months, with improvement in their condition, most patients in both groups said they would have chosen radiography if the choice had been available. The authors advise that patient education regarding radiography is important. Dr. Pringle commented that patients should be told, "The evidence of this study and others shows that X-rays do not improve therapy decisions or outcomes."

Reuters Health News: Railroad Ends DNA Testing in Wake of Lawsuit

NEW YORK Feb 13, 01 - The Burlington Northern and Santa Fe Railway Company said yesterday that it would stop DNA testing for carpal tunnel syndrome. The US Equal Opportunity Employment Commission (EEOC) on Friday filed a lawsuit challenging the railroad's DNA testing program as a violation of the Americans with Disabilities Act. The lawsuit, filed in federal court in Sioux City, Iowa, is the EEOC's first court action challenging genetic testing. Burlington Northern, based in Fort Worth, Texas, also agreed to suspend testing that would identify a genetic cause for carpal tunnel syndrome in response to employees' work-related medical claims for carpal tunnel. According to the EEOC's complaint, employees who submitted carpal tunnel claims were required to provide blood samples that were screened for Chromosome 17 deletion, said to be associated with a genetic predisposition for carpal tunnel syndrome. Laurie A. Vasichek, an EEOC senior trial attorney, told Reuters Health that the agency has agreed not to pursue a preliminary injunction for 60 days in exchange for Burlington Northern's agreement not to conduct further genetic testing or to use test results. If by that time it is unable to reach a legally enforceable agreement with railroad officials, the EEOC will pursue a preliminary injunction, she said.

"Ergonomic Interventions for Low Back Pain: Is the Glass Half-Full or Half-Empty?" BACK LETTER 16(3):25, 32-34, 2001, Lippincott Williams & Wilkins

When it comes to the efficacy of ergonomic interventions to prevent low back pain, high-quality scientific studies

and lesser-quality studies tell two different tales. Therein lies a dilemma for public policy makers and health care providers. Accurate characterization of evidence on ergonomic interventions has significant economic and public health implications. Congress recently killed the OSHA's sweeping ergonomic regulation, largely because of a lack of clear evidence demonstrating its effectiveness and cost-effectiveness. Implementation of the regulation was projected to cost industry anywhere from \$4 billion to \$125 billion per year. So what is an accurate assessment of the potential of ergonomic interventions to prevent low back pain? A judgment based solely on well-designed randomized controlled trials suggests the following: There is no conclusive evidence that reducing physical exposures in the workplace can prevent low back pain or low back pain disability. Similarly there is no conclusive evidence in favor of ergonomic job redesign or reorganization of the production process. The impact of altering organizational culture hasn't been adequately explored in high-quality studies. A recent review of the ergonomic literature by the National Academy of Sciences (NAS) offers starkly different conclusions: "Data from scientific studies of primary and secondary interventions indicate that low back pain can be reduced under certain conditions by engineering controls (e.g. ergonomic workplace redesign), administrative controls (specifically, adjusting organizational culture), programs designed to modify individual factors (specifically employee exercise), and combinations of these approaches," according to the NAS report. The NAS authors based these findings on a quirky three-part review of the evidence on ergonomic interventions. To make these conclusions the NAS panel had to dip into studies of dubious scientific quality and make some judgments that others might interpret as leaps of faith. (See National Research Council and the Institute of Medicine, 2001.) These conflicting views of the scientific evidence raise the obvious question: "Which approach is correct?" Should scientific reviews and public policy be guided by high-quality evidence or by the broader spectrum of research? The editorial stance of the BackLetter is that conclusive judgments should be based solely on high-quality evidence and that lesser-quality studies should serve to generate hypotheses for further high-quality research. This is a tough standard, but allows an accurate characterization of the scientific evidence at any given time. And it doesn't require speculation and guesswork. Based on that evidence standard, the NAS report appears to have come to inaccurate conclusions about the scientific data regarding ergonomic interventions. The NAS panel made the following conclusions after looking at the six pre-existing reviews of the ergonomic literature: "Collectively, the data in these six reviews indicate that certain engineering controls [e.g. ergonomic workplace redesign], administrative controls (specifically adjusting organizational culture), modifying individual factors (specifically, employee exercise), and the inclusion of a combination of interventions are the only strategies that have been shown to be positively associated with the reduction of work-related low back pain," the NAS panel concluded. However, this conclusion is not an entirely accurate characterization of these reviews -- if one applies the NAS panel's requirement that only studies with control groups should be considered. The reviews did not identify any studies with contemporaneous control groups that found a benefit for engineering controls (workplace redesign). These reviews did find controlled studies in favor of adjusting organizational culture and exercise. However, almost all the studies cited in the six reviews have major methodological flaws, as the reviews themselves point out. In some respects, the research effort to identify effective back pain prevention strategies has been a failure. Despite the best efforts of talented researchers, the back pain and disability crisis continues to rage. According to the NAS report, the overall prevalence of musculoskeletal disorders and related disability in the general population of the United States is still rising. Perhaps ergonomic interventions aimed at reducing physical exposures have the potential to stem the back pain and disability epidemic, as the NAS panel asserts. However, there is as yet no solid scientific documentation of this, despite 50 years of research.

Using Computer Doesn't Increase Risk Of Carpal Tunnel Syndrome, Study Finds Source: American Academy Of Neurology

Posted 6/12/2001... ST. PAUL, MN - Using a computer at work doesn't increase your chances of developing carpal

tunnel syndrome, according to a study published in the June 12 issue of *Neurology*, the scientific journal of the American Academy of Neurology. "We wanted to do this study because conventional wisdom says that using a computer increases your risk of developing carpal tunnel, but few studies have been done to see how often carpal tunnel actually occurs in computer users," said study author and neurologist J. Clarke Stevens, MD, of the Mayo Clinic in Rochester, Minn. Stevens said most of the studies showing that repetitive motion causes carpal tunnel involve workers in meatpacking plants or other industrial jobs, not computer users. This study examined 257 employees at the Mayo Clinic in Scottsdale, Ariz., who used a computer frequently in their jobs. "Many of the computer users in the study had experienced feelings of numbness or 'pins and needles' in their hands, but the percentage who actually met the medical criteria for carpal tunnel syndrome was similar to other estimates of how often carpal tunnel occurs in the general public," Stevens said. For the study, researchers sent a questionnaire to employees who used computers for much of their jobs, such as secretaries and transcriptionists. They reported using the computer for an average of six hours per day. Of the 257 people studied, 30 percent said they had experienced pins and needles sensations or numbness in their hands. Those people then completed a questionnaire on carpal tunnel symptoms and a diagram to show where their symptoms occurred to determine whether they met the clinical criteria for carpal tunnel syndrome. Twenty-seven people met the criteria, or 10.5 percent of the original study group. Stevens said those who had symptoms of numbness or tingling but did not have carpal tunnel had mild symptoms that occurred briefly. Some may have had problems with another nerve in the arm, the ulnar nerve. Carpal tunnel affects the median nerve. The researchers then tested the nerves of those who met the criteria to see if electrodiagnostic laboratory tests would confirm the diagnosis. The nerve conduction studies confirmed the diagnosis in nine people, or 3.5 percent of the 257 study participants. "These percentages are similar to percentages found in other studies looking at how often carpal tunnel occurs in the general population -- not just computer users," Stevens said. The researchers also found no significant differences between the computer users who had carpal tunnel and those who did not. "They had similar occupations, number of years using the computer and number of hours using the computer during the day," Stevens said. "So there were no differences that might point to computer use as a factor in causing carpal tunnel." Stevens said the results shouldn't be interpreted to mean that the repetitive motions involved in using a computer can never lead to problems for people. "There are a lot of aches and pains associated with using a computer," he said. "We just found that, at least in this group, frequent computer use doesn't seem to cause carpal tunnel syndrome." Additional studies with large groups of people should be done to see if these results can be confirmed, Stevens said. Note: This story has been adapted from a news release issued by American Academy Of Neurology for journalists and other members of the public. If you wish to quote from any part of this story, please credit American Academy Of Neurology as the original source. You may also wish to include the following link in any citation:

<http://www.sciencedaily.com/releases/2001/06/010612065139.htm>

Lechner, D. "PREWORK SCREENS: AN OPPORTUNITY FOR PREVENTING INJURIES", *OTHO PT PRACTICE*, vol 13, no 2, 2001

Important legal considerations as you develop a pre-work screening process to offer to employers. Excellent discussion on how to succeed with this venture. Deb describes one format for providing pre-wrok screening. Compare that to the alternative method we at SmartCare provide, as it is a quite different approach, serving a different objective.

Mitchell JM, de Lissovoy G. Comparison of resource use and cost in direct access versus physician referral episodes of physical therapy. *Phys Ther.* 1997;77:10-18

Study conducted by Dr. Jean Mitchell of Johns Hopkins University and Dr. Greg de Lissovoy of Georgetown University concluded that states and insurance companies that reimburse under direct access will realize cost

savings of approx. \$1200 per patient episode of care ([www.apta.org](http://www.apta.org)). They also cite a study performed in 1994 which found that the costs incurred for physical therapy visits were 123% higher when patients were first seen by a physician than when they went to a physical therapist directly. This study also showed that physician referral episodes generated 67% more physical therapy claims and 60% more office visits than did episodes when the patient went directly to the physical therapist without a physician referral

Liability Insurers and the Federation of State Boards of Physical Therapy (Health Providers Service Organization, in a March 22, 2001, letter to the APTA-on file)

affirms that direct access does not jeopardize the health, safety, or welfare of the patients/clients seeking physical therapists' services without referral. Health Providers Service Organization, the leading liability insurer of physical therapists in the united states, indicates in a March 22, 2001, letter that "direct access is not a risk factor that we specifically screen for in our program because it has not negatively impacted our claims experience in any way. In addition, we do not have a premium differential for physical therapists in direct access states."

Kolarczyk, D. "SUCCESSFUL ONSITE THERAPY", OTHRO PT PRACTICE, vol 13, no 2, 2001

A brief but excellent overview description of onsite PT services you may bring to client workplaces. This paper emphasizes outcomes measures you may use to track success and savings for client workplaces, a critical component to getting in the door of industry.

Ritch, J. "MARKETING YOUR PT PRACTICE TO EMPLOYERS, OTHRO PT PRACTICE, vol 13, no 2, 2001

An excellent lesson on marketing (so deficit a skill among most PT's!), from basic principles to specific tactics for industry. Essentially provides us a marketing plan for our industrial PT specialty.

Charney & Gasterlum: "Lift Teams - A one-year study: Another success story in an acute-care hospital" J Healthcare Safety, Compliance & Infect Control, 2001, Vol. 5, No. 2.

A one-year study was undertaken in a San Diego, California, acute-care hospital to test the viability of using lift teams to reduce workers' compensation claims due to lifting patients. The hospital has an approximate daily patient census of 350 with 2,000 employees. A multidisciplinary team was organized over a six-month period to develop the lift team and create parameters of implementation. A policy and procedure were developed that mandated nursing to use the lift team during its shift, and, for off-shifts, nursing had to use mechanical lifting equipment to generate a "no manual lift" policy. The job description of the lift team mandated that the team had to use mechanical lifting equipment for every total body lift of a patient. A mechanical lift inventory was completed prior to implementation, and the hospital discovered that it had very few mechanical lifts in the facility. A budget of \$160,000 was allocated to purchase mechanical equipment. The equipment inventory purchased was as follows: two total-lift lateral transfer stretchers per floor; and one vertical lift per floor. Injuries during the study period were reduced from 22 lost-time injuries to six. Days lost were reduced from 744 to zero, and workers' compensation costs were reduced from \$224,000 (hard costs, considered only compensation and medical) in the prior year to \$14,000 during the study year.

NYTimes.com...March 12, 2002... Prevention: Benefits of Being Ergonomically Correct... By ERIC NAGOURNEY

A study found equipping 356 state employees with workstations to reduce repetitive stress injuries led to a significant percent in computer-related health complaints in less than a year. Employees in the Office of Information Technology in New Jersey reported substantially fewer musculoskeletal problems at their backs, elbows, arms, hands, necks and eyes, according to a study in the Proceedings of the Human Factors and Ergonomics Society conducted by Dr. Alan Hedge of Cornell University and Mary Rudakewych and Lisa Valent-Weitz of the New Jersey

Health and Safety Office. The workers received ergonomic chairs, which provide good back support and can be easily adjusted; negative slope keyboard trays, which are highly adjustable; and mouse platforms that sit over the keyboards. Employees were trained in the use of the equipment, and were also offered accessories like document holders, antiglare screens and footrests. The workers were surveyed before the equipment was in place and about eight months later. In the first survey, only 16 percent reported no symptoms. In the second, more than 40 percent were free of symptoms. But Dr. Hedge said good equipment alone was not enough and emphasized the importance of taking breaks.

BACK BELTS ...Kraus, Jess, et al: "Reduction of Acute Low Back Injuries by Use of Back Supports," INTL J OCCUP & ENVIR HLTH, Oct-Dec 1996, Vol. 2 (3).

This paper is a well-controlled study of the effectiveness of low back support belts in reducing low back injuries. The study was sponsored by UCLA School of Public Health and the Southern California Injury Prevention Research Center as an objective study independent of the back support industry. The study of 36,000 employees at 31 Home Depot stores in California encompassing 101,000,000 work hours revealed a decrease of 34% in low back injuries following a mandatory policy on use of back supports among employees. Favorable effects were seen in both genders, young and old, new or experienced workers, low lifting intensity and high lifting intensity jobs. The study provides scientific evidence that proper use of back supports as part of a comprehensive back injury prevention program. can be effective in reducing back injuries.

BACK BELTS .. Kraus, J, et al: "Back Supports & Low Back Injuries: a Second Visit with the Home Depot Cohort Study Data", INT J OCCUP ENVIRON HEALTH, 1999, 5:9-13

This paper revisits data for the study demonstrating significant favorable effects of wear back supports in the workplace, to answer the firestorm of criticism from ergonomics professionals seeking to discredit the report. All the questions raised were examined and assessed for validity and objectivity. All issues were fully answered, reinforcing the validity of the findings that back supports did indeed reduce back injury lost days by 34% among 36,000 Home Depot employees over a six year period.

BACK BELTS .. Allen, S.K.; Wilder, K. "Back belts pay off for nurses", Occ. Health & Safety, 65 (1) (1996) 59-62.

**back belts** - the general use of back belts in the distribution industry has been questioned. However, in a study of 47 employees over a 6-month period, the use of back belts significantly reduced injury risks. The test group with back belts worked 22,243 hours and had no injuries, whereas the control group worked 23,109 hours and lost 80 hours due to back injuries

BACK BELTS .. Warren, L, et al, "Effects of Soft Lumbar Support Belt on Abdominal Oblique Muscle Activity in Nonimpaired Adults During Squat Lifting" J ORTHOP SPORTS PHYS THER, June, 2001; 31

Wearing soft lumbar support during squat lifting significantly decreases activity of abdominal obliques. This study shows back belts reduce muscle activity and this should be consistent with decreased loads on the spine, likely due to increased intra-abdominal pressure. This is consistent with other studies that, taken together, demonstrate the both abdominal and back muscles produce less force during lifting with a back support. Decreased coactivation of muscles around the spine suggests that spinal compressive forces are decreased. Loads on the spine during lifting tasks are positively correlated with increased muscle activity. Intra-abdominal pressure is significantly increased with wearing a back belt during lifting. Increased intra-abdominal pressure believed to result in decompression of spine during loading and decreased load on spinal muscles. There is also an increased recruitment of quadriceps muscle action during lifting with back belts, suggesting they encourage improved lifting technique. This paper mentions numerous studies in its text and its bibliography that add support to the hypothesis of the authors.

BACK BELTS .. Giorelli RJ, et al: "THE EFFECT OF WEARING A BACK BELT ON SPINE KINEMATICS DURING ASYMMETRIC LIFTING OF LARGE AND SMALL BOXES" SPINE, 2001;26(16):1794-8.

28 subjects with at least six months' materials handling experience and no histories of low back pain were involved in structured lifting tests, wearing the flexible back support and not wearing it. The research evaluated the effect on spinal kinematics (flexion, right and left bending, and right and left twisting, and lifting velocity) on experienced materials handlers wearing no-suspenders, flexible back supports ("belts") and lifting both small and larger boxes. Their results indicated that, under most test conditions, the "subjects with belts lifted more slowly and used more of a squat-lift technique, regardless of box size. Belts reduced more torso motions while lifting large boxes." Further, they state that, "belt use significantly affected spine kinematics by decreasing maximum spine flexion, maximum spine flexion angular velocity, maximum spine extension angular velocity, maximum torso left lateral bending velocity and maximum torso right lateral bending, and maximum torso left twisting for lifts with the large box." These findings indicate that belts offer the worker the reminder to lift object in a less-risky manner (less flexion and more deliberate movement), something previous research has been advocating for years. The authors were not willing to draw the conclusion themselves, but their results indicate that, under the test conditions, the belts offered workers a substantial protective effect. The flexible back support they tested was associated with subject behavior that has been shown to be protective against low back pain and injury.

D M Rempel, "A randomized controlled trial evaluating the effects pain of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators" *Occup. Environ. Med.* 2006;63:300-306

Forearm Support Reduces Pain among Computer Users... A simple workstation modification, the addition of a forearm support, was found to reduce upper body pain and prevent musculoskeletal disorders among customer service workers who use a computer for more than 20 hours per week. In this randomized controlled trial, the 182 participating workers were followed for 1 year. Based on a cost-benefit analysis, employers could see a full return on the cost of providing arm boards to all employees within 11 months of the investment. The Morency rest forearm supports are manufactured by R&D Ergonomics of Maine. The study received the 2006 International Ergonomics Association/Liberty Mutual Prize

MacDermid, J., "Clinical & Electrodiagnostic Testing of carpal Tunnel Syndrome", *JOSPT*, OCT 2004

Excellent review of various simple non-invasive diagnostic testing for CTS, with correlations to Electrodiagnostic testing. Includes highly valid testing per history, sensory screening, provocation tests, NVC-EMG.

Michlovitz, S., "Conservative Interventions for CTS," *JOSPT*, OCT 2004

Excellent review of current PT approaches to clinical management of CTS.

Lee, M, "Pronator Syndrome and Other Nerve Compressions That Mimic CTS," *JOSPT*, OCT 2004

Differential assessment of median nerve compressions of the upper extremity proximal to the wrist, mimicking CTS, along with treatment approaches for these.

Barr, A, "Work-Related Musculoskeletal Disorders of the Hand and Wrist," *JOSPT*, OCT 2004

Epidemiology, pathophysiology and sensorimotor changes are reviewed. Reviews many studies. Of particular note is the description of pathophysiology, especially describing histochemical changes that can trigger inflammatory responses systemically. Cytokines are released from local inflammatory sites may trigger systemic inflammatory responses, thus causing tendinitis symptoms to spreading to other sites. Of equal interest is the motor behavior

degradation that can occur with repetitive motion tasks, causing loss of motor control and a resulting loss of coordination and movement efficiency that may increase work damage. This may be the result of changes at the brain where repetitive movement causes degradation of motor cortex, distorting motor control. This is reorganization of CNS control of movement.

Novak, C, "Upper Extremity Work-Related Musculoskeletal Disorders: a Treatment Perspective," JOSPT, OCT 2004

This is an excellent discussion of various important pathomechanics of MSD. Of particular interest is the prevalence of multi-level neurovascular compressions (double-crush) {{a critical issue in prevention tactics where we address proximal posture risks to reduce distal repetitive motion problems}}. Static postures, particularly at the neck are also described {{another critical issue in prevention tactics where we address proximal posture risks to reduce distal repetitive motion problems}}. Posture risks at various articulations are described. Treatment approaches are also well-described in this paper.

Barr, A, Barbe, M: Pathophysiological Tissues Changes Associated with Repetitive Movement: A Review of the Evidence. Phys Ther. 2002 February; 82(2): 173-187.

This article presents several key considerations defining MSD pathophysiological mechanisms taken from extensive literature review, particularly among animal studies describing neuromusculoskeletal responses to repetitive or sustained loading demands. Key points include:

#### CELLULAR CHANGES:

Muscle tissue biopsies of humans with hand overuse symptoms showed histological and muscle fiber structure changes consistent with denervation or ischemic loss of type II fibers with hypertrophy of type I fibers. Upper trapezius samples showed changes consistent with hypoxia and reduced blood flow. Structural damage to tissues usually stimulates proliferation of progenitor cells of that tissue. Cell membrane damage releases intracellular factors that stimulate infiltration of lymphocytes and macrophages. These processes stimulate regeneration, or scarring if that damage is ongoing. In tendons this can result in fibroblast proliferation leading to fibrosis and collagen dysplasia within the extracellular matrix.

Ongoing mechanical or metabolic stress such as hypoxia, ischemia or inflammation leads to release of heat shock proteins (HSP) by cells such as neurons, glia, fibroblasts and muscle cells. This is a healing protective response whereby these HSP restore denatured proteins. HSP are stimulated by ischemia or tears in cell membranes releasing cytotoxic free radicals. Cell damage releases cytokines, mediators of inflammation, cell proliferation and regeneration. Cytokines are proinflammatory proteins including interleukins, tumor necrosis factor (TNF), COX2 and prostaglandin. These mediate proliferation of macrophages and fibroblasts. The phagocytic action of the macrophages can further increase damage and release more cytokines, thus creating a vicious cycle of chronic inflammation. Damaged cells release chemicals that damage more cells. This cycle is prolonged and magnified when exposure to repetitive tasks is ongoing.

#### CNS CORD CHANGES:

Chronic pain can lead to neuroplastic changes in nerves, cord and cortex. Sustained nociception afferent bombardment can increase release of excitatory neurotransmitters glutamate and substance P within the dorsal horn. These can activate and potentiate synapse activity both presynaptically and postsynaptically. This can also alter genetic expression in neurons to upregulate receptor sites. The end result is hyperalgesia (increased sensitivity to nociception) and allodynia (non-painful stimuli felt as pain). Clinicians often mistake this process as "symptom magnification" or psychological complications. Nerve constriction peripherally due to repetitive or sustained mechanical compression can also cause neuroplastic changes in the dorsal root ganglion that can increase

nociception transmission.

#### CNS CORTEX CHANGES:

Repetitive tasks can induce changes in cerebral cortex, particularly de-differentiation of cerebral cortex representation of the hand. This is induced by constrained and repeated motions at the upper limb. Loss of specific hand field representation of the cortex causes loss of coordination and changes in movement behaviors toward less efficient motor control. This loss of movement efficiency increase fatigue and pain risks during repetitive tasks. This is maladaptive movement behavior. It may be that this motor control degradation precedes the onset of pain and may even precipitate it.

#### SYSTEMIC INFLAMMATORY REACTION

Animal studies of this phenomenon revealed increased cellular chemical changes described above: increased HSP-72, COX2, and macrophage infiltration at levels 1000 times above baseline. BUT of particular note... these biochemical changes were seen also in the non-moving control limbs, suggesting a systemic inflammatory response to the high repetition low load tasks in the experiment. This suggests that repetitive task work can lead to not only local inflammatory reactions at the exposure site, but also leads to a wider systemic inflammatory response as well as neurological reorganization (neuroplasticity) centrally at the spinal cord, increasing nociception, and at the cerebral cortex, causing motor control degradation.

Reis, Eric, "Working Solutions: PTs & Ergonomics" PT MAGAZINE, Sept. 2004

An excellent description of the services PTs may provide to industry. Describes several PT workplace consulting practices. Gives good description of PT's qualifications and opportunities for this line of work. Good outcomes are also provided. Good web and literature references. Excellent.

\*\* Butler, David: THE SENSITIVE NERVOUS SYSTEM; Noigroup Publ, Adelaide, Australia, 2000.

This is an exceptional text on the neurophysiology of pain, with critical reference to neurovascular entrapment, AIGS, double crush, neural mobility, central excitation, upregulation of pain, and other issues that closely relate to extremity pain syndromes, particularly those involved with work disorders. Excellent description of underlying issues important to dealing with injured workers. Addresses mobilization of the peripheral nervous system, which may be a part of the stretching tactics we may consider for the workplace.

#### IMPORTANT WEB SITES OFFERING TOOLS FOR MSD-ERGONOMICS ASSESSMENT AND RISK CORRECTIONS..

<http://www.ergo.human.cornell.edu/cutools.html>

#### NIOSH LIFTING EQUATION...

<http://www.cdc.gov/niosh/docs/94-110/>

<http://www.ergonomics.com.au/niosh.htm>

#### ERGONOMICS ARTICLES CATALOG...

<http://www.workriteergo.com/ergonomics/articles.asp>

#### WASHINGTON STATE ERGONOMICS TOOLS...

<http://www.lni.wa.gov/Safety/Topics/Ergonomics/ServicesResources/Tools/default.asp>