REFERENCES

Åaras A [1994]. Relationship between trape-zius load and the incidence of musculoskele-tal illness in the neck and shoulder. Int J Ind Ergonomics *14*(4):341–348.

Abenhaim L, Suissa S [1988]. Economic scope of occupationally-induced back pain. Institute de recherche en sante et en securite du travail du Quebec. Quebec, Canada: IRSST, Research Summary No. 66.

AFL-CIO [1997]. Stop the pain. Washing-ton, DC: AFL-CIO.

Alexander and Alexander [1996]. 1996 U.S. risk management survey. New York, NY: Alexander and Alexander, Inc.

Allender E [1974]. Prevalence, incidence, and remission rates of some common rheumatic diseases or syndromes. Scand J Rheumatol *3*:145–153.

Alterman T, Shekells RB, Vernon SW, Burau KD [1994]. Decision latitude, psy-chologic demand, job strain and coronary heart disease in the Western Electric study. Am J Epidemiol *139*(6):620–627.

Amadio PC [1995]. De Quervain's disease and tenosynovitis. In: Gordon SL, Blair SJ, Fine LJ, eds. Repetitive motions disorders of the upper extremity. Rosemont, IL: American Academy of Orthopaedic Surgeons, pp. 435–448.

Amano M, Gensyo U, Nakajima H, Yatsuki K [1988]. Characteristics of work actions of shoe manufacturing assembly line workers and a cross-sectional factor-control study on occupational cervicobrachial disorders. Jpn J Ind Health *30*:3–12.

Andersen JH, Gaardboe O [1993a]. Muscu-loskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. Am J Ind Med *24*(6): 689–700.

Andersen JH, Gaardboe O [1993b]. Preva-lence of persistent neck and upper limb pain in a historical cohort of sewing machine operators. Am J Ind Med *24*:677–687.

Andersson GBJ [1981]. Epidemiologic aspects of low back pain in industry. Spine *6*:53–60.

Andersson GBJ [1996]. The epidemiology of spinal disorders. In: Frymoyer JW, ed. The adult spine: principles and practice. 2nd ed. New York, NY: Raven Press Ltd.

Andersson GBJ, Pope MH, Frymoyer JW, Snook S [1991]. Epidemiology and cost. In: Pope M, ed. Occupational low back pain. St. Louis, MO: Mosby Year Book.

Andersson JAD [1984]. Shoulder pain and tension neck and their relation to work. Scand J Work Environ Health *10*(6): 435–442.

Armstrong RB, Warren GL, Warren JA [1991]. Mechanisms of exercise-induced muscle fibre injury. J Sports Med *12*(3): 184–207.

Armstrong TJ, Chaffin DB [1979]. Carpal tunnel syndrome and selected personal attributes. J Occup Med *21*(7):481–486.

Armstrong TJ, Foulke JA, Joseph BS, Goldstein SA [1982]. Investigation of cumulative trauma disorders in a poultry processing plant. Am Ind Hyg Assoc J *43*(2):103–116.

Armstrong TJ, Fine LJ, Goldstein SA, Lifshitz YR, Silverstein BA [1987a]. Ergonomic considerations in hand and wrist tendinitis. J Hand Surg *12A*(5):830–837.

Armstrong TJ, Fine LJ, Radwin RG, Silverstein BS [1987b]. Ergonomics and the effects of vibration in hand-intensive work. Scand J Work Environ Health *13*:286–289.

Armstrong TJ, Punnett L, Ketner P [1989]. Subjective worker assessments of hand tools used in automobile assembly. Am Ind Hyg Assoc J *50*(12):639–645.

Armstrong TJ, Buckle P, Fine LJ, Hagberg M, Jonsson B, Kilbom Å [1993]. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health *19*(2):73–84.

Aro S, Leino P [1985]. Overweight and musculoskeletal morbidity: a ten-year follow-up. Int J Obes *9*:267–275.

Asbury FD [1995]. Occupational repetitive strain injuries and gender in Ontario 1986–1991. J Occup Environ Med *37*(4): 479–485.

Åstrand NE [1987]. Medical, psychological, and social factors associated with back abnormalities and self-reported back pain: a cross-sectional study of male employees in a Swedish pulp and paper industry. Br J Ind Med *44*(5):327–336.

Åstrand NE, Isacsson SO [1988]. Back pain, back abnormalities, and competing medical, psychological, and social factors as predictors of sick leave, early retirement, unemployment, labour turnover and mortality: a 22-year follow-up of male employees in a Swedish pulp and paper company. Br J Ind Med *45*(6):387–395.

Atterbury MR, Limke JC, Lemasters GK, Li Y, Forrester C, Stinson R, Applegate H [1996]. Nested case-control study of hand and wrist work-related musculoskeletal disorders in carpenters. Am J Ind Med *30*:695–701.

Barnhart S, Demers PA, Miller M, Longstreth WT Jr., Rosenstock L [1991]. Carpal tunnel syndrome among ski manufacturing workers. Scand J Work Environ Health *17*(1):46–52.

Baron S, Milliron M, Habes D, Fidler A [1991]. Hazard evaluation and technical assistance report: Shoprite Supermarkets, New Jersey—New York. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88–344–2092.

Battié MC, Bigos SJ, Fisher LD, Hansson TH, Jones ME, Wortley MD [1989]. Isometric lifting strength as a predictor of industrial back pain. Spine *14*(8):851–856.

Battié MC, Bigos SJ, Fisher LD, Spengler

DM, HanssonTH, Nachemson AL, et al. [1990]. The role of spinal flexibility in back pain complaints within industry: a prospective study. Spine *15*(8):768–793.

Battié MC, Videman T, Gibbons LE, Fisher L, Manninen H, Gill K [1995]. Determinants of lumbar disc degeneration: a study relating lifetime exposures and magnetic resonance imaging findings in identical twins. Spine *20*:2601–2612.

Behrens V, Seligman P, Cameron L, Mathias CGT, Fine L [1994]. The preva-lence of back pain, hand discomfort, and dermatitis in the U.S. working population. Am J Public Health *84*(11):1780–1785.

Bennett GE [1946]. Shoulder and elbow lesions distinctive of baseball players. Ann Surg *126*:107–110.

Berg M, Sanden Å, Torell G, Järvholm B [1988]. Persistence of musculoskeletal symp-toms: a longitudinal study. Ergonomics *31*(9):1281–1285.

Bergenudd H, Nilsson B [1988]. Back pain in middle age. Occupational workload and psychologic factors: an epidemiologic survey. Spine *13*(1):58–60.

Bergenudd H, Lindgärde, Nilsson B, Petersson C [1988]. Shoulder pain in middle age: a study of prevalence and relation to occupational work load and psychosocial factors. Clin Orthop Res *23*:234–238.

Bergqvist U [1984]. Video display terminals and health. Scand J Work Environ Health *10*(2):68–77.

Bergqvist U [1989]. Possible health effects of working with VDUs (editorial). Br J Ind Med *46*:217–221.

Bergqvist U, Wolgast E, Nilsson B, Voss M [1995a]. Musculoskeletal disorders among visual display terminal workers: individual, ergonomic, and work organizational factors. Ergonomics *38*(4):763–776.

Bergqvist U, Wolgast E, Nilsson B, Voss M [1995b]. The influence of VDT work on musculoskeletal disorders. Ergonomics *38*(4):754–762.

Bergqvist-Ullman M, Larsson N [1977]. Acute low back pain in industry. Acta Orthop Scand *170*(Suppl):1–117.

Berkeley M, Bennett J, Woods W [1985]. Elbow problems: injuries to the throwing arm. Zarins B, Andrews J, Carson W, eds. Phildelphia, PA: W.B. Saunders Publishing Company, pp. 235–249.

Bernard B, Sauter S, Fine LJ [1993]. Hazard evaluation and technical assistance report: Los Angeles Times, Los Angeles, CA. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 90–013–2277.

Bernard B, Sauter S, Fine LJ, Petersen M, Hales T [1994]. Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. Scand J Work Environ Health *20*(6):417– 426.

Biering-Sørensen F [1983]. A prospective study of low-back pain in a general population. I. Occurrence, recurrence, and aetilogy. Scand J Rehabil Med *15*:81–88.

Biering-Sørensen F [1984]. Physical measurements as risk indicators for low back trouble over a one-year period. Spine *9*(2):106–119.

Biering-Sørensen F, Thomsen CE, Hilden J [1989]. Risk indicators for low back trouble. Scand J Rehabil Med *21*:151–157.

Bigos SJ, Spengler DM, Martin NA, Zeh J, Fisher L, Nachemson A, et al. [1986a]. Back injuries in industry: a retrospective study. II. Injury factors. Spine *11*:246–251.

Bigos SJ, Spengler DM, Martin NA, Zeh J, Fisher L, Nachemson A [1986b]. Back injuries in industry: a retrospective study. III. Employee-related factors. Spine *11*:252–256.

Bigos SJ, Battié MC, Fisher LD [1991a]. Methodology for evaluating predictive factors for the report of back injury. Spine *16*(6):669–670.

Bigos SJ, Battié MC, Spengler DM, Fisher LD, Fordyce WE, Hansson TH, et al. [1991b]. A prospective study of work perceptions and psychosocial factors affecting the report of back injury. Spine *16*(1):1–6.

Bigos S, Bowyer O, Braen G, et al. [1994]. Acute low back problems in adults. Clinical practice guideline, quick reference guide No. 14. Rockville, MD: U.S. Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research, AHCPR Pub. No. 95–6043.

Bjelle A, Hagberg M, Michaelsson G [1979]. Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. Scand J Work Environ Health *5*(3):205–210.

Bjelle A, Hagberg M, Michaelson G [1981]. Occupational and individual factors in acute shoulder-neck disorders among industrial worker. Br J Ind Med *38*:356–363.

Blåder S, Barck-Holst U, Danielsson S, Ferhm E, Kalpamaa M, Leijon M, et al. [1991]. Neck and shoulder complaints among sewing-machine operators: a study concerning frequency, symptomatology and dysfunction. Appl Ergonomics *22*(4):251– 257.

Bleecker ML, Bohlman M, Moreland R, Tipton A [1985]. Carpal tunnel syndrome: role of carpal canal size. Neurol *35*(11): 1599–1604.

BLS [1995]. Workplace injuries and ill-nesses in 1994. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, USDL 95–508.

Bongers PM, Boshuizen HC [1990]. Back disorders and whole-body vibration at work [Dissertation]. Amsterdam, The Nether-lands: University of Amsterdam.

Bongers PM, de Winter CR [1992]. Psy-chosocial factors and musculoskeletal disease: a report of the literature. The Netherlands: TNO Institute of Preventive Health Care, Report No. 92–082.

Bongers PM, Boshuizen HC, Hulshof CTJ, Koemeester AP [1988]. Back disorders in crane operators exposed to whole-body vibration. Int Arch Occup Environ Health *60*:129–137.

Bongers PM, Hulshof CTJ, Dijkstra L, Boshuizen HC [1990]. Back pain and exposure to whole-body vibration in helicopter pilots. Ergonomics *33*:1007– 1026.

Bongers PM, de Winter CR, Kompier MAJ, Hildebrandt VH [1993]. Psychosocial factors at work and musculoskeletal disease. Scand J Work Environ Health *19*(5):297–312.

Boshuizen HC, Bongers PM, Hulshof CTJ [1990a]. Self-reported back pain in tractor drivers exposed to whole-body vibration. Int Arch Occup Environ Health *62*:109–115.

Boshuizen HC, Hulshof CTJ, Bongers PM [1990b]. Long-term sick leave and disability pensioning due to back disorders of tractor drivers exposed to whole-body vibration. Int Arch Occup Environ Health *62*:117–122.

Boshuizen HC, Bongers PM, Hulshof CTJ [1992]. Self-reported back pain in fork-lift truck and freight-container tractor drivers exposed to whole-body vibration. Spine *17*:59–65.

Boshuizen HC, Verbeek JHAM, Broersen JPJ, Weel ANH [1993]. Do smokers get more back pain? Spine *18*(1):35–40.

Bovenzi M [1990]. Medical aspects of the hand-arm vibration syndrome. Int J Ind Ergonomics *6*(1):61–73.

Bovenzi M, Italian study group on physical hazards in the stone industry [1994]. Hand-arm vibration syndrome and dose-response relation for vibration-induced white finger among quarry drillers and stonecarvers. Occup Environ Med *51*(9):603–611.

Bovenzi M, Zadini A [1992]. Self-reported low back symptoms in urban bus drivers exposed to whole-body vibration. Spine *17*(9):1048–1059.

Bovenzi M, Betta A [1994]. Low-back disorders in agricultural tractor drivers exposed to whole-body vibration and postural stress. Appl Ergonomics *25*:231–241.

Bovenzi M, Franzinelli A, Strambi F [1988]. Prevalence of vibration-induced white finger and assessment of vibration exposure among travertine workers in Italy. Int Arch Occup Environ Health *61*:25–34.

Bovenzi M, Zadini A, Franzinelli A, Borgogni F [1991]. Occupational mus-culoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. Ergonomics *34*(5): 547–562.

Bovenzi M, Franzinelli A, Mancini R, Cannava MG, Maiorano M, Ceccarelli F [1995]. Dose-response relation for vascular disorders induced by vibration in the fingers of forestry workers. Occup Environ Med *52*:722–730.

Boyce RW, Jones GR, Hiatt AR [1991]. Physical fitness capacity and absenteeism of police officers. J Occup Med *33*(11):1137–1143.

Brammer AJ, Taylor W, eds. [1981]. Vibration effects on the hand and arm in industry. New

York, NY: John Wiley and Sons.

Brattberg G, Thorslund M, Wikman A [1989]. The prevalence of pain in a general population: the results of a postal survey in a county of Sweden. Pain *37*:215–222.

Brinckmann P [1988]. Stress and strain of human lumbar discs. Clin Biomechanics *3*(4):232–235.

Broberg E [1984]. Ergonomic injuries at work: ISA-information system on occupa-tional injuries. Swedish National Board of Occupational Safety and Health, Report No. 1984:3E.

Bross JD [1966]. Spurious effects from an extraneous variable. J Chron Dis *19*:736–747

Brubaker R, Mackenzie C, Bates D [1983]. Vibration white finger disease among tree fellers in British Columbia. J Occup Med *25*(5):403–408.

Brubaker RL, Mackenzie CJG, Hertzman C, Hutton SG, Slakov J [1987]. Longitudinal study of vibration-induced white finger among coastal fallers in British Columbia. Scand J Work Environ Health *13*(4):305– 308.

Buckwalter JA, Woo SL-Y, Goldberg VM, Hadley EC, Booth F, Oegema TR, et al. [1993]. Current concepts review: soft-tissue aging and musculoskeletal function. J Bone Joint Surg [Am] *75A*(10):1533–1548.

Burdorf A [1992]. Exposure assessment of risk factors for disorders of the back in occupational epidemiology. Scand J Work Environ Health *18*(1):1–9.

Burdorf A, Zondervan H [1990]. An epi-demiological study of low-back pain in crane operators. Ergonomics *33*(8):981–987.

Burdorf A, Monster A [1991]. Exposure to vibration and self-reported health complaints of riveters in the aircraft industry. Ann Occup Hyg *35*(3):287–298.

Burdorf A, Govaert G, Elders L [1991]. Postural load and back pain of workers in the manufacturing of prefabricated concrete elements. Ergonomics *34*(7):909–918.

Burdorf A, Naaktgeboren B, deGroot HC [1993]. Occupational risk factors for low back pain among sedentary workers. J Occup Med *35*:1213–1220.

Burry HC, Gravis V [1988]. Compensated back injury in New Zealand. N Z Med J *101*(852):542–544.

Burt S, Hornung R, Fine L [1990]. Hazard evaluation and technical assistance report: Newsday, Inc., Melville, NY. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 89–250–2046.

Byström S, Hall C, Welander T, Kilbom Å [1995]. Clinical disorders and pressure-pain threshold of the forearm and hand among automobile assembly line workers. J Hand Surg [Br] *20B*(6):782–790.

Cady LD Jr., Bischoff DP, O'Connell ER, Thomas PC, Allan JH [1979]. Strength and fitness and subsequent back injuries in firefighters. J Occup Med *21*(4):269–272.

Cady LD Jr., Thomas PC, Karwasky RJ [1985]. Program for increasing health and physical fitness of firefighters. J Occup Med *27*(2):110–114.

Cannon LJ, Bernacki EJ, Walter SD [1981]. Personal and occupational factors associated with carpal tunnel syndrome. J Occup Med *23*(4):255–258.

CDC (Centers for Disease Control) [1989]. Occupational disease surveillance: carpal tunnel syndrome. MMWR *38*(28):485–489.

Chaffin DB [1973]. Human strength capability and low back pain. Unpublished paper presented at the American Industrial Health Conference, Denver, CO, April 16–19, 1973.

Chaffin DB [1979]. Manual materials handling the cause of overexertion injury and illness in industry. J Environ Pathol Toxicol *2*(5):67–73.

Chaffin DB, Park KS [1973]. A longitudinal study of low-back pain as associated with occupational weight lifting factors. Am Ind Hyg Assoc J *34*:513–525.

Chaffin DB, Andersson GBJ [1984]. Occupational biomechanics. New York, NY: John Wiley and Sons.

Chaffin DB, Herrin GD, Keyserling WM, Foulke JA [1977]. Preemployment strength testing in selecting workers for materials handling jobs. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77–163.

Chatterjee D [1992]. Workplace upper limb disorders: a prospective study with intervention. J Occup Med *42*(3):129–136.

Chatterjee DS, Barwick DD, Petrie A [1982]. Exploratory electromyography in the study of vibration-induced white finger in rock drillers. Br J Ind Med *39*:89–97.

Chiang H, Chen S, Yu H, Ko Y [1990]. The occurrence of carpal tunnel syndrome in frozen food factory employees. Kao Hsiung J Med Sci *6*:73–80.

Chiang H, Ko Y, Chen S, Yu H, Wu T, Chang P [1993]. Prevalence of shoulder and upper-limb disorders among workers in the fish-processing industry. Scand J Work Environ Health *19*(2):126–131.

Christensen H, Pedersen MB, Sjøgaard G [1995]. A national cross-sectional study in the Danish wood and furniture industry on working postures and manual materials handling. Ergonomics *38*(4):793–805.

Clemmer DI, Mohr DL, Mercer DJ [1991]. Low-back injuries in a heavy industry: I. Worker and workplace factors. Spine *16*(7):824–830.

Cohen S, Pyrrell DAJ, Smith AP [1991]. Psychological stress and susceptibility to the common cold. New Engl J Med *325*(9):606–612.

Cornfield J [1956]. A statistical problem arising from retrospective studies. Pro-ceedings of the third Berkely Symposium, pp. 135–148.

Cornfield J, Haenszel W, Hammond EC, Lilienfeld AM, Shimkin MB, Wynder EL [1959]. Smoking and lung cancer: recent evidence and a discussion of some questions. J Natl Cancer Inst *22*:173–203.

Cust G, Pearson JCG, Mair A [1972]. The prevalence of low back pain in nurses. Int Nurs Rev *19*(2):169–179.

CWCI [1993]. Report on CTDs. San Francisco, CA: California Workers' Compensation Institute.

Cyriax JH [1936]. The pathology and treatment of tennis elbow. J Bone Joint Surg Am *18*(4):921–940.

Damkot DK, Pope MH, Lord J, Frymoyer JW [1984]. The relationship between work history, work environment and low-back pain in men. Spine *9*(4):395–399.

Dammeskiold-Samsøe B, Christiansen E, Lund B, Andersen RB [1982]. Regional muscle tension and pain ("fibrositis"). Scand J Rehabil Med *15*:17–20.

Dehlin O, Berg S [1977]. Back symptoms and psychological perception of work: a study among nursing aides in a geriatric hospital. Scand J Rehabil Med *9*:61–65.

Dehlin O, Hedenrud B, Horal J [1976]. Back symptoms in nursing aides in a geriatric hospital. Scand J Rehabil Med *8*(2):47.

Dehlin O, Berg S, Hedenrud B, Anderson G, Grimby G [1978]. Muscle training, psychological perception of work and low back symptoms in nursing aides. Scand J Rehabil Med *10*(4):201–209.

Dehlin O, Berg S, Andersson GBJ, Grimby G [1981]. Effect of physical training and ergonomic counseling on psychological perception of work and on the subjective assessment of low-back insufficiency. Scand J Rehabil Med *13*:1–9.

deKrom MCT, Kester ADM, Knipschild PG, Spaans F [1990]. Risk factors for carpal tunnel syndrome. Am J Epidemiol *132*(6):1102–1110.

Deyo RA, Bass JE [1989]. Lifestyle and low back pain: the influence of smoking and obesity. Spine *14*(5):501–506.

Dieck GS, Kelsey JL [1985]. An epidemiologic study of the carpal tunnel syndrome in an adult female population. Prev Med *14*(1):63–69.

Dimberg L [1987]. The prevalence and causation of tennis elbow (lateral humeral epicondylitis) in a population of workers in an engineering industry. Ergonomics *30*(3):573–580.

Dimberg L, Oden A [1991]. White finger symptoms: a cross-sectional study. Aviat Space Environ Med *62*:879–883

Dimberg L, Olafsson A, Stefansson E, Aagaard H, Oden A, Andersson GBJ, et al. [1989]. The correlation between work environment and the occurrence of cervicobrachial symptoms. J Occup Med *31*(5): 447–453.

Dixon SJ [1973]. Progress and problems in back pain research. Rheumatol Rehabil *12*:165.

Dupuis H [1994]. Medical and occupational preconditions for vibration-induced spinal disorders: occupational disease No. 2110 in Germany. Int Arch Occup Environ Health *66*:303–308.

Earman WA, Andersson GB, Leavitt F, McNeill TW, Durudogan H, Reagan J [1996]. Factors influencing the cost of chronic low back injuries: an analysis of data from independent medical examinations. J Occup Rehabil *6*(1):5–16.

Ekberg K, Björkqvist B, Malm P, Bjerre-Kiely B, Karlsson M, Axelson O [1994]. Case-control study of risk factors for disease in the neck and shoulder area. Occup Environ Med *51*(4):262–266.

Ekberg K, Karlsson M, Axelson O [1995]. Cross-sectional study of risk factors for symptoms in the neck and shoulder area. Ergonomics *38*(5):971–980.

Eklund J, Odenrick P, Zettergren S, Johansson H [1994]. Head posture measure-ments among work vehicle drivers and implications for work and workplace design. Ergonomics *37*(4):623–639.

English CJ, Maclaren WM, Court-Brown C, Hughes SPF, Porter RW, Wallace WA [1995]. Relations between upper limb soft tissue disorders and repetitive movements at work. Am J Ind Med *27*(1):75–90.

Falck B, Aarnio P [1983]. Left-sided carpal tunnel syndrome in butchers. Scand J Work Environ Health *9*(3):291–297.

Färkkilä M, Aatola S, Starck J, Korhonen O, Pyykkö I [1986]. Hand-grip force in lumberjacks: two-year follow-up. Int Arch Occup Environ Health *58*:203–208.

Färkkilä M, Pykkö I, Jäntti V, Aatola S, Starck J, Korhonen O [1988]. Forestry workers exposed to vibration: a neurological study. Br J Ind Med *45*:188–192.

Feldman RG, Travers PH, Chirico-Post J, Keyserling WM [1987]. Risk assessment in electronic assembly workers: carpal tunnel syndrome. J Hand Surg [Am] *12A*(5): 849–855.

Ferguson D [1976]. Posture, aching and body build in telephonists. J Hum Ergol *5*:183–196.

Feyer A, Williamson A, Mandryk J, de Silva I, Healy S [1992]. Role of psychosocial risk factors in work-related low back pain. Scand J Work Environ Health *18*(6):368–375.

Finkelstein MM [1995]. Back pain and parenthood. Occup Environ Med *52*(1): 51–53.

Fishbein M, Middlestadt S, Ottati V, Straus S, Ellis A [1988]. Medical problems among ICSOM musicians: overview of a national survey. Med Prob Perform Art *1*:136–139.

Flodmark BT, Aase G [1992]. Musculo-skeletal symptoms and type A behaviour in blue collar workers. Br J Ind Med *49*(10): 683–687.

Frank JW, Pulcins IR, Kerr MS, Shannon HS, Stansfield SA [1995]. Occupational back pain—an unhelpful polemic. Scand J Work Environ Health *58*:203–208.

Franklin GM, Haug J, Heyer N, Checkoway H, Peck N [1991]. Occupational carpal tunnel syndrome in Washington State, 1984–1988. Am J Public Health *81*(6): 741–746.

Fransson-Hall C, Byström S, Kilbom Å [1995]. Self-reported physical exposure and musculoskeletal symptoms of the forearm-hand among automobile assembly-line workers. J Occup Environ Med *37*(9): 1136–1144.

Frymoyer JW, Pope MH, Costanza MC, Rosen JC, Goggin JE, Wilder DG [1980]. Epidemiologic studies of low-back pain. Spine *5*(5):419–423.

Frymoyer JW, Pope MH, Clements JH [1983]. Risk factors in low back pain. J Bone Joint Surg [Am] *65A*:213.

Frymoyer JW, Cats-Baril WL [1991]. An overview of the incidence and costs of low back pain. Orthop Clin North Am *22*: 262–271.

Futatsuka M, Uneno T [1985]. Vibration exposure and vibration induced white finger due to chain saw operation. J Occup Med 27:257–264.

Futatsuka M, Uneno T [1986]. A follow-up study of vibration-induced white finger due to chain saw operation. Scand J Work Environ Health 12(4):304–306.

Garg A, Moore SJ [1992]. Epidemiology of low-back pain in industry. Occup Med: State of the Art Rev *7*(4):593–608.

Gelberman RH, Herginroeder PT, Hargens AR, Lundborg GN, Akeson WH [1981]. The carpal tunnel syndrome: a study of carpal canal pressures. J Bone Joint Surg *63A*(3): 380–383.

Gemne G [1982]. Pathophysiology and multifactorial etiology of acquired vaso-spastic disease (Raynaud Syndrome) in vibration exposed workers. Scand J Work Environ Health *8*:243–249.

Gemne G, Lundström R, Hansson J [1993]. Disorders induced by work with hand-held vibrating tools: a review of current knowledge for criteria documentation. Arbete och Hälsa *6*:1–83.

Gerr F, Letz R [1992]. Risk factors for carpal tunnel syndrome in industry: blaming the victim? [Letter to the editor.] J Occup Med *34*(11):1117–1119.

Gerr F, Letz R, Landrigan PJ [1991]. Upper-extremity musculoskeletal disorders of occupational origin. Ann Rev Public Health *12*:543–566.

Graham NM, Douglas RM, Ryan P [1986]. Stress and acute respiratory infection. Am J Epidemiol *124*(3):389–401.

Grandjean E, Hunting W, Nishiyama K [1984]. Preferred VDT workstation settings, body posture and physical impairments. Appl Ergonomics *15*(2):99–104.

Guo HR, Tanaka S, Cameron LL, Seligman PJ, Behrens VJ, Ger J, et al. [1995]. Back pain among workers in the United States: national estimates and workers at high risk. Am J Ind Med *28*(5):591–602.

Hadler NM [1993]. Occupational musculoskeletal disorders. New York, NY: Raven Press.

Hadler N [1997]. Repetitive upper-extremity motions in the workplace are not hazardous. J Hand Surg [Am] *22A*(1):19–29.

Hagberg M [1981]. Work load and fatigue in repetitive arm elevations. Ergonomics *24*:543–555.

Hagberg M [1984]. Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible pathophysiology. Int Arch Occup Environ Health *53*:269–278.

Hagberg M, Kvarnström S [1984]. Muscular endurance and electromyographic fatigue in myofascial shoulder pain. Arch Phys Med Rehabil *65*:522–525.

Hagberg M, Wegman DH [1987]. Preva-lence rates and odds ratios of shoulder-neck diseases in different occupational groups. Br J Ind Med *44*(9):602–610.

Hagberg M, Morgenstern H, Kelsh M [1992]. Impact of occupations and job tasks on the prevalence of carpal tunnel syndrome. Scand J Work Environ Health *18*(6):337– 345.

Hagberg M, Silverstein B, Wells R, Smith M, Hendrick H, Carayon P [1995]. Work-related musculoskeletal disorders (WMSDs): a reference book for prevention. London, England: Taylor and Francis.

Hägg G, Suurküla J, Kilbom Å [1990]. Predictors for work-related shoulder/neck disorders: a longitudinal study of female assembly workers. Arbete och Hälsa *10*:1–78.

Hägg GM, Öster J, Byström S [1996]. Forearm muscular load and wrist angle among automobile assembly line workers in relation to symptoms. Appl Ergonomics *28*(1):41–47.

Hales TR, Fine L [1989]. Hazard evaluation and technical assistance report: Cargill Poultry Division, Buena Vista, CA. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 89–251–1997.

Hales TR, Sauter S [1992]. Hazard evalua-tion and technical assistance report: U.S. West Communications, Phoenix, AZ; Minneapolis, MN; Denver, CO. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 89–299–2230.

Hales TR, Habes D, Fine L, Hornung R, Boiano J [1989]. Hazard evaluation and technical assistance report: John Morrell and Co., Sioux Falls, SD. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88–180–1958.

Hales TR, Sauter SL, Peterson MR, Fine LJ, Putz-Anderson V, Schleifer LR, et al. [1994]. Musculoskeletal disorders among visual display terminal users in a telecom-munications company. Ergonomics *37*(10): 1603–1621.

Harms-Ringdahl K, Ekholm J [1986]. Intensity and character of pain and muscular activity levels elicited by maintained extreme flexion position of the lower-cervical-upper thoracic spine. Scand J Rehabil Med *18*:117–126.

Hart DA, Frank CB, Bray RC [1995]. Inflammatory processes in repetitive motion and overuse syndromes: potential role of neurogenic mechanisms in tendons and ligaments. In: Gordon SL, Blair SJ, Fine, LJ, eds. Repetitive motions disorders of the upper extremity. Rosemont, IL: American Academy of Orthopaedic Surgeons, pp. 247–262.

Hartz CR, Linscheid RL, Gramse RR, Daube JR [1981]. The pronator teres syndrome: compressive neuropathy of the median nerve. J Bone Joint Surg *63*(6): 885–890.

Heliövaara M [1987]. Occupation and risk of herniated lumbar intervertebral disc or sciatica leading to hospitalization. J Chronic Dis *40*(3):259–264.

Heliövaara M, Knekt P, Aromaa A [1987]. Incidence and risk factors of herniated lumbar intervertebral disc or sciatica leading to hospitalization. J Chronic Dis *40*:251– 258.

Heliövaara M, Mäkelä M, Knekt P, Impivaara O, Aromaa A [1991]. Determi-nants of sciatica and low back pain. Spine *16*(6):608–614.

Helliwell PS, Mumford DB, Smeathers JE, Wright V [1992]. Work-related upper limb disorders: the relationship between pain, cumulative load, disability, and psychological factors. Ann Rheum Dis *51*(12): 1325–1329.

Herberts P, Kadefors R [1976]. A study of painful shoulders in welders. Acta Orthop Scand *47*:381–387.

Herberts P, Kadefors R, Andersson G, Petersen I [1981]. Shoulder pain in industry: an epidemiological study on welders. Acta Orthop Scand *52*:299–306.

Herberts P, Kadefors R, Högfors C, Sigholm G [1984]. Shoulder pain and heavy manual labor. Clin Orthop *191*:166–178.

Herrin GD, Jaraiedi M, Anderson CK [1986]. Prediction of overexertion injuries using biomechanical and psychophysical models. Am Ind Hyg Assoc J *47*(6):322– 330.

Heyer N, Checkoway H, Daniell, et al. [1990]. Self-reported musculoskeletal symptoms among office video display terminal operators. In: Sakurai H, Okazaki I, Omae I, eds. Occupational epidemiology. Amsterdam, The Netherlands: Elsevier Science Publishers, B.V., pp. 255–258.

Higgs P, Young VL, Seaton M, Edwards D, Feely C [1992]. Upper extremity impairment in workers performing repetitive tasks. Plast Reconstr Surg *90*(4):614–620.

Hildebrandt VH [1987]. A review of epi-demiological research on risk factors of low back pain. In: Buckle P, ed. Musculoskeletal disorders at work. Proceedings of a con-ference held at the University of Surrey, Guilford, April, 1987. London, England: Taylor and Francis, pp. 9–16.

Hildebrandt VH [1995]. Back pain in the working population: prevalence rates in Dutch trades and professions. Ergonomics *38*(6):1283–1298.

Hildebrandt VH, Bongers PM, Dul J, van Dijk FJH, Kemper HCG [1996]. Identifica-tion of high-risk groups among maintenance workers in a steel company with respect to musculoskeletal symptoms and workload. Ergonomics *39*(2):232–242.

Hill AB [1965]. The environment and disease: association or causation. Proc Royal Soc Med *58*:295–300.

Hill AB [1966]. Principles of medical statistics. 8th ed. London, England: Lancet.

Hill AB [1971]. Principles of medical statistics. 9th ed. New York, NY: Oxford University Press.

Hoekstra EJ, Hurrell JJ, Swanson NG [1994]. Hazard evaluation and technical assistance report: Social Security Admin-istration Teleservice Centers, Boston, MA; Fort Lauderdale, FL. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. 92–0382–2450.

Holmström E [1992]. Musculoskeletal disorders in construction workers. Lund, Sweden: Lund University, Department of Physical Therapy, pp. 1–175.

Holmström E, Moritz U [1991]. Low back pain correspondence between questionnaire interview and clinical examination. Scand J Rehabil Med *23*:119–125.

Holmström EB, Lindell J, Moritz U [1992]. Low back and neck/shoulder pain in construction workers: occupational work-load and psychosocial risk factors. Spine *17*(6):663–671.

Holmström E, Lindell J, Moritz U [1993]. Healthy lower backs in the construction industry in Sweden. Work and Stress *7*(3):259–271.

Hopkins A [1990]. Stress, the quality of work, and repetition strain injury in Australia. Work and Stress *4*(2):129–138.

Horal J [1969]. The clinical appearance of low back disorders in the city of Gothen-burg, Sweden. Acta Orthop Scand *118*(Suppl):7–37.

Houtman ILD, Bongers PM, Smulders PGW, Kompier MAJ [1994]. Psychosocial stressors at work and musculoskeletal problems. Scand J Work Environ Health *20*(2):139–145.

Hrubec Z, Nashold BS [1975]. Epidemio-logy of lumbar disc lesions in the military in World War II. Am J Epidemiol *102*(5):366– 376.

Huang J, Ono Y, Shibata E, Takeucki Y, Hisanaga N [1988]. Occupational musculo-skeletal disorders in lunch centre workers. Ergonomics *31*(1):65–75.

Hughes RE, Silverstein BA, Evanoff BA [1997]. Risk factors for work-related musculoskeletal disorders in an aluminum smelter. Am J Ind Med *32*:66–75.

Hulshof C, Veldhuijzen van Zanten B [1987]. Whole-body vibration and low-back pain: a review of epidemiologic studies. Int Arch Occup Environ Health *59*:205–220.

Hunting KL, Welch LS, Cuccherini BA, Seiger LA [1994]. Musculoskeletal symptoms among electricians. Am J Ind Med *25*(2):149–163.

Hünting W, Läubli TH, Grandjean E [1981]. Postural and visual loads at VDT workplaces. I. Constrained postures. Ergonomics *24*(12):917–931.

Hurrell JJ, Murphy LR [1992]. Psycho-logical job stress. In: Rom WN, ed. Environmental and occupational medicine. 2nd ed. New York, NY: Little, Brown and Company, pp. 675–684.

Hurrell JJ Jr., Murphy LR, Sauter SL, Cooper CL [1988]. Occupational stress: issues and developments. New York, NY: Taylor and Francis.

Ignatius Y, Yee T, Yan L [1993]. Selfreported musculoskeletal problems amongst typists and possible risk factors. J Hum Ergol *22*:83–93.

ILO [1986]. Psychosocial factors at work: recognition and control. Geneva, Switzer-land: International Labour Office.

Iwata H, Makimo S [1987]. Prevalence of Raynaud's phenomenon in individuals not using vibrating tools. Sangyo Igaku *29*: 500–503.

Jensen RC [1987]. Disabling back injuries among nursing personnel: research needs and justification. Res Nurs Health *10*(1): 29–38.

Jensen RC [1988]. Epidemiology of work-related back pain. Top Acute Care Trauma Rehabil *2*(3):1–15.

Jensen RC [1990]. Back injuries among nursing personnel related to exposure. Appl Occup Environ Hyg *5*:38–45.

Johanning E [1991]. Back disorders and health problems among subway train operators exposed to whole-body vibration. Scand J Work Environ Health *17*(6):414– 419.

Johanning E, Wilder DG, Landrigan PJ, Pope MH [1991]. Whole-body vibration exposure in subway cars and review of adverse health effects. J Occup Med *33*(5):605–612.

Johansson JA [1994]. Work-related and non-work-related musculoskeletal symptoms. Appl Ergonomics *25*(4):248–251.

Johansson JA, Rubenowitz S [1994]. Risk indicators in the psychosocial and physical work environment for work-related neck, shoulder and low back symptoms: a study among blue and white collar workers in eight companies. Scand J Rehabil Med *26*:131–142.

Johnson JV, Stewart W, Hall EM, Fredlund P, Theorell T [1996]. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. Am J Public Health *86*(3):324–331.

Jonsson B [1988]. The static load component in muscle work. Eur J Appl Physiol *57*:305–310.

Jonsson BG, Persson J, Kilbom Å [1988]. Disorders of the cervicobrachial region among female workers in the electronics industry: a two-year follow-up. Int J Ind Ergo *3*(1):1–12.

Kaji H, Honma H, Usui M, Yasuno Y, Saito K [1993]. Hypothenar hammer syndrome in workers occupationally exposed to vibrating tools. J Hand Surg [Br] *18B*(6):761–766.

Kamwendo K, Linton, SJ, Moritz U [1991]. Neck and shoulder disorders in medical secretaries. Part I. Pain prevalence and risk factors. Scand J Rehabil Med *23*(3):127–33.

Karasek RA, Baker D, Marxer F, Ahlbom A, Theorell T [1981]. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. Am J Public Health *71*(7):694–705.

Karasek RA, Gardell B, Lindell J [1987]. Work and non-work correlates of illness and behaviour in male and female Swedish white collar workers. J Occup Behav *8*(3):187– 207.

Karasek RA, Theorell T, Schwartz JF, Schnall PL, Pieper CF, Michela JL [1988]. Job characteristics in relation to the preva-lence of myocardial infarction in the U.S. Health Examination Survey (HES) and the Health and Nutrition Examination Survey (HANES). Am J Public Health *78*(8):910– 918.

Katz JN, Punnett L, Simmons BP, Fossel AH, Mooney N, Keller RB [1996]. Workers compensation recipients with carpal tunnel syndrome: the validity of self-reported health measures. Am J Public Health *86*(1):52–56.

Kelley JD, Lombardo SJ, Pink M, Perry G, Giangarra CE [1994]. Electromyographic and cinematographic analysis of elbow function in tennis players with lateral epicondylitis. Am J Sports Med *22*(3): 359–363.

Kellgren JH, Lawrence JS [1958]. Osteo-arthrosis and disc degeneration in an urban population. Ann Rheum Dis *17*(4):338–397.

Kelsey CA, Mettler FA [1990]. Flexible protective gloves: the Emperor's new clothes? Radiology *174*(1):275–276.

Kelsey JL [1975a]. An epidemiological study of acute herniated lumbar inter-vertebral disc. Rheumatol Rehabil *14*:144.

Kelsey JL [1975b]. An epidemiological study of the relationship between occupations and acute herniated lumbar intervertebral discs. Int J Epidemiol *4*(3):197–205.

Kelsey JL, Hardy RJ [1975]. Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc. Am J Epidemiol *102*(1):63–73.

Kelsey JL, White AA [1980]. Epidemiology and impact on low back pain. Spine *5*(2): 133–142.

Kelsey JL, Golden AL [1988]. Occupational and workplace factors associated with low back pain. Occup Med: State of the Art Rev *3*(1):7–16.

Kelsey JL, Githens PB, White AA, Holford TR, Walter SD, O'Connor T, et al. [1984]. An epidemiologic study of lifting and twisting on the job and risk for acute pro-lapsed lumbar intervertebral disc. J Orthop Res *2*(1):61–66.

Kelsey JL, Golden AL, Mundt DJ [1990].

Low back pain/prolapsed lumbar inter-vertebral disc. Epidemiol Rheum Dis *16*(3):699–716.

Kennedy JC, Hawkins R, Krissoff WB [1978]. Orthopaedic manifestations of swimming. Am J Sports Med *6*:309–322.

Keyserling WM, Herrin GD, Chaffin DB [1980]. Isometric strength testing as a means of controlling medical incidents on stren-uous jobs. J Occup Med *22*(5):332–336.

Kiken S, Stringer W, Fine LJ [1990]. Hazard evaluation and technical assistance report: Perdue Farms, Lewiston, NC; Roberson-ville, NC. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 89–307–2009.

Kilbom Å [1994]. Repetitive work of the upper extremity. Int J Ind Ergonomics *14*(1/2):51–86.

Kilbom Å, Persson J [1987]. Work technique and its consequences for musculo-skeletal disorders. Ergonomics *30*(2): 273–279.

Kilbom Å, Horst D, Kemfert K, Richter A [1986]. Observation methods for reduction of load and strain on the human body—a review. Abetarskyddsstyrelsen Publikation Service *171*(84):92.

Kim SH, Chung MK [1995]. Effects of posture, weight and frequency on trunk muscular activity and fatigue during repetitive lifting tasks. Ergonomics *38*(5):853–863.

King JW, Brelsford HJ, Tullos HS [1969]. Analysis of the pitching arm of the pro-fessional baseball pitcher. Clin Orthop *67*:116–123.

Kivekäs J, Riihimäki H, Husman K, Hänninen K, Härkönen H, Kuusela T, et al. [1994]. Seven-year follow-up of white-finger symptoms and radiographic wrist findings in lumberjacks and referents. Scand J Work Environ Health *20*(2):101–106.

Kivi P [1984]. Rheumatic disorders of the upper limbs associated with repetitive occupational tasks in Finland, 1975–1979. Scand J Rheumatol *13*:101–107.

Klein BP, Jensen RC, Sanderson LM [1984]. Assessment of workers' compen-sation claims for back strains/sprains. J Occup Med *26*(6):443–448.

Kleinbaum DG, Kupper LL, Morgenstern H [1982]. Epidemiologic research: principles and quantitative methods. London, England: Lifetime Learning Publications.

Knave BG, Wibom RI, Voss M, Hedström LD, Bergqvist UO [1985]. Work with video display terminals among office employees. I. Subjective symptoms and discomfort. Scand J Work Environ Health *11*(6):457–466.

Knibbe JJ, Friele RD [1996]. Prevalence of back pain and characteristics of the physical workload of community nurses. Ergonomics *39*(2):186–198.

Kompier MAJ [1988]. Arbeid en gezondheid van stadsbus-chauffeurs. Delft Eburon (Proefschrift Rijksuniversitiet Groningen).

Kopf T, Von Feder T, Karmaus W [1988]. Risks for musculoskeletal disorders of the low back, the shoulders, the elbows, and the wrists in bricklayers. In: Hogstedt C, Reuterwall C, eds. Progress in occupational epidemiology. Amsterdam: Elsevier Science Publishers B.V., pp. 219–222.

Koskimies K, Färkkilä M, Pyykkö I, Jäntti V, Aatola S, Starck J, et al. [1990]. Carpal tunnel syndrome in vibration disease. Br J Ind Med *47*(6):411–416.

Koskimies K, Pyykkö I, Starck J, Inaba R [1992]. Vibration syndrome among Finnish forest workers between 1972 and 1990. Int Arch Occup Environ Health *64*:251–256.

Kukkonen R, Luopajärvi T, Riihimäki V [1983]. Prevention of fatigue amongst data entry operators. In: Kvalseth TO, ed. Ergonomics of workstation design. London, England: Buttersworth, pp. 28–34.

Kumar S [1994]. The back compressive forces during maximal push-pull activities in the sagittal plane. J Hum Ergol *23*(2):133– 150.

Kuorinka I, Koskinen P [1979]. Occupa-tional rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry. Scand J Work Environ Health *5*(Suppl 3):39–47.

Kuorinka I, Forcier L [1995]. Work-related musculoskeletal disorders (WMSDs): a reference book for prevention. London, England: Taylor & Francis, p. 1.

Kurppa K, Viikari-Juntura E, Kuosma E, Huuskonen M, Kivi P [1991]. Incidence of tenosynovitis or peritendinitis and epicondy-litis in a meat-processing factory. Scand J Work Environ Health *17*(1):32–37.

Kvarnström S [1983a]. Incidence of musculoskeletal disorders in a mechanical engineering plant, with emphasis on occupat-ional shoulder injuries. Abetarskyddssty-relsen Publikation Service *171*(84):79.

Kvarnström S [1983b]. Occurrence of musculoskeletal disorders in a manufac-turing industry with special attention to occupational shoulder disorders. Scand J Rehabil Med (Suppl 8):1–114.

Kvarnström S, Halden M [1983]. Occupa-tional cervicobrachial disorders in an engineering company. Scand J Rehabil Med *8*:1–114.

Lapidus PW, Guidotti FP [1970]. Lateral and medical epicondylitis of the humerus. Ind Med Surg *39*(4):30–32; 171–173.

Larsson SE, Bengtsson A, Bodegard L, Henriksson KG, Larsson J [1988]. Muscle changes in work-related chronic myalgia. Acta Orthop Scand *59*(5):552–556.

Larsson SE, Bodegard L, Henriksson KG, Öberg PA [1990]. Chronic trapezius myalgia: morphology and blood flow studied in 17 patients. Acta Orthop Scand *61*(5):394–398.

Lawrence JS [1955]. Rheumatism in coal miners. Part III: Occupational factors. Br J Ind Med *12*(3):249–261.

Leboeuf-Yde C, Klougart N, Lauritzen T [1996]. How common is low back pain in the Nordic population? Spine *21*(13):1518– 1526.

Leigh JP, Sheetz RM [1989]. Prevalence of back pain among full-time United States workers. Br J Ind Med *46*:651–657.

Leigh JP, Markowitz S, Fahs M, et al. [1996]. Costs of occupational injuries and illnesses in 1992. NIOSH cooperative agreement with ERC, Inc., contract no. U60/CCU902886.

Leino P [1989]. Symptoms of stress predict musculoskeletal disorders. J Epidemiol Community Health *43*(3):293–300.

Leino P, Lyyra A [1990]. The effect of mental stress and social support on the development of musculoskeletal morbidity in the engineering industry. In: Sakurai H, Okazaki L, Omae I, eds. Occupational epidemiology. Amsterdam, The Nether-lands: Elsevier Science Publishers B.V., pp. 267–272.

Leino P, Aro S, Hasan J [1987]. Trunk muscle function and low back disorders: a ten-year follow-up study. J Chronic Dis *40*(4):289–296.

Leino P, Hasan J, Karppi SL [1988]. Occupational class, physical workload, and musculoskeletal morbidity in the engineer-ing industry. Br J Ind Med *45*(10):672–681.

Letz R, Cherniack MG, Gerr F, Hershman D, Pace P [1992]. A cross-sectional epidemiological survey of shipyard workers exposed to hand-arm vibration. Br J Ind Med *49*(1):53–62.

Levitz CL, Iannotti JP [1995]. Overuse injuries of the shoulder. In: Gordon SL, Blair SJ, Fine LJ, eds. Repetitive motions disorders of the upper extremity. Rosemont, IL: American Academy of Orthopaedic Surgeon.

Liira JP, Shannon HS, Chambers LW, Haines TA [1996]. Long-term back problems and physical work exposures in the 1990 Ontario Health Survey. Am J Public Health *86*(3):382–387.

Liles DH, Deivanayagam S, Ayoub MM, Mahajan P [1984]. A job severity index for the evaluation and control of lifting injury. Hum Factors *26*(6):683–693.

Lindman R, Hagberg M, Ängqvist KA, Söderlund K, Hultman E, Thornell L [1991]. Changes in muscle morphology in chronic trapezius myalgia. Scand J Work Environ Health *17*(5):347–355.

Linton SJ [1990]. Risk factors for neck and back pain in a working population in Sweden. Work and Stress *4*(1):41–49.

Linton SJ, Kamwendo K [1989]. Risk factors in the psychosocial work environ-ment for neck and shoulder pain in secre-taries. J Occup Med *31*(7):609–613.

Liss GM, Jesin E, Kusiak RA, White P [1995]. Musculoskeletal problems among Ontario dental hygienists. Am J Ind Med *28*(4):521–540.

Loslever P, Ranaivosoa A [1993]. Biomechanical and epidemiological investigation of carpal tunnel syndrome at workplaces with high risk factors. Ergonomics *36*(5): 537–555.

Louis, Harris & Associates [1996]. Pain and absenteeism in the workplace. New York, NY: Louis, Harris & Associates.

Lukaš E [1970]. Lesion of the peripheral nervous system due to vibration. Work Environ Health *7*(1):67–79.

Lundberg U, Granqvist M, Hansson T, Magnusson M, Wallin L [1989]. Psychological and physiological stress responses during repetitive work at an assembly line. Work and Stress *3*(2):143–153.

Lundborg G, Dahlin LB, Danielsen N, Hansson HA, Necking LE, Pyykkö I [1987]. Intraneural edema following exposure to vibration. Scand J Work Environ Health *13*(4):326–329.

Lundborg G, Dahlin LB, Hansson HA, Kanje M, Necking LR [1990]. Vibration exposure and peripheral nerve fiber damage. J Hand Surg [Am] *15A*(2):346–351.

Luopajärvi T, Kuorinka I, Virolainen M, Holmberg M [1979]. Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. Scand J Work Environ Health *5*(Suppl 3):48–55.

Maeda K, Hirayama H, Takamatsu M [1977]. Occupational cervicobrachial disorders in workwomen in assembly lines of a cigarette factory. Jpn J Ind Health *19*:8–21.

Maeda K, Horiguchi S, Hosokawa M [1982]. History of the studies on occupa-tional cervicobrachial disorders in Japan and remaining problems. J Human Ergol *11*:17–29.

Magnusson M, Hanson T [1994]. The effect of seat back inclination on spine height changes. Appl Ergonomics *25*(5):294–298.

Magnusson ML, Pope MH, Wilder DG, Areskoug B [1996]. Are occupational drivers at an increased risk for developing musculoskeletal disorders? Spine *6*:710–717.

Magora A [1970]. Investigation of the relation between low back pain and occupation. Ind Med *39*:31–37.

Magora A [1972]. Investigation of the relation between low back pain and occupation. III. Physical requirements: sitting, standing, and weight lifting. Ind Med *41*(12):5–9.

Magora A [1973]. Investigation of the relation between low back pain and occupation. IV. Physical requirements: bending, rotation, reaching, and sudden maximal effort. Scand J Rehabil Med *5*:191–196.

Magora A, Schwartz A [1978]. Relation between the low back pain syndrome and x-ray findings. I. Degenerative osteoarthritis. Scand J Rehabil Med *10*:135–145.

Maizlish N, Rudolph L, Dervin K, Sankaranarayan M [1995]. Surveillance and prevention of work-related carpal tunnel syndrome: an application of the Sentinel Events Notification System for Occupational Risks. Am J Ind Med *27*(5):715–729.

Mäkelä M, Heliövaara M, Sievers K, Impivaara O, Knekt P, Aromaa A [1991]. Prevalence, determinants, and consequences of chronic neck pain in Finland. Am J Epidemiol *134*(11):1356–1367.

MaKinnon SE, Novak CB [1997]. Repeti-tive strain in the workplace. J Hand Surg [Am] *22A*(1):2–18.

Marcus M, Gerr F [1996]. Upper extremity musculoskeletal symptoms among female office workers: associations with video display terminal use and occupational psychosocial stressors. Am J Ind Med *29*(2):161–170.

Marley RJ, Fernandez JE [1995]. Psychophysical frequency and sustained exertion at varying wrist postures for a drilling task. Ergonomics *38*(2):303–325.

Marras WS, Schoenmarklin RW [1991]. Quantification of wrist motion in highly repetitive, hand-intensive industrial jobs. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

Marras W, Schoenmarklin RW [1993]. Wrist motions in industry. Ergonomics *36*(4):341–351.

Marras WS, Lavender SA, Leurgans SE, Rajulu SL, Allread WG, Fathallah FA, et al. [1993]. The role of dynamic three-dimen-sional trunk motion in occupationally-related low back disorders: the effects of work-place factors, trunk position, and trunk motion characteristics on risk of injury. Spine *18*(5):617–628.

Marras WS, Lavender SA, Leurgans SE, Fathallah FA, Ferguson SA, Allread WG, et al. [1995]. Biomechanical risk factors for occupationally-related low back disorders. Ergonomics *38*(2):377–410.

Martin DK, Dain SJ [1988]. Postural modifications of VDU operators wearing bifocal spectacles. Appl Ergonomics *19*(4):293–300.

Masset D, Malchaire J [1994]. Low back pain: epidemiologic aspects and work-related factors in the steel industry. Spine *19*(2):143–146.

Matheson LN, Brophy RG, Vaughan KD, Nunez C, Saccoman KA [1995]. Workers' compensation managed care: preliminary findings. J Occup Rehabil *5*(1):27–36.

Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S [1985]. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil *66*(2):69–72.

Matthews KA, Cottington EM, Talbott E, Kuller LH, Siegel JM [1987]. Stressful work conditions and diastolic blood pressure among blue collar factory workers. Am J Epidemiol *126*(2):280–290.

Mayer TG, Gatchel RJ, Kishino N, Keeley J, Capra P, Mayer H, et al. [1985]. Objective assessment of spinal function following industrial injury: a prospective study with comparison group and one-year follow-up. Spine *10*(6):482–493.

McCormack RR Jr., Inman RD, Wells A, Berntsen C, Imbus HR [1990]. Prevalence of tendinitis and related disorders of the upper extremity in a manufacturing workforce. J Rheumatol *17*:958–964.

McKenna K, McGrann S, Blann A, Allen J [1993]. An investigation into the acute vascular effects of riveting. Br J Ind Med *50*:160–166.

McNeil T, Warwick D, Andersson G, Schultz A [1980]. Trunk strengths in attempted flexion, extension, and lateral bending in healthy subjects and patients with low back disorders. Spine *5*(6):529–538.

Merriam WP, Burwell RG, Mulholland RC, Pearson JCG, Webb JK [1980]. A study revealing a tall pelvis in subjects with low back pain. J Bone Joint Surg [Br] *65B*:153–156.

Milerad E, Ekenvall L [1990]. Symptoms of the neck and upper extremities in dentists. Scand J Work Environ Health *16*(1): 129–134.

Mintz G, Fraga A [1973]. Severe osteo-arthritis of the elbow in foundry workers. Arch Environ Health *27*:78–80.

Mirbod SM, Inaba R, Iwata H [1992a]. A study on the vibration-dose limit for Japanese workers exposed to hand-arm vibration. Ind Health *30*:1–22.

Mirbod SM, Yoshida H, Nagata C, Inaba R, Komura Y, Iwata H [1992b]. Hand-arm vibration syndrome and its prevalence in the present status of private forestry enterprises in Japan. Int Arch Occup Environ Health *64*:93–99.

Mirbod SM, Yoshida H, Komura Y, Fujita S, Nagata C, Miyashita K, et al. [1994]. Prevalence of Raynaud's phenome-non in different groups of workers operating hand-held vibrating tools. Int Arch Occup Environ Health *66*:13–22.

Miyashita K, Morioka I, Iwata H, Takeda S [1992]. Symptoms of construction workers exposed to whole-body vibration and local vibration. Int Arch Occup Environ Health *64*:347–351.

Moon SD, Sauter SL [1996]. Beyond biomechanics: psychosocial aspects of musculoskeletal disorders in office work. London, England: Taylor and Francis.

Moore JS [1992]. Carpal tunnel syndrome. Occup Med: State of the Art Rev *7*(4):741–763.

Moore JS, Garg A [1991]. Determination of the operational characteristics of ergonomic exposure assessments for prediction of disorders of the upper extremities and back. In: Proceedings of the 11th Congress of the International Ergonomics Association. London, England: Taylor & Francis, pp. 144–146.

Moore JS, Garg A [1994]. A comparison of different approaches for ergonomic job evaluation for predicting risk of upper extremity disorders. IEA 94. Occup Health Saf *2*.

Morgenstern H, Kelsh M, Kraus J, Margolis W [1991]. A cross-sectional study of hand/wrist symptoms in female grocery check-ers. Am J Ind Med *20*(2):209–218.

Morris HH, Peters BH [1976]. Pronator syndrome: clinical and electrophysiological features in seven cases. J Neurol Neurosurg Psychiatry *39*:461–464.

Mostardi RA, Noe DA, Kovacik MW, Porterfield JA [1992]. Isokinetic lifting strength and occupational injury: a prospective study. Spine *17*(2):189–193.

Musson Y, Burdorf A, van Drimmelen D [1989]. Exposure to shock and vibration and symptoms in workers using impact power tools. Ann Occup Hyg *33*(1):85–96.

Nachemson A, Lindh M [1969]. Measurement of abdominal and back muscle strength with and without low back pain. Scand J Rehabil Med *1*:60–65.

Nachemson A, Elfstrom G [1970]. Intravital dynamic pressure measurements in lumbar discs. Scand J Rehabil Med *1*(Suppl):1–40.

Nagata C, Yoshida H, Mirbod S, Komura Y, Fujita S, Inaba R, et al. [1993]. Cutaneous signs (Raynaud's phenomenon, sclerodacty-lia, and edema of the hands) and hand-arm vibration exposure. Int Arch Occup Environ Health *64*:587–591.

Nathan PA, Meadows KD, Doyle LS [1988]. Occupation as a risk factor for impaired sensory conduction of the median nerve at the carpal tunnel. J Hand Surg [Br] *13B*(2): 167–170.

Nathan PA, Keniston RC, Myers LD, Meadows KD [1992a]. Longitudinal study of median nerve sensory conduction in industry: relationship to age, gender, hand dominance, occupational hand use, and clinical diagnosis. J Hand Surg [Am] *17A*(5):850–857.

Nathan PA, Keniston RC, Myers LD, Meadows KD [1992b]. 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 *34*(4):379–383.

Nathan PA, Keniston RC, Meadows KD, Lockwood RS [1993]. Validation of occupational hand use categories. J Occup Med *35*(10):1034–1042.

Nathan PA, Keniston RC, Meadows KD, Lockwood RS [1994a]. The relationship between body mass index and the diagnosis of carpal tunnel syndrome [letter to the editor]. Muscle Nerve, December 1994, pp. 1491–1492.

Nathan PA, Takigawa K, Keniston RC, Meadows KD, Lockwood RS [1994b]. Slowing of sensory conduction of the median nerve and carpal tunnel syndrome in Japanese and American industrial workers. J Hand Surg [Am] *19B*(1):30–34.

Necking LE, Dahlin LB, Fridin J, Lundborg G, Lundström R, Thornell LE [1992]. Vibration-induced muscle injury: an experimental model and preliminary findings. J Hand Surg [Br] *17B*:270–274.

Nicholas JA [1990]. Clinical observations on sports-induced soft-tissue injuries in sports-induced inflammation. In: Leadbetter WB, Buckwalter JA, Gordon SL, eds. Rosemont, IL: American Academy of Orthopedic Surgeons, p. 143.

Nilsson T, Burström L, Hagberg M [1989]. Risk assessment of vibration exposure and white fingers among platers. Int Arch Occup Environ Health *61*(7):473–481.

Nilsson T, Hagberg M, Burström L [1990]. Prevalence and odds ratio of numbness and carpal tunnel syndrome in different exposure categories of platers. In: Okada A, Dupuis WTH, eds. Hand-arm vibration. Kanazawa, Japan: Kyoei Press Co., pp. 235–239.

Nilsson T, Hagberg M, Burström L, Kihlberg S [1994]. Impaired nerve conduction in the carpal tunnel of platers and truck assemblers exposed to hand-arm vibration. Scand J Work Environ Health *20*:189–199.

Nilsson T, Hagberg M, Burström L, Lundström R [1995]. A five-year follow-up study of nerve conduction across the carpal tunnel among workers at a heavy engineer-ing production plant. In: International Conference on the Prevention of Musculo-skeletal Disorders (PREMUS). Montreal, Canada: International Committee on Occupational Safety and Health, pp.81–83.

NIOSH [1989]. NIOSH criteria for a recommended standard: occupational exposure to hand-arm vibration. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 89–106.

NIOSH [1991]. Epidemiological basis for manual lifting guidelines. In: Scientific support documentation for the revised 1991 NIOSH lifting equation: technical contract reports. Springfield, VA: National Technical Information Service (NTIS), NTIS No. PB–91–226274.

NIOSH [1996]. National occupational research agenda. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 96–115.

Nirschl RP [1973]. Tennis elbow. Orthop Clin North Am *4*(3):787–800.

Nirschl RP [1975]. The etiology and treatment of tennis elbow. J Sports Med *2*(6):308–319.

Nirschl R [1993]. Muscle and tendon trauma: tennis elbow. In: Morrey B, ed. The elbow and its disorders. 2nd ed. Philadel-phia, PA: W.B. Saunders Company, pp. 552–573.

Nordgren B, Schek R, Linrotn K [1980]. Evaluation and prediction of back pain during military field service. Scand J Rehabil Med *12*(1):1–8.

Ohara H, Nakagiri S, Itani T, Wake K, Aoyama H [1976]. Occupational health hazards resulting from elevated work rate situations. J Hum Ergol *5*(2):173–182.

Ohlsson K, Attewell R, Skerfving S [1989]. Self-reported symptoms in the neck and upper limbs of female assembly workers. Scand J Work Environ Health *15*(1):75–80.

Ohlsson K, Hansson GA, Balogh I, Strömberg U, Pålsson B, Nordander C, et al. [1994]. Disorders of the neck and upper limbs in women in the fish processing industry. Occup Environ Med *51*:826–832.

Ohlsson K, Attewell R, Paisson B, Karlsson B, Balogh I, Johnsson B, et al. [1995]. Repetitive industrial work and neck and upper limb disorders in females. Am J Ind Med *27*(5):731–747.

Olafsdottir H, Rafnsson V [1995]. New tech-niques increases the prevalences of musculoskeletal symptoms from upper limbs among women in fish fillet plants. In: Second International Scientific Conference on Prevention of Work-Related Musculoskeletal

Disorders. Montreal, Canada, pp. 248–249.

Ollivierre CO, Nirschl RP, Pettrone FA [1995]. Resection and repair for medical tennis elbow: a prospective analysis. Am J Sports Med *23*(2):214–221.

Onishi N, Namura H, Sakai K, Yamamoto T, Hirayama K, Itani T [1976]. Shoulder muscle tenderness and physical features of female industrial workers. J Hum Ergol *5*(2):87–102.

Osorio AM, Ames RG, Jones J, Castorina J, Rempel D, Estrin W, et al. [1994]. Carpal tunnel syndrome among grocery store workers. Am J Ind Med *25*(2):229–245.

Owen B, Damron C [1984]. Personal characteristics and back injury among hospital nursing personnel. Res Nurs Health *7*:305–313.

Parker KG, Imbus HR [1992]. Cumulative trauma disorders. Current issues and ergonomic solutions: a system approach. Chelsea, MI: Lewis Publishers.

Partridge REH, Duthie JJR [1968]. Rheumatism in dockers and civil servants: a comparison of heavy manual and sedentary workers. Ann Rheum Dis *27*:559–568.

Payne R [1988]. Individual differences in the study of occupational stress. In: Cooper CL, Payne R, eds. Causes, coping, and consequences of stress at work. Chichester, England: John Wiley & Sons, pp. 209–232.

Pecina M, Krmpotic-Nemanic J, Markiewitz A [1991]. Tunnel syndromes. Boston, MA: CRC Press.

Pietri-Taleb F, Riihimaki H, Viikari-Juntura E, Lindström K, Moneta GB [1995]. The role of psychological distress and personal-ity in the incidence of sciatic pain among working men. Am J Public Health *85:*541– 545.

Pope MH, Rosen JC, Wilder DG, Frymoyer JW [1980]. The relation between biomechanical and psychological factors in patients with low back pain. Spine *5*(2): 173–178.

Pope MH, Frymoyer JW, Andersson GBJ, et al. [1984]. Occupational low back pain. New York, NY: Praeger.

Pope MH, Andersson GBJ, Frymoyer JW, et al. [1991]. Occupational low back pain: assessment, treatment, and prevention. St. Louis, MO: Mosby-Year Book, pp. 105–108.

Porter RW [1987]. Does hard work prevent disc protrusion? Clin Biomechanics *2*(4): 196–198.

Pot F, Padmos P, Brouwers A [1987]. Determinants of the VDU operator's well-being. In: Knave B, Wideback PG, eds. Work with display units 86. Selected papers from the International Scientific Conference on Work with Display Units, Stockholm, Sweden, May 12–15, 1986. Amsterdam: Elsevier Science Publishers B.V., pp. 16–25.

Priest JD, Braden V, Gerberich SG [1980]. The elbow and tennis, part 1: an analysis of players with and without pain. Physician Sports Med *8*:81–91.

Priest JD, Hones HH, Tichenor CJ, Nagel DA [1977]. Arm and elbow changes in expert tennis players. Minn Med *60*:399– 404.

Punnett L, Robins JM, Wegman DH, Keyserling WM [1985]. Soft-tissue disorders in the upper limbs of female assembly workers: impact of length of employment, work pace, and selection. Scand J Work Environ Health *11*(6): 417–425.

Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB [1991]. Back disorders and nonneutral trunk postures of automobile assembly workers. Scand J Work Environ Health *17*(5):337–346.

Pyykkö I, Starak J [1986]. Pathophysiologic and hygienic aspects of hand-arm vibration. Scand J Work Environ Health *12*(4):237– 241.

Queinnec Y, Daniellou F, eds. [1991]. Shoulder symptoms and headache in light sedentary work. In: Designing for everyone. Proceedings of the 11th Congress of the International Ergonomics Association, Paris, France, July 15–20, 1991. London, England: Taylor and Francis, pp. 129–131.

Radecki P [1995]. Variability in the median and ulnar nerve latencies: implications for diagnosing entrapment. J Occup Med 37: 1293–1299.

Radwin RG, VanBergeijk E, Armstrong TJ [1989]. Muscle response to pneumatic hand tool torque reaction forces. Ergonomics *32*(6):655–673.

Ranney D, Wells R, Moore A [1995]. Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. Ergonomics *38*(7):1408– 1423.

Rathburn JB Macnab I [1970]. The micro-vascular pattern of the rotator cuff. J Bone Joint Surg [Br] *52B*(3):540–553.

Rempel D [1995]. Musculoskeletal loading and carpal tunnel pressure. In: Gordon SL, Blair SJ, Fine LJ, eds. Repetitive motions disorders of the upper extremity. Rosemont IL: American Academy of Orthopaedic Surgeons, pp. 123–133.

Rempel D, Harrison R, Barnhart S [1992]. Work-related cumulative trauma disorders of the upper extremity. JAMA *267*(6): 838–841.

Rempel D, Dennerlein J, Mote CD, Armstrong T [1994a]. A method of mea-suring fingertip loading during keyboard use. J Biomechanics *27*(8):1101–1104.

Rempel D, Manojlovic R, Levinsohn DG, Bloom T, Gordon L [1994b]. The effect of wearing a flexible wrist splint on carpal tunnel pressure during repetitive hand activity. J Hand Surg [Am] *19A*(1):106–110.

Riihimäki H [1991]. Low-back pain, its origin and risk indicators. Scand J Work Environ Health *17*(2):81–90.

Riihimäki H [1995]. Hands up or back to work—future challenges in epidemiologic research on musculoskeletal diseases. Scand J Work Environ Health *21*(6):401–403.

Riihimäki H, Tola S, Videman T, Hänninen K [1989a]. Low-back pain and occupation: a cross-sectional questionnaire study of men in machine operating, dynamic physical work, and sedentary work. Spine *14*: 204–209.

Riihimäki H, Wickström G, Hänninen K, Luopajärvi T [1989b]. Predictors of sciatic pain among concrete reinforcement workers and house painters: a five-year follow-up. Scand J Work Environ Health *15*(6):415– 423.

Riihimäki H, Wickström G, Hänninen K, Mattson T, Waris P, Zitting AG [1989c]. Radiographically detectable lumbar degenerative changes as risk indicators of back pain. Scand J Work Environ Health *15*:280–285.

Riihimäki H, Viikari-Juntura E, Moneta G, Kuha J, Videman T, Tola S [1994]. Incidence of sciatic pain among men in machine operating, dynamic physical work and sedentary work. Spine *19*(2):138–142.

Ringel SP, Treihaft M, Carry M, Fisher R, Jacobs P [1990]. Suprascapular neuropathy in pitchers. Am J Sports Med *18*(1):80–86.

Ritz BR [1995]. Humeral epicondylitis among gas- and waterworks employees. Scand J Work Environ Health *21*:478–486.

Rodgers SH, The Ergonomics Group, Health and Environment Laboratories, Eastman Kodak Co. [1986]. Ergonomic design for people at work. Vol. II: The design of jobs, including work patterns, hours of work, manual materials handling tasks, methods to evaluate job demands, and the physiological basis of work. New York, NY: Van Nostrand Reinhold Co., Inc.

Rose L, Ericson M, Glimskar B, Nordgren B, Ortengren R [1992]. Ergo-index: a model to determine pause needs after fatigue and pain reactions during work. In: Kumar S, ed. Advances in industrial ergonomics and safety, IV, Proceedings of the Annual International Industrial Ergonomics and Safety Conference, Denver, CO, June 10–14, 1992. London, England: Taylor and Francis, pp. 303–310.

Rossignol AM, Morse EP, Summers VM, Pagnotto LD [1987]. Video display terminal use and reported health symptoms among Massachusetts clerical workers. J Occup Med *29*(2):112–118.

Rothfleisch SD, Sherman S [1978]. Carpal tunnel syndrome: biomechanical aspects of occupational occurrence and implications regarding surgical management. Orthop Rev *7*(6):107–109.

Rothman KJ, ed. [1986]. Modern epidemiology. Boston, MA: Little, Brown, and Company.

Roto P, Kivi P [1984]. Prevalence of epicondylitis and tenosynovitis among meatcutters. Scand J Work Environ Health *10*(3):203– 205.

Rowe ML [1965]. Disc surgery and chronic low back pain. J Occup Med *7*(5):196–202.

Rowe ML [1985]. Backache at work. Fairport, NY: Perington Press.

Ruberman W [1992]. Psychosocial influences on mortality of patients with coronary heart disease. JAMA *267*(4): 559–560.

Ruberman W, Weinblatt E, Goldberg JD, Chaudhary BS [1984]. Psychosocial influences on mortality after myocardial infarction. N Engl J Med *311*(9):552–559.

Ryan GA, Bampton M [1988]. Comparison of data process operators with and without upper limb symptoms. Community Health Stud *12*(1):63–68.

Ryan GA, Hage B, Bampton M [1987]. Postural factors, work organization and musculoskeletal disorders. In: Buckle P, ed. Musculoskeletal disorders at work. Proceedings of a conference held at the University of Surrey, Guilford, April, 1987. London, England: Taylor and Francis, pp. 251–253.

Ryden LA, Molgaard CA, Bobbitt S, Conway J [1989]. Occupational low-back injury in a hospital employee population: an epidemiologic analysis of multiple risk factors of a high-risk occupational group. Spine *14*:315–320.

Sairanen E, Brüshaber L, Kaskinen M [1981]. Felling work, low back pain and osteoarthritis. Scand J Work Environ Health *7*(1):18–30.

Saito K [1987]. Prevention of the hand-arm vibration syndrome. Scand J Work Environ Health *13*:301–304.

Sakakibara H, Masaru M, Kondo T, Yamada S [1987]. Relation between overhead work and complaints of pear and apple orchard workers. Ergonomics *30*(5):805–815.

Sakakibara H, Miyao M, Kondo T, Yamada S [1995]. Overhead work and shoulder-neck pain in orchard farmers harvesting pears and apples. Ergonomics *38*(4):700–706.

Sauter SL [1984]. Predictors of strain in VDT users and traditional office workers. In: Grandjean E, ed. Ergonomics and health in modern offices. London, England: Taylor and Francis, pp. 129–135.

Sauter SL, Swanson NG [1996]. Psychological aspects of musculoskeletal disorders in office work. In: Moon S, Sauter S, eds. Psychosocial factors and musculoskeletal disorders. London, England: Taylor and Francis.

Sauter SL, Gottlieb MS, Jones KC, Dodson VN, Rohrer KM [1983]. Job and health implications of VDT use: initial results of the Wisconsin-NIOSH study. Commun of the ACM *26*(4):284–294.

Schibye B, Skov T, Ekner D, Christiansen J, Sjøgaard G [1995]. Musculoskeletal symptoms among sewing machine operators. Scand J Work Environ Health *21*:427–434.

Schierhout GH, Meyers JE, Bridger RS [1995]. Work-related musculoskeletal disorders and ergonomic stressors in the South African workforce. Occup Environ Med *52*(1):46–50.

Schlesselman J [1978]. Assessing the effects of confounding variables. Am J Epidemiol *108*:3–8.

Schlesselman J [1982]. Monographs in epidemiology and biostatistics. Case-control studies: design, conduct, analysis. New York, NY: Oxford University Press.

Schnall PL, Pieper C, Schwartz JE, Karasek RA, Schlussel Y, Devereux RB, et al. [1990]. The relationship between job strain, workplace diastolic blood pressure, and left ventricular mass: results of a case-control study. JAMA *263*(14):1929–1935.

Schnall PL, Schwartz JE, Landsbergis PA, Warren K, Pickering TG [1992]. The relationship between job strain, alcohol, and ambulatory blood pressure. Hypertension *19*:488–494.

Schnall PL, Landsbergis PA, Baker D [1994]. Job strain and cardiovascular disease. Ann Rev Public Health *15*:381–411.

Schottland JR, Kirschberg GJ, Fillingim R, Davis VP, Hogg F [1991]. Median nerve latencies in poultry processing workers: an approach to resolving the role of industrial "cumulative trauma" in the development of carpal tunnel syndrome. J Occup Med *33*(5):627–631.

Scott V, Gijsbers K [1981]. Pain perception in competitive swimmers. Br Med J *283*: 91–93.

Seidel H, Heide R [1986]. Long-term effects of whole-body vibration: a critical survey of the literature. Int Arch Occup Environ Health *58*:1–26.

Shinev V, Komleva L, Zhuravlev A, Druzhinin V [1992]. Study of the physical characteristics of percussive vibration of hand-held machines and its effect on the body. Noise and Vibration Bulletin, pp. 138–140.

Silverstein BA [1985]. The prevalence of upper extremity cumulative trauma disorders in industry [Dissertation]. Ann Arbor, MI: The University of Michigan.

Silverstein BA, Fine LJ, Armstrong TJ [1986]. Hand wrist cumulative trauma disorders in industry. Br J Ind Med *43*(11):779–784.

Silverstein BA, Fine LJ, Armstrong TJ [1987]. Occupational factors and the carpal tunnel syndrome. Am J Ind Med *11*(3):343– 358.

Silverstein B, Grossman E, Kalat J, Nelson N [in press]. Upper limb and low back musculoskeletal disorders: State and national estimates based on workers' compensation accepted claims. Proceedings for managing ergonomics in the 90's. Alexandria, VA: Center for Office Technology and the American Automobile Manufacturer's Association.

Sinclair A [1964]. Tennis elbow in industry. Br J Ind Med *22*:144–148.

Sjøgaard G [1988]. Intramuscular changes during long-term contraction. In: Corlett N, Wilson J, Manenica I, eds. The ergonomics of working postures: models, methods and cases. Proceedings of the First International Occupational Ergonomics Symposium, Zadar, Yugoslavia, April 18–20, 1985, London, England: Taylor and Francis, pp. 136–143.

Sjøgaard G, Savard G, Juel C [1988]. Muscle blood flow during isometric activity and its relation to muscle fatigue. Eur J Appl Physiol *57*:327–335.

Skie M, Zeiss J, Ebraheim NA, Jackson WT [1990]. Carpal tunnel changes and median nerve compression during wrist flexion and extension seen by magnetic resonance imaging. J Hand Surg [Am] *15A*(6):939.

Skov T, Borg V, Orhede E [1996]. Psycho-social and physical risk factors for musculoskeletal disorders of the neck, shoulders, and lower back in salespeople. Occup Environ Med *53*:351–356.

Skovron ML, Mulvihill MN, Sterling RC, Nordin M, Tougas G, Gallagher M, et al. [1987]. Work organization and low back pain in nursing personnel. Ergonomics *30*(2):359–366.

Skovron ML, Szpalski M, Nordin M, Melot C, Cukier D [1994]. Sociocultural factors and back pain: a population-based study in Belgian adults. Spine *19*(2):129– 137.

Slocum D [1960]. Overuse syndromes of the lower leg and foot in athletes. AAOS Instructional Course Lectures, pp. 359–367.

Smith MJ, Stammerjohn LW, Cohen BGF, Lalich NR [1977]. Job stress in video display operations. In: Grandjean E, Vigliani E, eds. Ergonomic aspects of video display terminals. London, England: Taylor and Francis, pp. 201–210.

Snook SH [1978]. The design of manual handling tasks. Ergonomics *21*(12):963– 985.

Snook SH [1982]. Low back pain in industry. In: White AA, Gordon SL, eds. American Academy of Orthopaedic Surgeons Symposium on Idiopathic Low Back Pain. St. Louis, MO: C.O. Mosby Company, pp. 23–38.

Snook SH [1987]. Approaches to preplacement testing and selection of workers. Ergonomics *30*(2):241–247.

Snook SH, Webster BS [1987]. The cost of disability. Clin Orthop *221*:77–84.

Snook SH, Ciriello VM [1991]. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics *34*(9):1197–1213.

Snook SH, Campanelli RA, Hart JW [1978]. A study of three preventive approaches to low back injury. J Occup Med *20*(7):478– 487.

Sokal RR, Rohlf FJ [1981]. Biometry: the principles and practice of statistics in biological research. 2nd ed. San Francisco, CA: WH Freeman and Co.

Sommerich CM, McGlothin JD, Marras WS [1993]. Occupational risk factors associated with soft tissue disorders of the shoulder: a review of recent investigations in the literature. Ergonomics *36*(6):697–717.

Spengler DM, Bigos S, Martin NA, Zeh J, Fisher L, Nachemson A [1986]. Back injuries in industry: a retrospective study. I. Overview and cost analysis. Spine *11*: 241–245.

Starck J, Jussi P, Ilmari P [1990]. Physical characteristics of vibration in relation to vibration-induced white finger. Am Ind Hyg Assoc J *51*(4):179–184.

Stenlund B [1993]. Shoulder tendinitis and osteoarthritis of the acromioclavicular joint and their relation to sports. Br J Sports Med *27*:125–128.

Stenlund B, Goldie I Hagberg M, Hogstedt C, Marions O [1992]. Radiographic osteoarthrosis in the acromioclavicular joint resulting from manual work or exposure to vibration. Br

J Ind Med *49*:588–593.

Stenlund B, Goldie I, Hagberg M, Hogstedt C [1993]. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scand J Work Environ Health *19*: 43–49.

Stetson DS, Keyserling WM, Silverstein BA, Leonard JA [1991]. Observational analysis of the hand and wrist: a pilot study. Appl Occup Environ Hyg *6*(11):927–937.

Stetson DS, Silverstein BA, Keyserling WM, Wolfe RA, Albers JW [1993]. Median sensory distal amplitude and latency: comparisons between nonexposed managerial/professional employees, and industrial workers. Am J Ind Med *24*:175–189.

Stevens JC, Sun MD, Beard CM, O'Fallon WM, Kurland LT [1988]. Carpal tunnel syndrome in Rochester, Minnesota, 1961 to 1980. Neurology *38*:134–138.

Stevens PH, Chase DO, Brownlie AW [1966]. Industrial design of a narrow aisle sit-down lift truck. Hum Factors *8*:317–325.

Stock SR [1991]. Workplace ergonomic factors and the development of musculo-skeletal disorders of the neck and upper limbs: a meta-analysis. Am J Ind Med *19*(1):87–107.

Stubbs DA [1986]. Back pain and its relationship to manual handling. In: Morrison D, Hartley L, Kemp D, eds. Trends in the ergonomics of work. Proceed-ings of the 23rd Annual Conference of the Ergonomics Society of Australia, pp. 118–128.

Susser M [1991]. What is a cause and how do we know one?: a grammar for pragmatic epidemiology. Am J Epidemiol *133*(7):635–648.

Svensson H [1982]. Low back pain in 40- to 47-year-old men: II. Socioeconomic factors and previous sickness absence. Scand J Re-habil Med *14*:55–60.

Svensson H, Andersson GBJ [1983]. Low-back pain in 40- to 47-year old men: work history and work environment factors. Spine *8*:272–276.

Svensson H, Andersson GBJ [1989]. The relationship of low-back pain, work history and work environment, and stress: a retrospective cross-sectional study of 38- to 64-year old women. Spine *14*(5):517–522.

Sweeney MH, Petersen M, O'Neill V [1994]. Hazard evaluation and technical assistance report: Registry of Interpreters for the Deaf, Ohio Chapter. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 92–0268–2477.

Szabo RM, Chidgey LK [1989]. Stress carpal tunnel pressures in patients with carpal tunnel syndrome and normal patients. J Hand Surgery [Am] *14A*(4):624–627.

Takala E, Viikari-Juntura E [1991]. Muscle force endurance and neck-shoulder symp-toms of sedentary workers: an experimental study on bank cashiers with and without symptoms. Amsterdam, The Netherlands: Elsevier Science Publishers. B.V., pp. 123–132.

Takala EP, Viikari-Juntara E, Moneta G,

Saarenmaa K, Kaivanto K [1991]. Predic-tors for the natural course of neck–shoulder symptoms and headache in light sedentary work. In: Queinnec Y, Daniellou F, eds. Designing for everyone. Proceedings of the 11th Congress of the International Ergono-mics Association, Paris, France, July 15–20, 1991. London, England: Taylor and Francis, pp. 129–131.

Takeuchi T, Futatsuka M, Imanishi H, Yamada S [1986]. Pathological changes observed in the finger biopsy of patients with vibration-induced white finger. Scand J Work Environ Health *12*:280–283.

Tanaka S, Wild DK, Seligman PJ, Halperin WE, Behrens VJ, Putz-Anderson V [1995]. Prevalence of work-related carpal tunnel syndrome among U.S. workers: analysis of the occupational health supplement data of 1988 National Health Interview Survey. Am J Ind Med *27*(4):451–470.

Tanaka S, Wild DK, Cameron L, Freund E [in press]. Association of occupational and non-occupational risk factors with the prevalence of self-reported carpal tunnel syndrome in a national survey of the working population. Am J Ind Med.

Tanii K, Kogi K, Sadoyama T [1972]. Spontaneous alteration of the working arm in static overhead work. J Hum Ergol *1*:143–155.

Tauber J [1970]. An unorthodox look at backaches. J Occup Med *12*(4):128–130.

Taylor W [1982]. Vibration white finger in the workplace. J Soc Occup Med *32*:159–166.

Theorell T, Harms-Ringdahl K, Ahlberg-Hultén G, Westin B [1991]. Psychosocial job factors and symptoms from the locomotor system: a multicausal analysis. Scand J Rehabil Med *23*(3):165–173.

Theorell T, Ahlberg-Hulten G, Jodko M, Sigala F, de la Torre B [1993]. Influence of job strain and emotion on blood pressure levels in female hospital personnel during work hours. Scand J Work Environ Health *19*(5):313–318.

Tola S, Riihimäki H, Videman T, Viikari-Juntura E, Hänninen K [1988]. Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work. Scand J Work Environ Health *14*(5):299–305.

Toomingas A, Hagberg M, Jorulf L, Nilsson T, Burström L, Kihlberg S [1991]. Outcome of the abduction external rotation test among manual and office workers. Am J Ind Med *19*(2):215–227.

Toomingas A, Theorell T, Michélsen H, et al. [1992]. Associations between preceived psychosocial job factors and prevalence of musculoskeletal disorders in the neck and shoulder regions. In: Hagberg M, Kilbom Å, eds. International Scientific Conference on Prevention of Work-Related Musculo-skeletal Disorders PREMUS, Sweden, May 12–14, 1992. Arbete och Hälsa 17:289.

Toroptsova NV, Benevolenskaya LI, Karyakin AN, Sergeev IL, Erdesz S [1995]. Cross-sectional study of low back pain among workers at an industrial enterprise in Russia. Spine *20*(3):328–332.

Torrell G, Sanden A, Järvholm B [1988]. Musculoskeletal disorders in shipyard workers.

J Soc Occup Med *38*(4):109–112.

Troup JDG [1978]. Driver's back pain and its prevention—a review of the postural, vibratory, and muscular factors, together with the problem of transmitted road shock. Appl Ergonomics *9*(4):207–214.

Troup JDG, Martin JW, Lloyd DC [1981]. Back pain in industry: a prospective survey. Spine *6*(1):61–69.

Troup JDG, Foreman TK, Baxter CE, Brown D [1987]. Musculoskeletal disorders at work, tests of manual working capacity and the prediction of low back pain. In: Buckle P, ed. Musculoskeletal disorders at work. London, England: Taylor and Francis, pp. 165–170.

Uhl JE, Wilkinson WE, Wilkinson CS [1987]. Aching backs? A glimpse into the hazards of nursing. AAOHN J *35*(1):13–17.

Ulin SS, Armstrong TJ, Snook SH, Keyserling WM [1993]. Perceived exertion and discomfort associated with driving screws at various work locations and at different work frequencies. Ergonomics *36*(7):833–846.

Undeutsch K, Gärtner KH, Luopajärvi T, Küpper R, Karvonen MJ, Löwenthal I, et al. [1982]. Back complaints and findings in transport workers performing physically heavy work. Scand J Work Environ Health *8*(Suppl 1):92–96.

Ursin H, Endresen IM, Ursin G [1988]. Psychological factors and self-reports of muscle pain. Eur J Appl Physiol *57*(3):282–290.

Veiersted KG, Westgaard RH [1992]. Work-related risk factors for trapezius myalgia. In: Hagberg M, Kolbom Å, eds. International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders PREMUS, Sweden, May 12–14, 1992. Arbete och Hälsa 17:307–309.

Veiersted KG, Westgaard RH [1994]. Subjectively assessed occupational and individual parameters as risk factors for trapezius myalgia. Int J Ind Ergo *13*(3):235–245.

Veiersted KB, Westgaard RH, Andersen P [1993]. Electromyographic evaluation of muscular work pattern as a predictor of trapezius myalgia. Scand J Work Environ Health *19*:284–290.

Vessey MP, Villard-Mackintosh L, Yeates D [1990]. Epidemiology of carpal tunnel syndrome in women of childbearing age. Findings in a large cohort study. Int J Epidemiol *19*(3):655–659.

Videman T, Nurminen T, Tola S, Kuorinka I, Vanharanta H, Troup JDG [1984]. Low-back pain in nurses and some loading factors of work. Spine *9*(4):400–404.

Videman T, Rauhala H, Asp S, Lindstrom K, Cedercreutz G, Kamppi M, et al. [1989]. Patient-handling skill, back injuries, and back pain: an intervention study in nursing. Spine *14*(2):148–156.

Videman T, Nurminen M, Troup JDG [1990]. Lumbar spine pathology in cadaveric material in relation to history of back pain, occupation, and physical loading. Spine *15*(8):728–740.

Vihma T, Nurminen M, Mutanen P [1982]. Sewing machine operators' work and musculoskeletal complaints. Ergonomics *25*(4):295–298.

Viikari-Juntura E [1995]. The role of physical stressors in the development of hand/wrist, and elbow disorders. In: Gordon SL, Blair SJ, Armstrong, et al., eds. Pathophysiology and clinical factors in upper extremity repetitive motion syndromes. Bethesda, MD: American Academy of Orthopedic Surgeons.

Viikari-Juntura EJ, Vuori J, Silverstein B, Kalimo R, Kuosma E, Videman T [1991a]. A life-long prospective study on the role of psychosocial factors in neck-shoulder and low back pain. Spine *16*:1056–1061.

Viikari-Juntura E, Kurppa K, Kuosma E, Huuskonen M, Kuorinka I, Ketola R, et al. [1991b]. Prevalence of epicondylitis and elbow pain in the meat-processing industry. Scand J Work Environ Health *17*(1):38–45.

Viikari-Juntura E, Riihimäki H, Tola S, Videman T, Mutanen P [1994]. Neck trouble in machine operating, dynamic physical work and sedentary work: a prospective study on occupational and individual risk factors. J Clin Epidemiol *47*(12):1411– 1422.

Virokannas H [1995]. Dose-response relation between exposure to two types of hand-arm vibration and sensorineural per-ception of vibration. Occup Environ Med *52*:332–336.

Virokannas H, Tolonen U [1995]. Responses of workers exposed to vibration in autono-mic nervous function tests. Int Arch Occup Environ Health *67*(3):201–205.

Waersted M, Bjorklund R, Westgaard RH [1986]. Generation of muscle tension related to a demand of continuing attention. In: Knave B, Wideback PG, eds. Work with display units. Amsterdam, The Netherlands: Elsevier Science Publishers, B.V. North-Holland, pp. 288–293.

Walsh K, Varnes N, Osmond C, Styles R, Coggin D [1989]. Occupational causes of low back pain. Scand J Work Environ Health *15*(1):54–59.

Waris P, Kuorinka I, Kurppa K, Luopajärvi T, Virolainen M, Pesonen K, et al. [1979]. Epidemiologic screening of occupational neck and upper limb disorders: methods and criteria. Scand J Work Environ Health *5*(Suppl 3):25–38.

Washington State Department of Labor and Industries [1996]. Work-related musculo-skeletal disorders. Washington State summary 1992–1994. Olympia, WA: Washington State Department of Labor and Industries, Consultation and Compliance Services Division.

Waters TR, Putz-Anderson V, Garg A, Fine LJ [1993]. Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics *36*:749–776.

Webster BS, Snook SH [1994a]. The cost of compensable upper extremity cumulative trauma disorders. J Occup Med *36*(7):713–727.

Webster BS, Snook SH [1994b]. The cost of 1989 workers' compensation low back pain claims. Spine *19*(10):1111–1116.

Weiss ND, Gordon L, Bloom T, So Y, Rempel DM [1995]. Position of the wrist associated with the lowest carpal-tunnel pressure: implications for splint design.

J Bone Joint Surg *77A* (11):1695–1699.

Welch LS, Hunting KL, Kellogg J [1995]. Work-related musculoskeletal symptoms among sheet metal workers. Am J Ind Med *27*(6):783–791.

Wells JA, Zipp JF, Schuette PT, McEleney J [1983]. Musculoskeletal disorders among letter carriers. J Occup Med *25*(11):814–820.

Werner RA, Franzblau A, Albers JW, Buchele H, Armstrong TJ [1997]. Use of screening nerve conduction studies for predicting future carpal tunnel syndrome. Occup Environ Med *54*:96–100.

Werner RA, Franzblau A, Johnston E [1994a]. Quantitative vibrometry and electrophysiological assessment in screening for carpal tunnel syndrome among industrial workers: a comparison. Arch Phys Med Rehabil *75*:1228–1232.

Werner S, Albers JW, Franzblau A, Armstrong TJ [1994b]. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. Muscle Nerve *December*:1492.

Westerling D, Jonsson BG [1980]. Pain from the neck-shoulder region and sick leave. Scand J Soc Med *8*(3):131–136.

Westgaard R, Aaras A [1985]. The effect of improved workplace design on the development of work-related musculoskeletal disorders. Appl Ergonomics *16*(2):91–97.

Westgaard R, Bjorklund R [1987]. Generation of muscle tension additional to postural muscle load. Ergonomics *30*(7):911–923.

White AA, Gordon SL [1982]. Synopsis: workshop on idiopathic low back pain. Spine *7*(2):141–149.

WHO [1985]. Identification and control of work-related diseases. Geneva, Switzerland: World Health Organization. WHO Technical Report Series 714.

WHO [1989]. Work with visual display terminals: psychosocial aspects and health. J Occup Med *31*(12):957–968.

Wickström BO, Kjellberg A, Landström U [1994]. Health effects of long-term occupational exposure to whole-body vibration: a review. Int J Ind Ergonomics *14*:273–292.

Wieslander G, Norbäck D, Göthe CJ, Juhlin L [1989]. Carpal tunnel syndrome (CTS) and exposure to vibration, repetitive wrist movements, and heavy manual work: a case-referent study. Br J Ind Med *46*(1): 43–47.

Wiktorin C, Karlqvist L, Winkel J [1993]. Validity of self-reported exposures to work postures and manual materials handling. Scand J Work Environ Health *19*:208–214.

Wilder DG, Pope MH [1996]. Epidemiological and aetiological aspects of low back pain in vibration environments—an update. Clin Biomechanics *11*:61–73.

Wilson RN, Wilson S [1957]. Tenosynovi-tis in industry. Practitioner *178*:612–615.

Winkel J, Westgaard R [1992]. Occupational and individual risk factors for shoulder-neck complaints. Part II: the scientific basis (literature review) for the guide. Int J Ind Ergonomics *10*:85–104.

Winkel J, Westgaard R [1992]. Occupational and individual risk factors for shoulder-neck complaints. Part II. The scientific basis (literature review) for the guide. Int J Ind Ergonomics *10*:85–104.

Winn FJ, Habes DJ [1990]. Carpal tunnel area as risk factor for carpal tunnel syndrome. Muscle Nerve *13*:254–258.

Wisseman C, Badger D [1976]. Hazard evaluation and technical assistance report: Eastman Kodak, Windsor, Colorado. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Report No. TA 76–0131.

Yu ITS, Wong TW [1996]. Musculoskeletal problems among VDU workers in a Hong Kong bank. Occup Med *46*(4):275–280.

Zwerling C, Ryan J, Schootman M [1993]. A case-control study of risk factors for industrial low back injury: the utility of preplacement screening in defining high-risk groups. Spine *18*(9):242–247.

APPENDIX A
Epidemiologic Review

Various investigators have used different occupational epidemiologic methods to identify the patterns of work-related MSD occurrence in different working groups, as well as the factors that influence these disease patterns. The following section briefly summarizes these study designs and then addresses the most common biases (such as misclassification or selection) that can affect the results of these studies.

TYPES OF EPIDEMIOLOGIC STUDY DESIGNS REVIEWED

The NIOSH reviewers have first addressed studies that use a prospective approach. **Prospective cohort studies**, identify groups of subjects (exposed and nonexposed) and observe them over a period of time to compare the number of new work-related MSD cases in the two groups. All subjects are initially disease-free. The rate (or risk) of new cases (the incidence) is calculated for both groups, and the ratio of these two incidences (the relative risk or rate ratio, RR) can be used to assess the association of the exposure with the occurrence of the MSD. A RR greater than 1.0 implies that the incidence of cases was higher in the exposed group than in the nonexposed group and that an association has been observed between the exposure and the disease. A confidence interval (CI) is derived, which is an estimated range of values within which the true RR is likely to fall. The CI reflects the precision of the effect observed in the study. Ordinarily, if the CI includes 1.0, the association between the exposure and the MSD could be due to chance alone and the elevated odds ratio (OR) is not considered statistically significant.

The cohort study ensures that the exposure to work-related factors occurs before the observation of the MSD, thereby allowing a causal interpretation of the observed association. Cohort studies are often done prospectively; they follow a group of current workers forward in time. The length of time required for a prospective study depends on the problem studied. With adverse health conditions that occur as a result of long-term exposure to some factor in the workplace, many years may be needed. Extended time periods make prospective studies costly. Arguing causation is more difficult with extended time periods because other events may affect outcome. Prospective studies that require long periods of time are especially vulnerable to problems associated with worker follow-up, particularly worker attrition (workers discontinue participation in the study) and worker migration (diseased workers move to other employment before investigators ascertain their disease).

The second type of epidemiologic study evaluated for this document is the **case-control study**, which is retrospective and examines differences in exposures among workers with (cases) and without (controls) MSDs. In such studies, cases should be all incident (new) cases in a given population over a defined period or a representative sample of the cases. Controls should be a representative sample of non-cases from the same population. The ratio of the odds of exposed cases to the odds of exposed controls is called the OR. An OR above 1.0 indicates an association between the exposure and the work-related MSD, and a 95% CI indicates the probable range of the true OR. Case control studies are useful for evaluating rarely occurring conditions or small numbers of cases. One limitation of case control studies is the difficulty of obtaining accurate information about past exposures. In occupational studies of MSDs, a further limitation of case-control studies is the difficulty of identifying cases who are representative of all cases that occurred in a defined period (many of these workers will have left the workforce). Another problem with case-control studies is the selection of an inappropriate control group.

Third, the reviewers considered **cross-sectional studies**. Cross-sectional studies provide a “snapshot in time” of a disease process; that is, they measure both health outcomes and exposures at a single point in time. These studies usually identify occupations with differing levels of exposure and compare the prevalences of MSDs in each group. Cross-sectional studies are most useful for identifying risk factors of a relatively frequent disease with a long duration that is often undiagnosed or unreported [Kleinbaum et al. 1982]. Typically, cross-sectional studies do not provide the evidence of the correct temporal relationship between exposure and disease inherent in prospective studies, but they nevertheless can be valuable. Some cross-sectional studies discussed here had inclusion criteria such as working at a specific job for a defined period of time before onset of symptoms. This condition adds a dimension of temporality to the studies. A common problem with cross-sectional studies that use surveys is obtaining sufficiently large response rates; many people who are asked to participate decline because they are busy, not interested, etc. The conclusions are therefore based on a subset of workers who agree to participate, and these workers may not be representative of or similar to the entire population of workers. Furthermore, cross-sectional studies are often confined to current workers who may not be representative of true prevalence rates if workers with disease have left the workforce. (The problem of representativeness is not confined to cross-sectional studies and may occur in the other study designs mentioned whenever subjects are selected, decline, or drop out.) Either ORs or prevalence ratios (PRs) (proportion of diseased in exposed divided by the proportion of diseased in unexposed) may be used to report results in cross-sectional studies.

The last type of observational study used is the **case-series study**, in which certain characteristics of a group (or series) of cases (or patients) are described. The simplest design is a set of case reports for which the author describes some interesting or intriguing observations that occurred in a small number of patients. Cases included in case series have usually been drawn from a single patient population, whose makeup may have influenced the observations noted because of selection bias. Case-series studies frequently lead to a generation of hypotheses that are subsequently investigated in a cross-sectional, case-control, or prospective study. Because case-series do not involve comparison groups (who do not have the condition or exposure to the risk factors being studied), some investigators would not consider them epidemiologic studies because they are generally not planned studies and do not involve any research hypotheses.

BIASES AND OTHER ISSUES IN EPIDEMIOLOGIC STUDIES

In interpreting the validity of epidemiologic studies to provide evidence for work-relatedness of MSDs, several assumptions and sources of bias must be considered when analyzing the findings from such studies.

1. Selection bias (internal validity). In occupational health studies, at least two types of selection bias may occur: (a) a selection of "healthy workers" in the work population studied, and (b) an exclusion of "sick" workers who leave the active workforce. Both of these biases tend to cause an underestimate of the true relationship between a workplace risk factor and an observed health effect because the workers who are in better health tend to be those in the workforce and available for study.

   A basic assumption underlying the analysis of these studies is that the selected cases of work-related MSDs in the specific studies are representative of all workers at that worksite with work-related MSDs. In a single study, representativeness generally increases with increasing population size and participation rate. A parallel assumption is that the nondiseased groups are representative of the entire nondiseased population. The fact that some cases leave the workforce causes the disease prevalence among currently employed workers to be underestimated. However, if cases are missing from the current workforce in equal proportion for both nonexposed and exposed workers, the underestimate of prevalence will not affect the internal validity of the study.

2. Generalizability (external validity). Some studies are based on a single population, occupation, or restricted data base (individual insurance companies, specific industrial settings) and, therefore, the sample may not be representative of the general population. Another assumption is that MSD cases in one study are comparable to cases in another study. This assumption needs particular scrutiny in work-related MSD studies because no standardized case definitions may exist for the particular illnesses.

3. Misclassification bias. Misclassification bias may be introduced during selection of cases and determination of their exposure. Erroneous diagnoses may result in work-related MSD cases misclassified as noncases, and similarly, noncases may be misclassified as cases. The calculated RR or OR would usually underestimate the true association because of a dilutional effect if both exposed and nonexposed cases are equally misclassified. Similarly, misclassification can occur when determining the exposure factor of interest. Again, such misclassification will create a bias towards finding no association if equal misclassification is assumed for cases and noncases.

4. Confounding and effect modification. Other factors may explain the supposed relationship between work and disease. Confounding is a situation in which the relationship (in this case with MSDs) appears stronger or weaker than it truly is as a result of something (the confounder) being associated with both the outcome and the apparent causal factor. In other words, the risk estimate is distorted because symptoms of exposed and nonexposed workers differ because of some other factors that cause disease. For example, diabetes might result in abnormal nerve conduction testing, a sign of CTS. If a higher proportion of exposed workers than nonexposed workers were diabetic, diabetes would act as a positive confounder, causing an apparent exposure-disease association.

   An effect modifier is a factor that alters the effect of exposure on disease. For example, it is possible that repetitive motion causes tendinitis only in older workers; in this case, age would be an effect modifier. Although effect modification is not a bias per se, if an investigator has failed to analyze old and young workers separately, the investigator might have missed a true work/disease association.

5. Sample size, precision, and CIs. The CI around an estimated measure of effect (such as a RR) is an estimated range of values in which the true effect is likely to fall. It reflects the precision of the effect observed in the study. Large studies generally have smaller CIs and can estimate effects more precisely. In studies that are “statistically significant” the CI excludes the null value for no effect (for example, a RR of 1.0). Small studies are generally less precise, lead to wider CIs, and less likely to be “statistically significant” even if the exposed have a greater prevalence of disease than the nonexposed.

APPENDIX B
Individual Factors Associated with Work-Related Musculoskeletal Disorders (MSDs)

Although the purpose of this document is to examine the weight of evidence for the contribution of work factors to MSDs, the multifactorial nature of MSDs requires a discussion of individual factors that have been studied to determine their association with the incidence and prevalence of work-related MSDs. These factors include age [Guo et al. 1995; Biering-Sorensen 1983; English et al. 1995; Ohlsson et al. 1994]; gender [Hales et al. 1994; Johansson 1994; Chiang et al. 1993; Armstrong et al. 1987a]; anthropometry [Werner et al. 1994b; Nathan et al. 1993, Heliövaara 1987]; and cigarette smoking [Finkelstein 1995; Owen and Damron 1984; Svensson and Andersson 1983; Kelsey et al. 1990; Hildebrandt 1987], among others. Nonoccupational physical activities, such as nonoccupational VDT use, hobbies, second jobs, and household activities that might increase risk for MSDs are described in the detailed tables for those studies in which they were analyzed as risk factors.

A worker's ability to respond to external work factors may be modified by his/her own capacity, such as tissue resistance to deformation when exposed to high force demands. The level, duration, and frequency of the loads imposed on tissues, as well as adequacy of recovery time, are critical components in whether increased tolerance (a training or conditioning effect) occurs, or whether reduced capacity occurs which can lead to MSDs. The capacity to perform work varies with gender and age, among workers, and for any worker over time. The relationship of these factors and the resulting risk of injury to the worker is complex and not fully understood.

Certain epidemiologic studies have used statistical methods to take into account the effects of these individual factors (e.g., gender, age, body mass index), that is, to control for their confounding or modifying effects when looking at the strength of work-related factors. Studies that fail to control for the influence of individual factors may either mask or amplify the effects of work-related factors. The comments column of the detailed tables notes whether studies have adjusted for potential confounders.

A number of factors can influence a person's response to risk factors for MSDs in the workplace and elsewhere. Among these are the following:

AGE

The prevalence of MSDs increases as people enter their working years. By the age of 35, most people have had their first episode of back pain [Guo et al. 1995; Chaffin 1979]. Once in their working years (ages 25 to 65), however, the prevalence is relatively consistent [Guo et al. 1995; Biering-Sorensen 1983]. Musculoskeletal impairments are among the most prevalent and symptomatic health problems of middle and old age [Buckwalter et al. 1993]. Nonetheless, age groups with the highest rates of compensable back pain and strains are the 20–24 age group for men, and 30–34 age group for women. In addition to decreases in musculoskeletal function due to the development of age-related degenerative disorders, loss of tissue strength with age may increase the probability or severity of soft tissue damage from a given insult.

Another problem is that advancing age and increasing number of years on the job are usually highly correlated. Age is a true confounder with years of employment, so that these factors must be adjusted for when determining relationship to work. Many of the epidemiologic studies that looked at populations with a wide age variance have controlled for age by statistical methods. Several studies found age to be an important factor associated with MSDs [Guo et al. 1995; Biering-Sorensen 1983; English et al. 1995; Ohlsson et al. 1994; Riihimäki et al. 1989a; Toomingas et al. 1991] others have not [Herberts et al. 1981; Punnett et al. 1985]. Although older workers have been found to have less strength than younger workers, Mathiowetz et al. [1985] demonstrated that hand strength did not decline with aging; average hand pinch and grip scores remained relatively stable in their population with a range of 29 to 59 years. Torell et al. [1988] found no correlation between age and the prevalence of MSDs in a population of shipyard workers. They found a strong relationship between workload (categorized as low, medium, or heavy) and symptoms or diagnosis of MSDs.

Other studies have also reported a lack of increased risk associated with aging. For example, Wilson and Wilson [1957] reported that the age and gender distribution of 88 patients with tenosynovitis from an ironworks closely corresponded to that of the general population of that plant. Similarly, Wisseman and Badger [1976] reported that the median age of workers with chronic hand and wrist injuries in their study was 23 years, while the median age of the unaffected workers was 24 years. Riihimäki et al. [1989a] found a significant relationship between sciatica and age in machine operators, carpenters, and sedentary workers. Age was also a strong risk factor for neck and shoulder symptoms in carpenters, machine operators and sedentary workers [Riihimäki et al. 1989a]. Some authors may have incorrectly attributed age as the sole cause of their findings in their analysis, when data presented suggested a relationship with work [Schottland et al. 1991].

An explanation for the lack of an observed relationship between an increased risk for MSDs and aging may be “survivor bias” (this is different from the “healthy worker effect”). If workers who have health problems leave their jobs, or change jobs to one with less exposure, the remaining population includes only those workers whose health has not been adversely affected by their jobs. As an example, in a study of female plastics assembly workers, Ohlsson et al. [1989] reported that the degree of increase in the odds of neck and shoulder pain with the duration of employment depended on the age of the worker. For the younger subjects, the odds increased significantly as the duration of employment increased (p=0.01), but for the older ones no statistical change was found with length of employment. The older women who had been employed for shorter periods of time had more reported symptoms than the younger ones, while older workers with longer employment times reported fewer symptoms than younger workers. Ohlsson et al. [1989] interviewed 76 former assembly workers and found that 26% reported pain as the cause of leaving work. This finding supports the likely role of a survivor bias in this study, the effect of which is to underestimate the true risk of developing MSDS, in this case in the older workers.

GENDER

Some studies have found a higher prevalence of some MSDs in women [Bernard et al. 1994; Hales et al. 1994; Johansson 1994; Chiang et al. 1993]. A male to female ratio of 1:3 was described for carpal tunnel syndrome (CTS) in a population study in which occupation was not evaluated [Stevens et al. 1988]. However, in the Silverstein [1985] study of CTS among industrial workers, no gender difference could be seen after controlling for work exposure. Franklin et al. [1991] found no gender difference in workers compensation claims for CTS. Burt et al. [1990] found no gender difference in reporting of neck or upper extremity MSD symptoms among newspaper employees using video display terminals (VDTs). Nathan et al. [1988, 1992a] found no gender differences for CTS. In contrast, Hagberg and Wegman [1987] reported that neck and shoulder muscular pain is more common among females than males, both in the general population and among industrial workers. Whether the gender difference seen with some MSDs in some studies is due to physiological differences or differences in exposure is unclear. One laboratory study, Lindman et al. [1991], found that women have more type I muscle fibers in the trapezius muscle than men, and have hypothesized that myofascial pain originates in these Type I muscle fibers. Ulin et al. [1993] noted that significant gender differences in work posture were related to stature and concluded that the lack of workplace accommodation to the range of workers' height and reach may, in part, account for the apparent gender differences. The reporting bias may exist because women may be more likely to report pain and seek medical treatment than men [Armstrong et al. 1993; Hales et al. 1994]. The fact that more women are employed in hand-intensive jobs and industries may account for the greater number of reported work-related MSDs among women. Byström et al. [1995] reported that men were more likely to have deQuervain’s disease than women; they attributed this to more frequent use of hand tools. Some studies have reported that workplace risk factors account for increased prevalence of MSDs among women more than personal factors (e.g., Armstrong et al. [1987a], McCormack et al. [1990]). In a recent evaluation of Ontario workers compensation claims for “RSI,” Asbury [1995] reported a RR for female to male claims ranging from 1.3 to 1.6 across industries. Within 5 different broad occupational categories, females were approximately 2–5 times as likely to have a lost-time RSI claim. No information on gender differences in hand intensive jobs was reported. May researchers have noted that men and women tend to be employed in different jobs.

In order to separate the effect of work risk factors from potential effects that might be attributable to biological differences, researchers must study jobs that men and women perform relatively equally.

SMOKING

Several papers have presented evidence that a positive smoking history is associated with low back pain, sciatica, or intervertebral herniated disc [Finkelstein 1995; Owen and Damron 1984; Frymoyer et al. 1983; Svensson and Anderson 1983; Kelsey et al. 1984]; whereas in others, the relationship was negative [Kelsey et al. 1990; Riihimäki et al. 1989b; Frymoyer 1993; Hildebrandt 1987]. Boshuizen et al. [1993] found a relationship between smoking and back pain only in those occupations that required physical exertion. In their study, smoking was more clearly related to pain in the extremities than to pain in the neck or the back. Deyo and Bass [1989] observed that the prevalence of back pain increased with the number of pack-years of cigarette smoking and with the heaviest smoking level. Heliövaara et al. [1991] only observed a relationship in men and women older than 50 years. Two studies did not find a relationship between sciatica and smoking among concrete reinforcement workers and house painters [Heliövaara et al. 1991; Riihimäki et al. 1989b].

In the Viikari-Juntura et al. [1994] prospective study of machine operators, carpenters, and office workers, current smoking (OR 1.9 1.0–3.5), was among the predictors for change from "no neck trouble" to "severe neck trouble." In a study of Finnish adults ages 30–64, [Mäkelä et al. 1991], neck pain was found to be significantly associated with current smoking (OR 1.3, 95% CI 1–1.61) when the logistic model was adjusted for age and gender. However, when the model included mental and physical stress at work, obesity, and parity, then smoking (OR 1.25, 95% CI 0.99–1.57) was no longer statistically significant [Mäkelä et al. 1991]. With univariate analysis, Holmström [1992] found a PRR of 1.2 (95% CI 1.1–1.3) for neck-shoulder trouble in "current" smokers versus "never" smokers. But using multiple logistic regression, when age, individual and employment factors were in the model, only "never smoked" contributed significantly to neck-shoulder trouble. Toomingas et al. [1991] found no associations between multiple health outcomes (including tension neck, rotator cuff tendinitis, CTS or problems in the neck/scapula or shoulder/upper arm) and nicotine habits among platers, assemblers and white collar workers. In a case/referent study, Wieslander et al. [1989] found that smoking or using snuff was not related to CTS among men operated on for CTS .

Several explanations for the relationship have been postulated. One hypothesis is that back pain is caused by coughing from smoking. Coughing increases the abdominal pressure and intradiscal pressure and puts strain on the spine. A few studies have observed this relationship [Deyo and Bass 1989; Frymoyer et al. 1980; Troup et al. 1987]. The other mechanisms proposed include nicotine-induced diminished blood flow to vulnerable tissues [Frymoyer et al. 1983], and smoking-induced diminished mineral content of bone causing microfractures [Svensson and Andersson 1983]. Similar associations with diminished blood flow to vulnerable tissues have been found between smoking and Raynaud's disease.

PHYSICAL ACTIVITY

The relationship of physical activity and MSDs is more complicated than just "cause and effect." Physical activity may cause injury. However, the lack of physical activity may increase susceptibility to injury, and after injury, the threshold for further injury is reduced. In construction workers, more frequent leisure time was related to healthy lower backs [Holmström et al. 1993] and severe low back pain was related to less leisure time activity [Holmström et al. 1992]. On the other hand, some standard treatment regimes have found that musculoskeletal symptoms are often relieved by physical activity. Having good physical condition may not protect workers from risk of MSDs. NIOSH [1991] stated that persons with high aerobic capacity may be fit for jobs that require high oxygen uptake, but will not necessarily be fit for jobs that require high static and dynamic strengths and vice versa.

When physical fitness is examined as a risk factor for MSDs, results are mixed. For example, some early case series reported an increased risk of MSDs associated with playing professional sports [Bennet 1946; Nirschl 1993], or with physical fitness and exercise [Kelsey 1975b; Dehlin et al. 1978, 1981] while other studies indicate a protective effect and reduced risk [Cady et al. 1979; Mayer et al. 1985; Åstrand et al. 1987; Biering-Sorensen 1984]. Boyce et al. [1991] reported that only 7% of absenteeism could be explained by age, sex, and physical fitness among 514 police officers 35 years or older. Cady et al. [1979, 1985], on the other hand, found that physical capacity was related to musculoskeletal fitness. Cady defined fitness for most physical activities as combinations of strength, endurance, flexibility, musculoskeletal timing and coordination. Cady et al. [1979] evaluated male fire fighters and concluded that physical fitness and conditioning had significant preventive effects on back injuries (least fit 7.1% injured, moderately fit 3.2% injured and most fit 0.8% injured). However, the most fit group had the most severe back injuries. Low cardiovascular fitness level was a risk factor for disabling back pain in a prospective longitudinal study among aerospace manufacturing workers by Battie et al. [1989]. Good endurance of back muscles was found to be associated with low occurrence of low back pain [Biering-Sorensen 1984].

Few occupational epidemiologic studies have looked at non-work-related physical activity in the upper extremities. Most NIOSH studies [Hales and Fine 1989; Kiken et al. 1990; Burt et al. 1990; Baron et al. 1991; Hales et al. 1994; Bernard et al. 1994] have excluded MSDs due to sports injury or other nonwork-related activity or injury and have not included these factors in analyses. However, many of the risk factors that are important in occupational studies occur in sports activities—forceful, repetitive movements with awkward postures. A combination of high exposure to load lifting and high exposure to sports activities that engage the arm was a risk factor for shoulder tendinitis, as well as osteoarthritis of the acromioclavicular joint [Stenlund et al. 1993]. Kennedy et al. [1978] found that 15% of competitive swimmers with repetitive overhead arm movements had significant shoulder disability primarily due to impingement from executing butterfly and freestyle strokes. Epicondylitis in professional athletes has been well documented, and many of the biomechanical and physiological studies of epicondylitis have been conducted

in professional tennis players and baseball pitchers [King et al. 1969; Nirschl 1993]. One prospective study of healthy baseball players has found slowing of the suprascapular nerve function as the season progresses [Ringel et al. 1990]. Scott and Gijsbers [1981] found an association between athletic performance and pain tolerance, and suggested that physically fit persons may have a higher threshold for injury.

In summary, although physical fitness and activity is generally accepted as a way of reducing work-related MSDs, the present epidemiologic literature does not give such a clear indication. The sports medicine literature, however, does give a better indication that sports involving activities of a forceful, repetitive nature (such as tennis and baseball pitching) are related to MSDs. It is important to note that professional sports activities usually provide players (i.e., workers) with more substantial breaks for recovery and shorter durations for intense tasks as compared with more traditional work settings in which workers are required to perform repetitive, forceful work for 8 hours per day, 5 days per week.

STRENGTH

Some epidemiologic support exists for the relationship between back injury and a mismatch of physical strength and job tasks. Chaffin and Park [1973] found a sharp increase in back injury rates in subjects performing jobs requiring strength that was greater or equal to their isometric strength-test values. The risk was three times greater in the weaker subjects. In a second longitudinal study, Chaffin et al. [1977] evaluated the risk of back injuries and strength and found the risk to be three times greater in the weaker subjects. Keyserling et al. [1980] strength-tested subjects, biomechanically analyzed jobs, and assigned subjects to either stressed or non-stressed jobs. Following medical records for a year, they found that job matching based on strength criteria appeared to be beneficial. In another prospective study, Troup et al. [1981] found that reduced strength of back flexor muscles was a consistent predictor of recurrent or persistent back pain, but this association was not found for first time occurrence of back pain.

Other studies have not found the same relationship with physical strength. Two prospective studies of low back pain reports (or claims) of large populations of blue collar workers [Battie et al. 1989; Leino 1987] failed to demonstrate that stronger (defined by isometric lifting strength) workers are at lower risk for low back pain claims or episodes. One study followed workers for ten years after strength testing and the other followed workers for a few years. Neither of these studies included precise measurement of exposure level for each worker, so the authors could not estimate the degree of mismatch between workers' strength and tasks demands. Battie et al. [1990] compared workers with back pain with other workers on the same job (by isometric strength testing) and did not find that workers with back pain were weaker. In two studies of nurses [Videman et al. 1989; Mostardi et al. 1992] lifting strength was not a reliable predictor of back pain.

When examined together, these studies reveal the following: The studies that found a significant relationship between strength/job task and back pain used more thorough job assessment or analysis and have focused on manual lifting jobs. However, these studies only followed workers for a period of one year, and whether this same relationship would hold over a much longer working period remains unclear. Studies that did not find a relationship, although they followed workers for a longer period of time, did not include precise measurements of exposure level for each worker, so they could not assess the strength capabilities that were important in the individual jobs. Therefore, they could not estimate the degree of mismatch between workers' strength and task demands.

ANTHROPOMETRY

Weight, height, body mass index (BMI) (a ratio of weight to height squared), and obesity have all been identified in studies as potential risk factors for certain MSDs, especially CTS and lumbar disc herniation.

Few studies examining anthropometric risk factors in relationship to CTS have been occupational epidemiologic studies; most have used hospital-based populations who may differ substantially from working populations. Nathan et al. [1989, 1992, 1994] have published several papers on the basis of a single industrial population and have reported an association between CTS and obesity; however, the methods employed in their studies have been questioned in a number of subsequent publications [Gerr and Letz 1992; Stock 1991; Werner et al. 1994b]. Several investigators have reported that their industrial study subjects with CTS were shorter and heavier than the general population [Cannon et al. 1981; Dieck and Kelsey 1985; Falk and Aarnio 1983; Nathan et al. 1992; Werner et al. 1994b; Wieslander et al. 1989]. In the Werner et al. [1994b] study of a clinical population requiring electrodiagnostic evaluation of the right upper extremity, patients classified as obese (BMI>29) were 2.5 times more likely than slender patients (BMI<20) to be diagnosed with CTS. Werner et al. [1994b] developed a multiple linear regression CTS model (with the difference between median and ulnar sensory latencies as the dependent variable) that demonstrated that BMI was the most influential variable, but still only accounted for 5% of the variance in the model. In Nathan's [1994a] logistic model, body mass index accounted for 8.6% of the total risk; however, this analysis used both hands from each study subject as separate observations, although they are not independent of each other. Falck and Aarnio [1983] found no difference in BMI among 17 butchers with (53%) and without (47%) CTS. Vessey et al. [1990] found that the risk for CTS among obese women was double for that of slender women. The relationship of CTS and BMI has been suggested to relate to increased fatty tissue within the carpal canal or to increased hydrostatic pressure throughout the carpal canal in obese persons compared with slender persons [Werner 1994b].

Carpal tunnel canal size and wrist size has been suggested as a risk factor for CTS, however, some studies have linked both small and large canal areas to CTS [Bleecker et al. 1985; Winn and Habes 1990].

For back MSDs, Hrubec and Nashold [1975] found that height and weight were predictive of herniated disc disease among World War II U.S. army recruits compared with age-matched controls. Some studies have reported that people with back pain, are, on the average, taller than those without it [Rowe 1965; Tauber 1970; Merriam et al. 1980; Biering-Sorensen 1983]. Heliövaara et al. [1987], in a Finnish population study, found that height was a significant predictor of herniated lumber disc in both sexes, but a moderately increased BMI was predictive only in men. Severe obesity (exceeding 30 kg/m^2) involved less risk than moderate obesity. Kelsey [1975a] and Kelsey et al. [1984] failed to reveal any such relationships between height or BMI among patients with herniated lumber discs and control subjects. Magora and Schwartz [1978] found an association between obesity and radiological disc degeneration, but Kellgren and Lawrence [1958] did not. A study of Finnish white collar and blue collar workers found no association between overweight (relative weight (>120%) and lumbosacral disorders either cross-sectionally or in a 10-year follow-up [Aro and Leino 1985].

Schierhout et al. [1995] found that short stature was significantly associated with pain in the neck and shoulder among workers in 11 factories, but not in the back, forearm, hand and wrist. Height was not a factor for neck, shoulder or hand and wrist MSDs among newspaper employees [Bernard et al. 1994]. Kvarnström [1983a] found no relationship between neck/shoulder MSDs and body height in a Swedish engineering company with over 11,000 workers.

Anthropometric data are conflicting, but in general indicate that there is no strong correlation between stature, body weight, body build and low back pain. Obesity seems to play a small but significant role in the occurrence of CTS.

APPENDIX C
Summary Tables

Appendix C contains summary tables of articles reviewed in this document. These tables provide a concise overview of the studies reviewed relative to the evaluation criteria, risk factors addressed, and other issues.

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Andersen 1993a	Andersen 1993b	Baron 1991	Bergqvist 1995a	Bergqvist 1995b	Bernard 1994	Ferguson 1976	Hales 1989
Study type	CS	CS	CS	CS	CS	CS	CS	CS
Participation rate $70%	Y	Y	N	Y	Y	Y	Y	Y
Outcome	S	S and PE	S and PE	S and PE	S and PE	S	S	S and PE
Exposure	Job title categorization	Categorization by job duration	Observation, video analysis, measurement of items, (assessment was for hand/wrist, not neck)	Questionnaire, observation	Questionnaire, observation	Observation, questionnaire	Measurements, observation, questionnaire	Observation, video taping, job categorization, (assessment was for hand/wrist, not neck)
Covariates considered	Age, having children, not exercising, smoking, SES, marital status	Age, having children, not exercising, smoking, SES	Age, gender, duration of work environment	Age, gender	Adjustments made for confounders	Age, gender, height, psychosocial factors	Height, weight	Age, duration of employment
Investigators blinded	Y	Y	Y	Y	Y	Y	NR	Y
Repetition	Combined	Combined	Combined	Repeated work movements: 3.6 (0.4-29.6)	Combined	Time spent typing: NS	Õ	Combined
Force	Combined	Combined	Combined	Õ	Õ	Õ	Õ	Combined
Extreme posture	Combined	Õ	Combined	Too highly placed keyboard: 4.4 (1.1-17.0)	Õ	Time spent on telephone: 1.4 (1.0-1.8)	NR, sig.	Õ
Vibration	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ

See footnotes at end of table.

(Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Andersen 1993a	Andersen 1993b	Baron 1991	Bergqvist 1995a	Bergqvist 1995b	Bernard 1994	Ferguson 1976	Hales 1989
Risk factors (combined)	Sewing operators vs. referents: 4.9 (2.0-12.8)	Current high exposure: 1.6 (0.7-3.6) 8 to 15 years: 6.8 (1.6-28.5)	Checkers vs. noncheckers: 2.0 (0.6-6.7)	Õ	VDT work >20 hr and eye glasses at VDT: 6.9 (1.1-42)	Õ		High exposure vs. Low exposure jobs (estimated crude OR): 3.7 (0.4-164) Outcome, neck symptoms: RR=1.64 (0.4-3.9)
Duration of employment	0 to 7 years: 1.9 (1.3-2.9) 8 to 15 years: 3.8 (2.3-6.4) >15 years: 5.0 (2.9-8.7)	0 to 7 years: 2.3 (0.5-11) 8 to 15 years: 6.8 (1.6-28.5) >15 years: 16.7 (4.1-67.5)	NS	Õ	Õ	NS	Õ	Adjusted for in analysis
Physical workload	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ
Psychosocial factors	Õ	Õ	Job satisfaction: NS	Limited break opportunity: 7.4 (3.1-17.4)		Deadline hr: 1.7 work variance: 1.7 management issues: 1.9	Õ	Õ
Individual/other factors considered	Age at least 40 years: 1.5 (1.1-2.2); having children: 1.3 (0.8-2.0); SES: 1.29 (0.7-2.3); smoking: 1.39 (0.99-1.9)	Age $ 40 years: 1.9 (0.9-4.1); having children: 0.5 (0.1-1.7); exercise: 1.4 (0.6-2.9); smoking: 1.5 (0.7-3.3)	Age, gender, hobbies controlled for in analysis	Females with children: 6.4; smoking, stress reaction, stomach-related stress, use of spectacles, peer contacts, rest breaks, work task flexibility, overtime, static work position, nonuse of lower arm support, hand in non-neutral posture, high visual angle to VDT, glare on VDT	Smoking, stress reaction, stomach-related stress, use of spectacles, peer contacts, rest breaks, work task flexibility, overtime, static work position, nonuse of lower arm support, hand in non-neutral posture, high visual angle to VDT, glare on VDT	Age, gender, height, psychosocial factors; VDT use outside of work	Õ	Age
Dose/response	Years worked: Sig.	Õ	Õ	Õ	Õ	Õ	Õ	Õ

See footnotes at end of table. (Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Hales 1994	Hunting 1994	Kamwendo 1991	Kiken 1990	Knave 1985	Kukkonen 1983	Kuorinka 1979	Linton 1990
Study type	CS	CS	CS	CS	CS	Prospective, intervention	CS	CS
Participation rate $70%	Y	Y	Y	Y	Y	NR	Y	Y
Outcome	S and PE	S	S	S and PE	S	S and PE	S and PE	S
Exposure	Observation, questionnaire	Questionnaire	Questionnaire	Observation, (assessment was for hand/wrist, not neck)	Observation, gaze direction instrument, job title or self-report	Observation, interview	Observation, job analysis, video taping (assessment was for hand/wrist, not neck)	Questionnaire
Covariates considered	demographics, work practices, age, gender, hobbies	Years worked, age, current work as electrician, gender	Age, length of employment, psychosocial work environment	Age, gender	Age, gender, smoking, educational status, drinking	Gender, prospective design	Age, duration of employment, BMI, metabolic disease, hobbies, "extra work"	Age, gender, exercise, eating regularly, smoking, alcohol consumption, psychosocial variables
Investigators blinded	Y	NR	NR	Y	NR	Y	NR	NR
Repetition	Õ	Õ	Combined	Combined	Combined	Combined	Scissor makers vs. Referents: 4.1 (2.3-7.5) Short cycle tasks vs. long cycle tasks: 1.64 (0.7-3.8)	Õ
Force	Õ	Õ	Õ	Combined	Õ	Õ	Combined	Õ
Extreme posture	Use of bifocals: 3.8 (1.5-9.4)	Õ	Combined	Combined	Combined	Combined	Combined	Uncomfortable posture and poor psychosocial environment: 3.5 (2.7-4.5)
Vibration	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Univariate analysis showed elevated OR for vibration

See footnotes at end of table. (Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Hales 1994	Hunting 1994	Kamwendo 1991	Kiken 1990	Knave 1985	Kukkonen 1983	Kuorinka 1979	Linton 1990
Risk factors (combined)	Õ	Õ	Work with office machines >5 hr/day: 1.65 (1.02-2.67)	High exposure vs. low exposure jobs: 1.3 (0.2-11)	Typing hr: Sig.	Intervention group: PRR=3.6 (2.2-5.9) No intervention 1.0	Scissor-makers vs. department store shop assistants: OR=4.1 (2.3-7.5)	Õ
Duration of employment	NS	1 to 3 years: 1 4 to 5 years: 1.3 6 to 10 years: 1.6 >10 years: 1.3	Length of employment: Sig.	Õ	Õ	Õ	Controlled for	Õ
Physical workload	Õ	Õ	Being given too much to do: Sig.	Õ	Õ	Õ	Õ	Õ
Psychosocial factors	Decision making: 4.2; productivity standard: 3.5; fear of replacement by computer: 3.0; higher information processing demands: 3.0; job task variety: 2.9; work pressure: 2.4		Ability to influence work, cooperative spirit between co-workers: sig.	Õ	Interest in work, positive attitude	Õ		Monotonous work SS, work content, work load, social support
Individual/other factors considered	Electronic performance monitoring, keystrokes, hobbies, recreational activities: NS	Age group, current work as electrician: NS	Sitting 5 or more hr/day: 1.6 (0.9-2.8); age: Sig.	Õ	Õ	Õ	Extra work, hobbies, outside activities: NS	Exercise, eating, smoking, alcohol consumption
Dose/response	Õ	Õ	Õ	Õ	Between registered work duration and musculoskeletal complaints	Õ	Õ	Õ

See footnotes at end of table.

(Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Liss 1995	Luopajärvi 1979	Milerad 1990	Ohlsson 1989	Ohlsson 1995	Onishi 1976	Ryan 1988	Sakakibara 1987
Study type	CS	CS	CS	CS	CS	CS	CS	CS
Participation rate $70%	N	Y	Y	NR	Y	NR	Y	Y
Outcome	S	S and PE	S	S	S and PE	S and PE	S and PE	S
Exposure	Questionnaire	Observation, video analysis, interviews	Questionnaire	Questionnaire	Videotaping, observation, analysis of posture, flexion of neck, questionnaire	Observation, then job categorization	Observation measurements at work stations	Observation job analysis and neck angle measurements
Covariates considered	N	Age, gender, social background, hobbies, amount of housework	Gender, age, leisure-time exposure, systemic disease	Age, gender, duration of employment	Age , gender, psychosocial scales	Õ	Age, height, length of training time	Õ
Investigators blinded	N	Y	NR	NR	Blinded to exposure information but "Not possible to completely blind the examiners."	NR	Y	NR
Repetition	Combined	Combined	Combined	Combined	Combined	Combined	Õ	Combined
Force	Combined	Combined	Õ	Õ	Industrial workers exposed to repetitive tasks vs. referents: 3.6 (1.5-8.80)	Combined	Õ	Õ
Extreme posture	Combined	Combined	Combined	Combined	Õ	Combined	Significant difference in mean elbow angle and shoulder flexion of left arm	Combined
Vibration	Õ	Õ	NS for exposure to vibration	Õ	Õ	Õ	Õ	Õ

See footnotes at end of table.

(Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Liss 1995	Luopajärvi 1979	Milerad 1990	Ohlsson 1989	Ohlsson 1995	Onishi 1976	Ryan 1988	Sakakibara 1987
Risk Factors (Combined)	Dental hygienists vs. dental assistants: 1.7 (1.1-2.6)	Assembly workers vs. shop assistants: 1.6 (0.9-2.7)	Dentists compared to pharmacists: 2.1 (1.4-3.1)	Assemblers vs. referents pain in last 12 months: 1.9 (0.9-3.7)	Õ	Film rolling workers: 3.8 Lamp assemblers: 3.8 (2.1-6.6) Teachers and nurses: 1.5 (0.7-3.2)	Õ	Pear work vs. apple work right side: $p<0.05$ Pear work vs. Apple work at left side: $p<0.01$
Duration of employment	NS	Õ	NS	Employees <35 years: Sig.	Õ	Õ	NS	Õ
Physical workload	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ
Psychosocial factors	Õ	Õ	Õ	Increased OR for medium and fast paced work compared to slow paced but OR lower for very fast paced work		Õ	Insufficient rest, break time, more boredom, more stress, lower peer cohesion, lower antonomy, lower job clarity, higher staff support, higher work pressure	Õ
Individual/other factors considered	Gender (99% females in study group); had to modify work or unable to work at some point: 2.4 (1.1-5.4)	Õ	Leisure time exposure, smoking systemic disease		Õ	Õ	Age, height, marital and parental status, handedness, length of training time	Õ
Dose/response	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ

See footnotes at end of table. (Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Sakakibara 1995	Schibye 1995	Veiersted 1994	Viikari-Juntuna 1994	Welch 1995	Wells 1983	Yu 1996
Study type	CS	Cohort	Cohort	Cohort	CS	CS	CS
Participation rate $70%	Y	Y	N (55%)	Y	Y (83%)	Y	Y
Outcome	S and PE	S	S and PE/ pain diaries	S	S	S	S
Exposure	Observation, measurements	Questionnaire	EMG, interviews every 10 weeks	Questionnaire, observation	Questionnaire	Questionnaire, interview	Questionnaire
Covariates considered	Õ	Subjects served as their own controls	Metabolic or other diseases, gender	All male, smoking, age, physical exercise, occupation, duration of work, car driving	Smoking, years of employment	Age, gender, number of years on job, previous work experience, education, marital status, quetelet ratio	Age, gender, "other covariates"
Investigators blinded	NR	NR	NR	Y	N	NR	NR
Repetition	Õ	Combined	Õ	Õ	Combined	Õ	Frequent VDT use: 28.9 (2.8-291.8)
Force	Õ	Combined	Strenuous previous work: 6.7 (1.6-28.5)	Combined	Õ	Combined	Õ
Extreme posture	Combined	Combined	Strenuous postures: 7.2 (2.1-25.3)	No neck pain to severe, machine operators vs. office workers: 3.9 (2.3-6.9) Persistently severe: 4.2 (2.0-9.0)	Percent of time hanging duct: 7.5 (0.8-68)	Combined	Inclining neck at work: 784.4 (33.2-18,630)
Vibration	Õ	Õ	Vibration (floor or machine)	Combined (machine operators)	Õ	Õ	Õ

See footnotes at end of table. (Continued)

Appendix C Table C-1. Summary table for epidemiologic studies evaluating work-related neck musculoskeletal disorders

Components of study	Sakakibara 1995	Schibye 1995	Veiersted 1994	Viikari-Juntuna 1994	Welch 1995	Wells 1983	Yu 1996
Risk factors (combined)	Pear vs. Apple bagging: 1.5 (0.99-2.35)	Other employment group vs. garment workers: 3.3 (1.4-7.7)	Physical environment: 0.9 (0.5-1.7)	Occupation Sig. from no neck trouble to moderate neck trouble; occupation Sig. from no neck to severe neck trouble Carpenters vs. Office workers persistently severe: 3.0 (1.4-6.4)	õ	All letter carriers vs. Clerks and readers: 2.57 (1.13-6.2)	Frequent video display terminal use: 28.9 (2.8-291.8)
Duration of employment	õ	NS	õ	õ	õ	Controlled for in analysis	õ
Physical workload			õ	õ	õ	õ	õ
Psychosocial factors`	õ	õ	Psychosocial factors: 3.3 (0.8-14.2)	Job satisfaction: NS	õ	õ	õ
Individual/other factors considered	õ	Age	Anthropometrics, general health, previous employment variables, draft, noise, personality	Current smoking and age Sig. in model of "no neck trouble to severe neck trouble"	õ	Education, marital status, quetelet ratio	General health
Dose/response	õ	õ	õ	õ	õ	õ	õ

õ Not studied.
BMI Body mass index.
CS Cross-sectional.
EMG Electromyography.
hrs Hours.
MSD Musculoskeletal disorders
MVC Maximum voluntary contraction.
N No.
NR Not reported.
NS Not statistically significant.
OR Odds ratio.
PE Physical examination.
PRR Prevalence rate ratio.
S Symptoms.
SES Socioeconomic status.
Sig. Statistically significant.
VDT Video display terminal.
vs. Versus.
Y Considered (yes).

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Åaras 1994	Andersen 1993a	Andersen 1993b	Bergqvist 1995a	Bergqvist 1995b	Bjelle 1981	Blåder 1991	Ekberg 1994
Study type	Prospective	CS	CS	CS	CS	Case Control	CS	Case Control
Participation rate $70%	NR	Y	Y	Y	Y	NR	Y	Y
Outcome	S and Records	S	S and PE	S	S and PE	S and PE	S and PE	S
Exposure	Observation and EMG	Job title categorization	Categorization by job duration	Observation, measurements	Job title and questionnaire	Observation, videotape analysis	Questionnaire	Questionnaire
Covariates considered	ð	Age, having children, education, marital status, smoking, not exercising	Age, having children, education, marital status, smoking, not exercising	Age, gender, smoking, rest breaks, stress	Age, gender, smoking	Age, anthropometric data	Age, nationality, employment time, working hr/week	Age, gender, smoking, having preschool children
Investigators blinded	NR	Y	Y	Y	Y	Y; Videotape analysis blinded to case status	N	NR
Repetition	ð	Combined	Combined	For intensive neck/shoulder discomfort: 3.6 (0.4-29.6)	<20 hr/week VDT use: 1.2 (0.4-3.7) >20 hr/week VDT use: 0.7 (0.3-1.5)	No sig difference in cycle time	Combined	Precise repetitive movements High: 15.6 (2.2-113.0)
Force	Static trapezius load dropped from 4.1 to 1.4% NR, Sig.	Combined	Combined	ð	ð	Cases had significantly higher shoulder loads than controls	ð	ð
Extreme posture	Intervention consisted of equipment and tool adjustment to create relaxed position of shoulders and neck: NR, Sig.	ð	ð	For tension neck syndrome: too highly placed VDT: 4.4 (1.1-17.6)	ð	Cases with longer duration and higher frequency of abduction or forward flexion than referents: NR, Sig.	Combined	Work with lifted arms 4.8 (1.3-18); uncomfortable sitting posture: 3.6 (1.4-9.3)
Vibration	ð	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Åaras 1994	Andersen 1993a	Andersen 1993b	Bergqvist 1995a	Bergqvist 1995b	Bjelle 1981	Blåder 1991	Ekberg 1994
Risk factors (combined)	ō	Sewing machine operators vs. referents: 4.6 (2.2-10.2)	Current high exposure (yes vs. no): 1.6 (0.7-3.6)	ō	VDT work >20 hr and stressful stomach reactions: 3.9 (1.1-13.8) VDT work $ 20 hr and bifocals or progressive glasses: 6.9 (1.1-42.1)	ō	Working >30 hr per week: *p*<0.05	ō
Duration of employment	ō	Years as sewing machine operators 0 to 7 years: 3.2 (0.6-16.1) 8 to 15 years: 11.2 (2.4-52) >15 years: 36.7 (7.1-189)	Years as sewing machine operators 0 to 7 years: 2.3 (0.5-11) 8 to 15 years: 6.8 (1.6-28.5) >15 years: 16.7 (4.1-67.5)	ō	ō	ō	Working >30 hr/week and tension neck syndrome: *p*<0.05	ō
Physical workload	ō	ō	ō	ō	ō	ō	ō	ō
Psychosocial factors	ō	ō	ō	For cervical diagnoses: Stressful stomach reactions: 5.4 (1.6-17.6)	Combined	ō	Smaller randomized study group interviewed by sociologist and psychologist for psychosocial history	High work pace: 3.5 (1.3-9.4); Low work content: 2.6 (0.7-9.4); Work role ambiguity: 16.5 (6.0-46); Demands on attention: 3.8 (1.4-11)
Individual/ other factors considered	Median sick days decreased from 22.9 to 1.8	Age >40 yrs: 1.96 (0.8-5); exercise: 1.28 (0.5-3.4); smoking: 2.3 (0.9-6.1); children: 0.35 (0.1-1.9)	Age $ 40 years: 1.9 (0.9-4.1); children: 0.5 (0.1-1.7); exercise: 1.4 (0.6-2.96); smoking: 1.5 (0.7-3.3)	Children at home, negative, affectivity, peer contacts, overtime, work task flexibility, visual angle to VDT	Children at home, negative, affectivity, peer contacts, overtime, work task flexibility, visual angle to VDT	Age-isometric testing	Cervical syndrome correlated with age	Female: 11.4 (4.7-28); immigrant status: 4.9 (1.8-14); current smoker: 8.2 (2.3-29)
Dose/respon se	ō	Duration of employment as sewing machine operator	Duration of employment	ō	ō	ō	ō	Repetitive precision movements, work pace

See footnotes at end of table.

(Continued)

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Ekberg 1995	Holmström 1992	Hünting 1981	Jonsson 1988	Kilbom 1986, 1987	Linton 1989	Maeda 1982	Milerad 1990
Study type	CS	CS	CS	Cohort	CS	CS	CS	CS
Participation rate $70%	Y	Y	NR	Y	Y	Y	NR	Y
Outcome	S	S	S and PE	S and PE	S and PE	S	S	S
Exposure	Questionnaire	Questionnaire	Observation, questionnaire	Observation, video taping, job analysis, MVC of forearm	Observation, video taping, job analysis, MVC of forearm	Questionnaire dealing with psychosocial issues	Observation, measurement	Questionnaire
Covariates considered	Age, smoking, exercise habits, family situations with preschool children, immigrant status, gender	Age, physical factors, psychosocial stress scales	Psychosocial factors	Used prospective cohort design with same study sample	Age, spare time physical activities, hobbies, psychosocial stress, muscle strength	ð		Gender, leisure time, smoking, systemic disease
Investigators blinded	NR	Y	NR	Y	Y	NR	NR	NR
Repetition	Repetitive movements demanding precision: 1.2 (1.0-1.3)	ð	Combined	Combined	Combined	ð	ð	Combined
Force	ð	ð	ð	Combined	Combined	ð	ð	ð
Extreme posture		Hand above shoulder: <1 hr/day: 1.1 (0.8-1.5) 1 to 4 hr/day: 1.5 (1.2-1.9) >4 hr/day: 2.0 (1.4-2.7)	Combined/head inclination >56E Sig. for neck/shoulder MSDs	Combined	Combined	ð	Constrained tilted head posture: $p<0.05$	Combined
Vibration	ð	ð	ð	ð	ð	ð	ð	NS

See footnotes at end of table. (Continued)

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Ekberg 1995	Holmström 1992	Hünting 1981	Jonsson 1988	Kilbom 1986, 1987	Linton 1989	Maeda 1982	Milerad 1990
Risk factors (combined)	ð	Roofers: 1.6 Plumbers: 1.5 Floor workers: 1.3	Data entry workers vs. non-keyboard-using office workers: 9.9 (3.7-26.9)	At third year, 38 workers reallocated had improved, 26% with unchanged conditions deteriorated further: NR, Sig.	Average time/work cycle in neck flexion sig, Upper arm abducted 0-30E: NR, Sig.	ð	ð	Dentists vs. pharmacists: 2.1 (1.3-3.0); males: 2.6 (1.2-5.0); females 2.0 (1.3-3.1)
Duration of employment	ð	ð	ð	ð	NS	ð	ð	NS
Physical workload	ð	ð	ð	ð	ð	ð	ð	ð
Psychosocial factors	ð	Qualitative demands: 1.4 (1,2) Quantitative demands: 3.0 (2.1-4) Solitary work: 1.5 (1.2-1.8) Anxiety: 3.2 (2.5-4)	Job satisfaction; relationship with supervisors, colleagues; decision making, use of skills all NS	Job satisfaction, productivity	Productivity, work satisfaction, perceived stress: NS	Poor work content: 2.5 (1.3-4.9) Lack of social support: 1.6 (0.9-2.8) Work demand social support at work	ð	ð
Individual/ other factors considered	Immigrant status: 1.3 (1.1-1.5) Social work climate, work planning, job security, job constraints	Psychosomatic: 5.0 (3.6-6.9) Psychological: 4.7 (3.6-6) Stress: 3.4 (2.6-4.2) Discretion, support, under stimulation, anxiety, job satisfaction, quality of life	Medical findings in neck and shoulder significant for typists with head rotation >20E compared to < 20E	ð	Age, muscle strength, rest pauses: NS	ð	Age	Leisure time, smoking NS
Dose/response	ð	Stress index and neck-shoulder MSDs	ð	ð	ð	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Ohara 1976	Ohlsson 1995	Punnett 1991	Rossignol 1987	Ryan 1988	Tola 1988	Vihma 1982	Viikari-Juntura 1991a
Study type	CS and Cohort	CS	CS	CS	CS	CS	CS	Cohort
Participation rate $70%	CS study: NR; Cohort: Y	Y	Y	N to Y (6 industries)	Y	Y overall: 67% carpenters 67% office workers	NR	Y
Outcome	S and PE	S and PE	S	S	S	S	S	S and PE
Exposure	Observation	Observation, video, analysis, muscle strength testing	Observation, questionnaire	Questionnaire	Observation, workstation measurement, questionnaire	Occupation title	Observation, interview	Questionnaire
Covariates considered	Used prospective cohort design with same study sample	Age, gender, psychosocial scales	Age, gender	Age, cigarette smoking, industry, education, VDT training	Height, weight, gender, age, marital status, parental status	Years in occupation, age, leisure time activities, car driving, general health	Age, duration of employment	Physical hobbies, creative hobbies
Investigators blinded	NR	Y to exposure information, no for physical	NR	NR	Y	NR	NR	NR
Repetition	Combined	Repetitive work: 4.6 (1.9-12)	Combined	Combined	ð	ð	Combined	ð
Force	ð	ð	Combined	ð	ð	ð	ð	ð
Extreme posture	Combined	Significant time spent in neck flexion <60°: NR	Associated with extended duration of and lifting weight in abduction/flexion and extension of the shoulder	Combined	More non-cases trained in adjustment of furniture than cases: NR, Sig.	Use of twisted or bent postures during work: Little (referent): 1.0 Moderate: 1.2 (1.0-1.5) Rather much: 1.6 (1.4-1.9) Very much: 1.8 (1.5-2.2)	Combined Sewing machine operator with significantly greater static work compared to seamstresses	Sitting in a forward posture 1-3 hr/day: 10.7 (0.4-291); >3 hr/day: 1.5 (0.7-29.5)
Vibration	ð	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table. (continued)

Appendix C Table C-2. Summary table for evaluating work-related neck/shoulder disorders

Components of study	Ohara 1976	Ohlsson 1995	Punnett 1991	Rossignol 1987	Ryan 1988	Tola 1988	Vihma 1982	Viikari-Juntura 1991a
Risk factors (combined)	Operators hired post-intervention had less reports of MSDs	Industrial workers vs. referents: 2.7 (1.2-6.3)	Male: 1.8 (1.0-3.2) Female: 0.9 (0.5-1.9)	½ to 3 hr of VDT use: 1.8 (0.5-6.8) 4 to 6 hr of VDT use: 4.0 (1.1-14.8) 7 $ hr of VDT use: 4.6 (1.7-13.2)	ō	Machine operators vs. office workers: 1.7 (1.5-2.0) Carpenters vs. office workers: 1.4 (1.1-1.6)	Sewing machine operators vs. seamstresses: 1.6 (1.1-2.3)	ō
Duration of employment	ō		ō	ō	ō	ō	ō	ō
Physical workload	ō	ō	ō	ō	ō	ō	Cases had significantly higher shoulder loads	ō
Psychosocial factors	ō	Stress/worry tendency: 1.9 (1.1-3.5)	ō	ō	Adequate rest breaks, boredom, work stress job pressure, autonomy, peer cohesion, role ambiguity, staff support	Job satisfaction, poor vs. very good: 1.2 (1.1-1.4)	ō	Social confidence, much fear vs. none: 1.4 (0.05-42.2); Sense of coherence: 0.95 (0.9-0.99)
Individual/other factors considered	ō	Muscle tension tendency: 2.3 (1.3-4.9)	ō	Smoking, industry, education	ō	Working in a draft: 1.1 (1.0-1.3)	ō	Alexithymia 1.02 (0.97-1.1)
Dose/response	ō	ō	ō	Hours of VDT use	ō	Use of twisted or bent posture	ō	ō

ō Not studied
CI Confidence interval
CS Cross-sectional
EMG Electromyography
hr Hours
Med. Medium
MSDS Musculoskeletal disorders
MVC Maximum voluntary contraction
N No
NR Not reported
NS Not statistically significant
OR Odds ratio
PE Physical examination
S Symptoms
Sig. Statistically significant
VDT Video display terminal
vs. Versus
Y Considered (yes)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Andersen 1993a	Andersen 1993b	Baron 1991	Bergenudd 1988	Bernard 1994	Bjelle 1979	Bjelle 1981	Burdorf 1991
Study type	CS	CS	CS	CS	CS	Case control	Case control	CS
Participation rate $70%	Y	Y	N	N	Y	NR	NR	Y for riveters; N for referents
Outcome	S	S and PE	S and PE	S and PE	S	S and PE	PE	S
Exposure	Job title, categorization by job duration	Job title, categorization by job duration	Observation and videotape analysis, weight of scanned items, job category	Questionnaire, job classification (light, moderate, heavy physical demands)	Questionnaire and observation	Observation, measurement, EMG on 15 cases, open muscle biopsies on 11 cases	Measurement, videotape analysis, observation, EMG on 3 subjects and 2 healthy volunteers	Observation, measurement of vibration
Covariates considered	Age, having children, not exercising, duration of employment, socioeconomic status, smoking status, current neck/shoulder exposure	None for the shoulder analysis	Age, gender, hobbies, duration of work, second job, metabolic disease, duration of employment	Gender	Age, race, gender, height, medical conditions, psychosocial factors, typing hr away from work	Age, gender, and workshop	Age, gender, and place of work	Height, weight, smoking status
Investigators blinded	Y	Y	Y	NR	N	N	Y	NR
Repetition for shoulder	Combined	Combined	Combined	õ	R no surrogate for hand used: number of hr typing	Combined	Combined	õ
Force	Combined	Combined	Combined	õ	õ	Combined	Cases had Sig. higher shoulder loads than controls	õ
Extreme posture	Combined	Combined	Combined	õ	õ	Combined	Combined	õ

See footnotes at end of table. (Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Andersen 1993a	Andersen 1993b	Baron 1991	Bergenudd 1988	Bernard 1994	Bjelle 1979	Bjelle 1981	Burdorf 1991
Vibration	õ	õ	õ	õ	õ	õ	õ	1.5 (no confidence limits)
Risk factors (combined)	Increasing years of experience: 1.38-10.25 (Sig.)	Chi sq test for trend using exposure time in years for rotator cuff syndrome: 9.51; *p*<0.01	Checkers vs. others 3.9 (1.4-11.0) Checkers using scanners vs. others 8.6 (1.0-72.2)	õ	õ	Work at or above shoulders, cases (65%) vs. referents (15%): 10.6 (2.3-54.9)	Cases had Sig. longer duration and higher frequency of abduction or forward flexion than controls, *p*<0.001	õ
Duration of employment	See under "Physical workload"	See under "Risk factors combined"	Number of hr per week as a checker Sig.	õ	Years at newspaper: 1.4 (1.2-1.8)	õ	õ	Years of riveting: 0.05# *p*<0.10
Physical workload	0 to 7 years: 1.56 (0.76-3.75) 8 to 15 years: 4.28 (2.14-10.0) >15 years: 7.27 (3.82-16.3)	õ	õ	Prevalence of occupational workload in subjects with shoulder pain: Heavy, 11%; Moderate, 49%; Light, 40%	õ	õ	õ	õ
Psychosocial factors	õ	õ	õ	Females showed Sig. association with shoulder pain and dissatisfaction	Lack of decision making participation: 1.6 (1.2-2.1) job pressure: 1.5 (1.0-2.2)	õ	õ	õ
Individual/other factors considered	Age-matched controls	Age-matched controls	Age, gender, metabolic disease	Gender	Gender, race, height	Age, gender	Age, gender; median number of sick-leave days Sig. different between cases and controls, *p*=0.01	Age
Dose/response	Y with years of employment	Y with years of exposure	õ	õ		õ	õ	õ

See footnotes at end of table. (Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Burt 1990	Chiang 1993	English 1995	Flodmark 1992	Hales 1989	Hales 1994	Herberts 1981	Herberts 1984
Study type	CS	CS	Case control	CS	CS	CS	CS	CS
Participation rate $70%	Y	Y	Y	Y	Y	Y	NR	NR
Outcome	S	S and PE	S and PE	S	S and PE	S and PE	S and PE	S and PE
Exposure	Observation, questionnaire, job sampling	Observation and recording of representative jobs, hand F estimation	Self-reports	õ	Observation walk-through, job categorization High vs. low exposure (hand/wrist exposure)	Observation and questionnaire	Analyses by job title	Analyses by job title
Covariates considered	Age, gender, psychosocial factors, metabolic disease duration of employment	Age, gender, metabolic diseases	Age, height, gender, weight, injury, study center, hobbies, sporting activities, average hr of driving, compensation claim made	Age, headache, tiredness, medical problems, sleeping problems or lack of concentration, sleep	Age and duration of employment	Age, race, gender, work practices, work organization factors, individual factors, electronic performance monitoring, recreational activities, hobbies	Age, job duration	Controls matched for age and gender
Investigators blinded	õ	Y	Y	õ	Y	Y	NR	NR
Repetition for shoulder	Typing speed fast compared to slow: 4.1 (1.8-9.4)	Repetitive movement of upper limb: 1.6 (1.1-2.5)	Combined	õ	Combined	No	Combined	Combined
Force	õ	Sustained forceful movement of upper limb: 1.8 (1.2-2.5)	õ	õ	Combined	õ	Welders vs. office workers: 15-18	Welders vs. office workers: 15-18
Extreme posture	õ	õ	Combined	õ	Combined	Number of times arising from chair: 1.9 (1.2-15.5)	Combined	Combined

See footnotes at end of table.

(Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Burt 1990	Chiang 1993	English 1995	Flodmark 1992	Hales 1989	Hales 1994	Herberts 1981	Herberts 1984
Vibration	ð	ð	ð	ð	ð	ð	ð	ð
Risk factors (combined)	ð	Repetition multiplied by force: 1.4 (1.0-2.0)	Repeated shoulder rotation with elevated arm: 2.3, $p<0.05$	ð	Any symptom of shoulder: 49% vs. 43%; 1.2 (0.7-2.0) Period prevalence: 19% vs. 4%; 3.8 (0.6-22.8) Point prevalence: 7% vs. 4%;0.9 (0.1-7.3)	ð	Welders vs. office workers: shoulder symptoms: 15.2 (2.1-108) Shoulder Tendinitis: 8.3 (NS)	ST results of 23 welders called back for clinical follow-up exams: 16 had ST; 18.3 (13.7-22.1) (90% CI) ST results of 30 plate-workers called back for clinical follow-up exams: 15 plate-workers had ST: 16.2 (10.9-21.5) (90% CI)
Duration of employment	NS	ð	ð	ð	ð	ð	ð	ð
Physical workload	ð	ð	ð	ð	ð	ð	NS	ð
Psychosocial factors	Job dissatisfaction: 2.3 (1.2-4.3)	ð	ð	Type A Behavior: $p<0.001$	ð	Fear of replacement by computers: 1.5 (1.1-2.0)	ð	ð
Individual/other factors considered	Pre-existing arthritis: 2.3 (1.2-4.4)	Plant effect age: 1.0 (0.9-1.1) Gender: 1.1 (0.7-1.7)	Per 5 years of age: 1.4 (1.2-1.5)	ð	ð	Typing outside of work	ð	ð
Dose/response	ð	Dose response found for shoulder diagnosis as exposure status increased from Group 1 to Group 3	ð	ð	ð	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Component of study	Hoekstra 1994	Hughes 1997	Ignatius 1993	Jonsson 1988	Kiken 1990	Kilbom 1986, 1987	Kvarnström 1983	McCormack 1990
Study type	CS	CS	CS	Prospective	CS	CS	CS and Case control	CS
Participation rate $70%	Y	N	N	Y	Y	Y	NR	Y
Outcome	S	S and PE	S	S and PE	S and PE	S and PE	S and PE	S and PE
Exposure	Analyses based on questionnaire, self-reports	Observation and job analysis	Observation, questionnaire, weight of mail bags	Observation, measurement of exertion, videotaping	Observation (exposure based on repetitive and forceful hand motions, not shoulder)	Observation, measurement, videotaping, observation	Observation, interview, questionnaire	Observation
Covariates considered	Age, seniority, gender	Controlled for age, smoking status, sports, hobbies	Age, duration of employment, bag weight, walking time	Age, hobbies, spare time, physical action, psychosocial factors, breaks, rest pauses	Age and gender	Age, years of employment, productivity, muscle strength	ð	Age, gender, race, job category, duration of employment, general health history
Investigators blinded	Y	NR	NR	Y	Y	Y	N	N
Repetition for shoulder	ð	ð	Combined	Combined	Combined	Fewer total number of upper arm flexions/hr. (*p*<0.05)	Combined	Combined
Force	ð	ð	Combined	ð	Combined	ð	Combined	ð
Extreme posture	Non-optimally adjusted desk height work: 5.1 (1.7-15.5)	Years of forearm twist: 46.0 (3.8-550)	Combined	Relative time spent with shoulder elevated negatively related to ‘remaining healthy ‘ after both 1 and 2 years: Sig.	Combined	Greater percentage of work cycle time with upper arm abducted 0-30° (*p*<0.05)	Combined	Combined
Vibration	ð	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Component of study	Hoekstra 1994	Hughes 1997	Ignatius 1993	Jonsson 1988	Kiken 1990	Kilbom 1986, 1987	Kvarnström 1983	McCormack 1990
Risk factors (combined)	Center B compared to Center A: 4.0 (1.2-13.1)	ð	Letter delivery postal workers compared to other postal workers Recurrent: 1.8 (1.5-2.2) Severe joint pain: 2.2 (1.5-3.1)	38 subjects who were reallocated to more varied tasks improved	Plant #1 Any symptom for shoulder: 46% vs. 28%; 1.6 (0.9-2.9) Period prevalence: 13% vs. 3%; 4.0 (0.6-29) Plant #2 Any symptom for shoulder: 50% vs. 30%; 1.7 (0.8-3.3) Period prevalence: 14%vs. 5%; 2.8 (0.4-19.6)	ð	Die casting machine operators: 5.4; plastic workers: 2.2; spray painters: 3.7; surface treatment operators: 4.7; assembly line workers: 5.2	Boarding workers vs. knitting workers: 2.1 (0.6-7.3)
Duration of employment	ð	ð	ð	ð	ð	Years of employment in electronics: $p<0.05$	ð	NS
Physical workload	ð	ð	ð	Low muscle strength no a predictor for shoulder MSD	ð	ð	ð	ð
Psychosocial factors	Job dissatisfaction, exhaustion (not for shoulder)	Low decision latitude: 4.0 (0.8-19)	ð	Strong negative relationship between remaining health and satisfaction with colleagues	ð	ð	9 cases and 1 control reported poor relationship with supervisor. Sig. differences in group piece rate, shift work, heavy work, monotonous work, stressful work,	ð
Individual/other factors considered	Location	Age: 0.93 (0.8-1.0); good health: 0.35 (0.1-0.87)	Age, work experience, bag weight, walking time	Predictors of deterioration, previously physically heavy job, high productivity, and sick leave	ð	Shorter stature: $p<0.05$, productivity: NS, muscle strength: NS	Sig. differences in heavy lifting and unsuitable working conditions	ð
Dose/response	ð	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Milerad 1990	Ohara 1976	Ohlsson 1989	Ohlsson 1994	Ohlsson 1995	Onishi 1976	Punnett 1985	Rossignol 1987
Study type	CS	CS and Prospective	CS	CS	CS	CS	CS	CS
Participation rate $70%	Y	NR (CS), Y (Prospective)	NR	Y	Y	NR	Y	Y: clerical workers N: industry groups
Outcome	S	S and PE	S	S and PE	S and PE	S, PE, and measurement	S and PE	S
Exposure	Questionnaire	Observation	Job categorization	Observation, questionnaire, video analysis	Observation, video analysis, measurement	Observation	Observation and questionnaire	Observation and questionnaire
Covariates considered	Age, gender, leisure time exposure, smoking, systemic disease, duration of employment	ô	Age, gender (females only)	Sports activities, age, gender (females only) psychosocial factors	Age, employment status	Body height, weight, grip strength	Age, number of years employed, native language	Age, cigarette smoking, industry, VDT educational training
Investigators blinded	NR	NR	NR	Y	Yes, to exposure information	NR	NR	ô
Repetition for shoulder	Combined	Combined	Combined	Combined	Combined	Combined	Combined	4-6 hrs. VDT use: 4.0 (1.0-16.9) >7 hrs. VDT use: 4.8 (1.6-17.2)
Force	Combined	Combined	Combined	Combined	Combined	Combined	Combined	ô
Extreme posture	Combined	Combined	Combined	Combined	Combined	Combined	Combined	ô
Vibration	NS	ô	ô	ô	ô	ô	ô	ô

See footnotes at end of table. (Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Milerad 1990	Ohara 1976	Ohlsson 1989	Ohlsson 1994	Ohlsson 1995	Onishi 1976	Punnett 1985	Rossignol 1987
Risk factors (combined)	Dentists vs. pharmacists: males: 2.4 (1.0-5.4), females: 2.4 (1.5-3.7)	Shoulder stiffness: cashiers (81% vs. office workers (72%), 1.7 (1.0-2.8) Shoulder dullness and pain: cashiers (49%) vs. other workers (68%), 2.0 (1.4-2.8); vs. office workers (30%), 2.2 (1.4-3.5)	Assemblers vs. referents shoulder pain last 7 days: 3.4 (1.6-7.1)	Supraspinatus, infraspinatus, or bicipital tendinitis working in the fish industry: OR=3.03 (2.5-7.2) Shoulder tendinitis alone: PRR=3.5 (2.0-5.9)	Assembly work compared to referent 5.0 (2.2-11.0)	Shoulder tenderness: assemblers vs. ref.: 1.1 (0.6-1.9); film rollers vs. ref.: 6.0 (3.0-12.2); teachers vs. ref.: 1.6 (0.7-3.3) Shoulder stiffness: reservationists vs. ref: 2.5 (1.1-5.6); assemblers vs. ref.: 3.7 (2.0-7.0); film rollers vs. ref.: 2.7 (1.5-4.9); teachers vs. ref.: 2.1 (0.9-4.6)	Garment workers vs. hospital employees 2.2 (1.0-4.9)	ð
Duration of employment	NS	ð	Sig. with duration of employment (*p*=0.03) for younger workers but not older workers	For age <45 years, duration of employment showed dose-response with shoulder MSDs	<10 years: 9.6 (2.8-33.0) 10-19 years: 4.4 (1.5-13.0) >20 years: 3.8 (1.4-10.0)	ð	NS	ð
Physical workload	ð	ð	ð	ð	ð	ð	ð	ð
Psychosocial factors	ð	ð	Increasing work pace	Stress, worry factors, tendencies towards muscle tension Sig.	Control, stimulation, psychosocial climate, work strain, social support, psychosomatic symptoms	ð	ð	ð
Individual/other factors considered		ð		Sports activities: 4-9	Employment status	Body height and weight: NS		ð
Dose/response	ð	ð	Reported pain increased with increasing work pace except for very high paces	For age <45 years, duration of employment and shoulder MSDs	ð	ð	ð	As VDT use increased, shoulder symptoms increased

See footnotes at end of table.

(Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Sakakibara 1987	Sakakibara 1995	Schibye 1995	Stenlund 1992	Stenlund 1993	Sweeney 1994	Wells 1983
Study type	CS	CS	Cohort	CS	CS	CS	CS
Participation rate $70%	Y	Y	Y (But there was a significant dropout of work as a sewing machine operator in those >35 years	Y	Y	N	Y
Outcome	S	S and PE	S	S and PE	S and PE	S and PE	S
Exposure	Observation and measurement of postures	Observation and measurement of representative workers or job titles	Questionnaire	Questionnaire, self-reports, weight of tools job title, duration of employment	Questionnaire and self-reports	Questionnaire	Questionnaire, job categorization
Covariates considered	Gender, age	ô	Cohort study: followed same workers over time	Age, smoking, dexterity, ethnicity	Age, handedness, smoking, sports activities, duration of employment	ô	Age, number of years on job, quetelet ratio, previous work experience, education
Investigators blinded	ô	NR	NR	Y	Y	Yes	NR
Repetition for shoulder	ô	Combined	Combined	ô	ô	Combined	ô
Force	ô	ô	Combined	Combined	Manual work: right side: 1.1 (0.7-1.8) left side: 1.9 (1.0-3.4)	ô	Combined
Extreme posture	Thinning out, bagging pears had significantly more forward shoulder flexion than bagging apples	Combined	Combined	ô	ô	Combined	Combined
Vibration	ô	ô	ô	Right side: 2.2 (1.0-4.6) Left side: 3.1 (1.4-6.9)	Right side 1.7 (1.1-2.6) left side 1.8 (1.1-3.1)	ô	ô

See footnotes at end of table.

(Continued)

Appendix C Table C-3. Summary table for evaluating work-related shoulder musculoskeletal disorders

Components of study	Sakakibara 1987	Sakakibara 1995	Schibye 1995	Stenlund 1992	Stenlund 1993	Sweeney 1994	Wells 1983
Risk factors (combined)	ō	Pear baggers compared to apple baggers: 1.7 (1.1-2.9) Posture: NR, Sig.	Development of shoulder symptoms not related to work exposure but significant dropout of workers >35 years	Rockblasters vs. Foremen: 4.0 (1.8-9.2) Bricklayers compared to foremen: right side: 2.2 (1.0-4.7)	Rock blasters compared to foremen: right side: 1.7 (0.7-4.0) left side: 3.3 (1.2-9.3)	>20 hrs./ week signing: 2.5 (0.8-8.2)	Letter carriers with increased shoulder load vs. postal clerks: 5.7 (2.1-17.8)
Physical workload	ō	ō	ō		Right side: 1.0 (0.6-1.8) left side: 1.8 (0.9-3.4)	ō	ō
Psychosocial factors	ō	ō	ō		ō	ō	ō
Individual/other factors considered	ō	ō	ō	Rock blasters compared to foremen: Right side: 2.1 (0.9-4.6) Left side: 4.0 (1.8-9.2)	ō	ō	
Duration of employment	ō	ō	ō	Right side: 2.9 (1.2-7.4) Left side: 2.5 (1.0-5.9)		ō	NS
Dose/response	ō	ō	None for increasing piece work in previous years	As length of employment and exposure to vibration and amount lifted increased, osteoarthritis of shoulder increased	High vibration compared to low vibration	ō	ō

ō Not studied.
EMG Electromyography.
F Force.
MSD Musculoskeletal disorders.
N Considered (no).
NR Not reported.
NS Not statistically significant.
R Repetition.
Ref. Referents.
S Symptoms.
Sig. Significant.
ST Supraspinatus tendinitis.
PE Physical examination.
VDT Video display terminals.
Y Considered (yes).

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Andersen 1993a	Baron 1991	Bovenzi 1991	Burt 1990	Byström 1995	Chiang 1993	Dimberg 1987	Dimberg 1989
Study type	CS	CS	CS	CS	CS	CS	CS	CS
Participation rate $70%	Y	N	NR	Y	Y	Y	Y	Y
Outcome	S	S and PE	S and PE	S	S and PE	S and PE	S and PE	S and PE
Exposure	Job categorization by job duration	Observation videotape, questionnaire	Observation, checklist, vibration measured	Questionnaire	Observation, videotape analysis, EMG of forearm muscle load collected, however, job title used for analysis	Observation videotape analysis, EMG	Observation job analysis categorization	Observation, job analysis, categorization
Covariates considered	Age, number of children, smoking, socioeconomic status	Age, gender, hobbies, second jobs, height, systemic disease	Age, ponderal index	Age gender, years on job, psychosocial factors	Gender, age >40 years, psycho-social variables and potential confounders addressed by Fransson-Hall et al. 1995	Age, gender, metabolic disease	Gender, age, employee category, degree of stress, tennis playing	Ponderal index, gender, age, time in present job, height, weight, smoking, house ownership, racquet sports
Investigators blinded	Y	Y	Y	Y	Y to questionnaire responses, No to exposure status	Y	NR	NR
Repetition	Combined	Combined	ô	80% of time reported typing vs. 0-19% of time: 2.8 (1.4-5.7)	Combined	Combined	ô	ô
Force	Combined	Combined	ô	Combined	Combined	Combined	Combined	Combined
Extreme posture	Combined	Combined	ô	Combined	Combined	Combined	Combined	Combined

See footnotes at end of table. (Continued)

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Andersen 1993a	Baron 1991	Bovenzi 1991	Burt 1990	Byström 1995	Chiang 1993	Dimberg 1987	Dimberg 1989
Vibration	õ	õ	Vibration-exposed forestry workers vs. referents: 4.9 (1.27-56.0)	õ	õ	õ	õ	*p*<0.01
Risk factors (combined)	Sewing machine operators vs. general population 1.7 (0.9-3.3)	Checkers vs. Noncheckers: 2.3 (0.5-11.0)	õ	Reporters compared to others: 2.5 (1.5-4.0)	Assembly line workers vs. population referen ts: 0.74 (0.04-1.7)	Group III vs. Group I (females): 1.44 (0.3-5.6) High force/high repetition vs. low force/low repetition: (males) 6.75 (1.6-32.7)	Force and posture: NR, Sig.	Force and posture: NR, NS
Physical workload	õ	õ	õ	õ	õ	õ	õ	õ
Psychosocial factors	õ	Job satisfaction: NS	õ	Job control and satisfaction: NS	Addressed by Fransson-Hall et al. 1995	õ	õ	Mental stress at the onset of symptoms: *p*<0.001
Individual/other factors considered	õ	õ	õ	Sick leave more common among strenuous jobs than nonstrenuous jobs	õ	õ	"Work" the cause in 35% of elbow problems, most white collar	Ponderal index associated with elbow symptoms
Duration of employment	õ	NS	õ	õ	õ	õ	õ	õ
Dose/response	õ	õ	õ	Y for time spent typing	õ	Y for males with increasing force/repetition	õ	õ

See footnotes at end of table. (Continued)

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Fishbein 1988	Hales 1994	Hoekstra 1994	Hughes 1997	Kopf 1988	Kurppa 1991	Luopajärvi 1979	McCormack 1990
Study type	CS	CS	CS	CS	CS	Cohort	CS	CS
Participation rate $70%	N	Y	Y	N	N	Y	Y	Y
Outcome	S	S and PE	S	S and PE	S	S and PE	S and PE	S and PE
Exposure	Questionnaire	Observation and Questionnaire	Observation and Questionnaire	Observation, checklist, formal job analysis	Questionnaire, job categories	Observation, measurements, categorized by job titles	Observation, interviews, videotape analysis	Observation, job categories based on manual exposure
Confounders considered	Age, gender stratification, smoking status, alcohol, beta blockers, other drugs	Age, gender, metabolic disorder, hobbies, recreation	Age, gender, location, seniority	Age, smoking status, sports, hobbies, metabolic diseases, acute traumatic injuries, smoking	Age, job satisfaction, job security, moistness, vibration, Scheuerman's Disease	Workers used as their own controls; age, gender, duration of employment (with exceptions)	Age, gender, social background, hobbies, amount of housework, length of employment	Gender, age, race, job category, years of employment
Investigators blinded	NR	Y	Y	NR	NR	NR	Y	NR
Repetition	Combined	Number of key-strokes per day: NS	ð	ð	Combined	Combined	Combined	Combined
Force	ð	ð	ð	Number of years handling >2.5 kg/hand: NS	Combined	Combined	Combined	Combined
Extreme posture	Combined	ð	Non optimally adjusted chair: 4.0 (1.2-13.1)	Wrist flexion/ extension: NS; years of ulnar deviation: NS; years of forearm twisting: 37 (3.0-470.0)	Combined	Combined	Combined	ð
Vibration	ð	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Fishbein 1988	Hales 1994	Hoekstra 1994	Hughes 1997	Kopf 1988	Kurppa 1991	Luopajärvi 1979	McCormack 1990
Risk factors (combined)	Female musicians compared to males: 2.04 (1.6-2.6)	ò	ò	ò	Bricklayers compared to manual workers: 2.8; Increasing job demands OR increased from 1.8 to 3.4	Workers in strenuous vs. nonstrenuous jobs: 6.7 (3.3-13.9)	Assembly workers vs. shop assistants: for epicondylitis: 2.7 (0.66-15.9)	Boarding vs. Non-office workers: 0.5 (0.09-2.1) Knitting vs. Non-office workers: 1.2 (0.5-3.4)
Physical workload	ò	ò	ò	Push/pull; lift carry: NS	Sig	ò	ò	ò
Psychosocial factors	ò	Fear of replacement by computers: 2.9 (1.4-6.1); decision making: 2.8 (1.4-5.7); surge in workload: 2.4 (1.2-5.0)	Job dissatisfaction; exhaustion	Low decision latitude: 3.5 (0.6-19.0)	ò	ò	ò	ò
Individual/other factors considered	ò	Race (non-white): 2.4 (1.2-5.0)	ò	Age: 0.96 (0.9, 1.2)	ò	ò	ò	Age, race Sig
Duration of employment	ò	ò	ò	ò	ò	ò	ò	Y, Sig, with <6 months and >13 years
Dose/response	ò	ò	ò	ò	Yes, increasing levels of job demands	ò	ò	No

See footnotes at end of table. (Continued)

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Moore 1994	Ohlsson 1989	Punnett 1985	Ritz 1995	Roto 1984	Viikari-Juntura 1991b
Study type	CS	CS	CS	CS	CS	CS
Participation rate $70%	Y	NR	Y for cases N for referents	NR	Y	Y
Outcome	PE records	S	S	S and PE	S and PE	S and PE
Exposure	Observation, videotape analysis, job strain index	Questionnaire, job categorization	Questionnaire, job category	Observation and record review and employee interviews	Job categorization	Observation, job analysis; weights of items
Confounders considered	Age, gender, duration of employment	Age, gender, duration of employment	Age, number of years employed, native language	Age, age-squared, and "history of cervical spine symptoms". Having ever played tennis, squash, other racquet sports, rowing, bowling,	Gender, other work tasks	Age, gender, duration of employment, leaving the company, changing the task, being on sick leave
Investigators blinded	Y	NR	NR	Y	Y	NR
Repetition	õ	Combined	Combined	õ	Combined	Combined
Force	5.5 (1.5-62)	õ	Combined	10 years of high exposure to elbow straining work: 1.7 (1.0-2.7)	Combined	Combined
Extreme posture	NR: was not found to be sig. associated with "hazardous" jobs.	Combined	Combined	õ	Combined	õ
Vibration	õ	õ	-	õ	õ	õ
Risk factors (combined)	õ	Non significant pain in last year assembly vs. referents: 1.5 (0.6-3.4) Work inability in last year assembly vs. Referents: 2.8 (0.8-10.7)	Garment workers vs. hospital employees: 2.4 (1.2-4.2)	õ	Meatcutters vs. construction workers: 6.4 (0.99-40.9), *p*=0.05	Strenuous vs. nonstrenuous: NS; difference: 0.88 (0.27-2.8)

See footnotes at end of table. (Continued)

Appendix C Table C-4. Summary table for evaluating elbow musculoskeletal disorders

Components of study	Moore 1994	Ohlsson 1989	Punnett 1985	Ritz 1995	Roto 1984	Viikari-Juntura 1991b
Physical workload	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ
Psychosocial factors	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ
Individual/other factors considered	ŏ	Not associated with work pace	Age; Non-English speakers sig. less likely to report symptoms	ŏ	ŏ	ŏ
Duration of employment	ŏ	No association	ŏ	Increased duration of current exposure increased risk of epicondylitis	All with epicondylitis had >15 years of employment	ŏ
Dose/response	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ

ŏ Not studied.
CS Cross-sectional.
EMG Electromyography.
F force.
Hrs Hours.
MSD Musculoskeletal disorders.
N no.
NR Not reported.
NS Not statistically significant.
PE Physical examination.
R Repetition.
Sig. Statistically significant.
S Symptoms.
Y Considered (yes).

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Armstrong 1979	Barnhart 1991	Baron 1991	Bovenzi 1991	Bovenzi 1994	Cannon 1981	Chatterjee 1982	Chiang 1990
Study type	CS	CS	CS	CS	CS	Case control	Case control	CS
Participation rate $70%	NR	N	N	NR	Y	NR	Y	Y
Outcome	S or surgery or PE findings	PE and NCS	S and PE	S and PE	S and PE	Industry medical records	S and PE and NCS	S and PE and NCS
Exposure	Observation, video, EMG	Observation	Observation, videotape analysis, job category	Observation, measurement	Observation, vibration, measurement	Medical records, job category	Observation, Measurement	Observation
Covariates considered	Gender, metabolic or soft tissue disease	Age, gender	Age, gender, hobbies, past employment, years on job	Age, gender, weight	Age, smoking, alcohol, upper limb injuries	Age, gender, race, weight, occupation, years employed, workers compensation status, history of metabolic disease, hormonal status, gynecologic surgery	Age, gender	Age, gender, length of employment, history of metabolic disease
Investigators blinded	N	Y, but clothing may have biased observation	Y	Y	N	NR	Y	Y
Repetition	ô	Repetitive ski manufacturing vs. others NCS: 1.9 (1.0-3.6) PE+NCS: 4.0 (1.0-15.8) S+PE+NCS: 1.6 (0.8-3.2)	Combined	ô	ô	2.1 (0.7-5.3)	ô	1.87 (*p*<0.018)

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Armstrong 1979	Barnhart 1991	Baron 1991	Bovenzi 1991	Bovenzi 1994	Cannon 1981	Chatterjee 1982	Chiang 1990
Force	Pinch F: 2.0 (1.6-2.5) Hand F: 1.05 (1.0-1.2)	ð	Combined	ð	ð	ð	ð	ð
Extreme posture	Pinch force exertion: 2.0 (1.6-2.5)	ð	ð	ð	ð	ð	ð	ð
Vibration	ð	ð	ð	23.1 (no confidence limits) *p*=0.002	Quarry drillers and stone carvers vs. polishers and machine operators: 3.4 (1.4-8.3)	7.0 (3.0-170.0)	10.89 (1.02-524.0)	ð
Risk factors (combined)	ð	ð	Grocery checkers vs. other grocery workers: 3.7 (0.7-16.7)	Chain saw operators vs. maintenance workers: 18.8 (2.7-795)	ð	ð	ð	High cold/ high repetition: 11.66 (2.92-46.6)
Duration of employment	ð	ð	Y, Sig.	ð	ð	0.09 (0.8-10)	ð	NS
Physical workload	ð	ð	ð	ð	ð	ð	ð	ð
Psychosocial factors	ð	ð	ð	ð	ð	ð	ð	ð
Individual/other factors considered	ð	ð	ð	ð	ð	ð	ð	ð
Dose/response	ð	ð	Y, Sig.	ð	Y, NS	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Chiang 1993	deKrom 1990	English 1995	Färkkilä 1988	Feldman 1987	Franklin 1991	Koskimies 1990	Liss 1995
Study type	CS	CS	Case control	CS	CS for symptoms and cohort for NCS	Retrospective cohort	CS	CS
Participation rate $70%	Y	Y	Y	NR	Y	Y	NR	No
Outcome	S and PE	S and PE and NCS	S and PE	S and PE and NCS	S and in some PE and NCS	Records review of workers' compensation cases	S and PE and NCS	Mailed survey
Exposure	Observation, measurement, EMG	Questionnaire	Questionnaire	Interview	Observation, biomechanical analysis, videotaping	Job title and industry	Records of vibration exposure	Mailed survey
Covariates considered	Age, gender, metabolic disease, hormonal status	Age, gender, weight, slimming courses	Gender, height, weight	Alcohol	Gender, past medical history, cigarette smoking, hobbies (No analyses performed to take these into account)	None	NR	Gender, age
Investigator blinded	Y	NR, participants blinded	Y	NR	NR	Y	NR	N
Repetition	Repetitive fish processing vs. other: 1.1 (0.7-1.8)	ŏ	CTS patients vs. other patients: 0.4 (0.2-0.7)	ŏ	Combined	Combined	ŏ	Combined
Force	Repetitive fish processing vs. other: 1.8 (1.1-2.9)	ŏ	ŏ	ŏ	Combined	Combined	ŏ	ŏ
Extreme posture	ŏ	Reported 20 to 40 hrs./week Flexed wrist: 8.7 (3.1-24.1) Extended 5.4 (1.1-27.4)	CTS patients vs. other patients: 1.8 (1.2-2.8)	ŏ	ŏ	Combined	ŏ	Combined

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Chiang 1993	deKrom 1990	English 1995	Färkkilä 1988	Feldman 1987	Franklin 1991	Koskimies 1990	Liss 1995
Vibration	ð	ð	ð	Vibration: $p< 0.05$	ð	ð	Vibration exposure time and NCS Sig. Right hand: r=-0.27; *p*=0.01 Left hand r=-0.12 *p*=NS	ð
Risk factors (combined)	Repetitive and forceful fish processing vs. others: 1.1 (0.7-1.8) Female poultry workers hi R/hi F vs. low R F: 2.6 (1.0-7.3)	ð	ð	ð	Year 2 vs. Year 1, numbness and tingling in fingers: 2.26 (1.14-4.46)	Oyster and crab packers vs. industry-wide rates: 14.8 (11.2-19.5)	ð	CTS symptoms, dental hygienists vs. dental assistants: 3.7 (1.1-11.9) Responder told that they had CTS: 5.2 (0.9-32.0)
Duration of employment	Y,<12 months; No for 12 to 60 months and >60 months	ð	ð	ð	ð	ð	Exposure time Sig.	ð
Physical workload	Y	ð	ð	ð	ð	ð	ð	ð
Psychosocial factors	ð	ð	ð	ð	ð	ð	ð	ð
Individual/other factors considered	ð	ð	ð	ð	ð	ð	ð	ð
Dose/response	Y, Sig.	Y, Sig.	ð	ð	ð	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Loslever 1993	Marras 1991	McCormack 1990	Morgenstern 1991	Moore 1994	Nathan 1988	Nathan 1992a	Nathan 1992b
Study type	CS	CS	CS	CS	Retrospective cohort	CS	Cohort	Longitudinal
Participation rate $70%	Jobs selected due to CTS occurrence	NR	Y	Y	Y	NR	N	Y=Japanese N=Overall
Outcome	S	Records and medical records	S and PE	S	PE and NCS from records	NCS	S and NCS	S and NCS
Exposure	Observation; measurements, videotaping	Observation; measurements	Observation, job title	Survey	Observation, videotape, measurement	Observation	Observation	Questionnaire
Covariates considered	Gender, age, years on the job, hand orientation	Age, gender, handedness, job satisfaction	Age, gender, race, job category, years of employment	Age, gender, pregnancy status, work history job tasks, use of selected drugs, history of wrist injury	None	Age, gender	Age, gender, hand dominance, duration of employment and industry	Gender, hand dominance, occupational hand use, duration of employment, industry, leisure exercise, heavy lifting, keyboard use, coffee, tea, alcohol
Investigator blinded	N	NR	NR	N	Y	NR	NR	NR
Repetition	ð	Number of wrist movements: NS	Combined	1.88 (0.9-3.8)	Combined	Group II vs. Group 1:1.0 (0.05-2.0)	Combined	Found to be "protective"
Force	Combined	Grip forces three times as great in high-risk jobs	Combined	ð	Combined	Combined	Combined	
Extreme posture	Combined	Radial/ulnar ROM: 1.52 (1.1-2.1); Flexion/extension ROM: 1.3 (1.0-1.7); Pronation/supination ROM: 1.2 (0.9-1.6)	ð	ð	Combined	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Loslever 1993	Marras 1991	McCormack 1990	Morgenstern 1991	Moore 1994	Nathan 1988	Nathan 1992a	Nathan 1992b
Vibration	ô	ô	ô	ô	ô	ô	ô	ô
Risk factors (combined)	High force with high flexion: r=0.62; high force and high extension: r=0.29	Flexion/extension velocity: 3.8 (1.5-9.6) Flexion/extension acceleration: 6.1 (1.7-22)	Boarding vs. non-office: 0.5 (0.05-2.9) Packing vs. Non-office 0.4 (0.04-2.4) Sewing vs. Non-office 0.9 (0.3-2.9)	ô	Meat processors in hazardous vs. safe jobs: 2.8 (0.2-36.7)	Group I vs. Group III: 1.7 (1.3-2.3) Group I vs. Group V: 2.2 (1.3-3.3)	Group V vs. Group I: 1.0 (0.5-2.2) Group IV vs. Group I: 1.4 (0.9-2.1) Group III vs. Group I: 1.5 (1.0-2.2)	Americans with significantly greater prevalence of CTS compared to Japanese
Duration of employment	ô	Sig.	Prevalence higher in workers with <3 years employment	>34 hrs./week: 1.9 (1.1-3.1) >9 years: 1.7 (1.0-3.2)	ô	ô	ô	Duration of employment found to be protective
Physical workload	ô	ô	ô	ô	ô	ô	ô	ô
Psychosocial factors	ô	Job satisfaction: NS	ô	ô	ô	ô	ô	ô
Individual/other factors considered	ô	trunk depth: Sig.	ô	ô	ô	ô	Age, hand dominance sig.	Mean age, body mass index and leisure exercise Sig., cigarettes Sig .
Dose/response	ô	ô	ô	ô	ô	Y, Sig.	ô	ô

See footnotes at end of table. (Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Osorio 1994	Punnett 1985	Schottland 1991	Silverstein 1987	Stetson 1993	Tanaka (*In Press*)	Weislander 1989
Study type	CS	CS	CS	CS	CS	CS	Case control
Participation rate $70%	Y	Y for cases; N for comparison group	NR	Y	Y	Y	Y
Outcome	S and PE, NCS	S and PE	NCS	S and PE	S and PE and NCS	S	S and PE and NCS
Exposure	Job title, observation	Observation, questionnaire	Job title	Observation, videotape analysis, EMG	Observation, questionnaire, job analysis	Questionnaire	Telephone interview
Covariates considered	Age, gender, alcohol, medical history	Age, gender, hormonal status, native language, history of metabolic disease	Age, gender	Age, gender, plant, years on job	Age, height, skin temperature, dominant index finger circumference	Age, gender, race, cigarettes, income, education, BMI	Age, gender, year of operation
Investigator blinded	Y	NR	NR	Y	NR	No	No
Repetition	Combined	Combined	Combined	Repetition: 5.5 *p*<0.05	NS	ð	2.7 (1.3-5.4)
Force	Combined	Combined	Combined	Combined	Y, Sig. combined	ð	ð
Extreme posture	ð	ð	Combined	Ulnar deviation and pinching, elevated but NS	Combined (pinch grip)	Bending/twisting of the wrist: 5.9 (3.4-10.2)	ð
Vibration	ð	ð	ð	5.3 (no confidence limits)	ð	Vibration: 1.85 (1.2-2.8)	Vibrating tool use 3.3 (1.6-6.8)
Risk factors (combined)	NCS: 6.7 (0.8-52.9) Super-market workers, high vs. low exposure symptoms: 8.3 (2.6-26.4)	Force, repetition, posture: 2.7 (1.2-7.6)	Workers vs. applicants: females, right hand: 2.86 (1.1-7.9); males, right hand: 1.87 (0.6-9.8)	High force/high repetition vs. low force/low repetition: 15.5 (1.7-142.0)	Y, Sig. median sensory amplitudes Sig. smaller (*p* < 0.01) and latencies longer (*p*<0.05) with exposure to high pinch grip forces	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-5a. Summary table for evaluating work-related carpal tunnel syndrome (CTS)

Components of study	Osorio 1994	Punnett 1985	Schottland 1991	Silverstein 1987	Stetson 1993	Tanaka (*In Press*)	Weislander 1989
Duration of employment	Y	NS	õ	0.9 $p>0.09$	õ	õ	õ
Physical workload	Y	õ	õ	õ	õ	õ	Loads on wrist 1.8 (1.0-3.5)
Psychosocial factors	õ	õ	õ	õ	õ	õ	õ
Individual/other factors considered	õ	õ	õ	õ	õ	Female gender: 2.4 (1.6-3.8); BMI $25: 2.1 (1.4-3.1); white race: 4.2 (1.9-15.6) Cigarettes: 1.6 (1-2.5); annual income $$20,000: 1.5 (1-2.4)	õ
Dose/response	Y, Sig.	õ	õ	Y, Sig.	õ	õ	õ

õ Not studied
BMI Body Mass Index
CS Cross-sectional
CTS Carpal tunnel syndrome
EMG Electromyography
F Force
hrs Hours
NCS Nerve conduction studies
NR Not reported
NS Not statistically significant
PE Physical examination
R Repetition
Sig. Statistically significant
S Symptoms
Y Considered (yes)

See footnotes at end of table.

(Continued)

Appendix C Table C-5b. Summary table for evaluating work-related hand/wrist tendinitis

Components of study	Amano 1988	Armstrong 1987a	Byström 1995	Kuorinka 1979	Kurppa 1991	Luopajärvi 1979	McCormack 1990	Roto 1984
Study type	CS	CS	CS	CS	Cohort	CS	CS	CS
Participation rate $70%	NR	Y	Y	Y	Y	Y	Y	Y
Outcome	S and PE	S and PE	S and PE	S and PE	S and PE	S and PE	S and PE	S and PE
Exposure	Job titles or self-reports	Observation, measurements, video analysis, EMG	Questionnaire, observation, measurements, videotape analysis, EMG	Records, observation, measurements, videotape analysis	Observation, measurements, video analysis. Reader referred to methods found in previous publications	Observation, measurements, video analysis	Observation, job category	Job title
Covariates considered	Age, gender	Age, gender, years on job, and industrial plant	Age, gender, psychosocial factors (addressed by Fransson-Hall et al. 1995)	Age, gender, body mass index, "muscle-tendon" syndrome	Age, gender	Gender (only females in study groups), age, hobbies, housework, medical conditions	Race, age, gender	Rheumatoid arthritis
Investigators blinded	NR	Y	No	NR	NR No=occupation of subjects	Y	NR	Y=occupation meat processing No=construction foremen (referent)
Repetition	Combined	Combined	Combined	Combined	Combined	Combined	Combined	Combined
Force	Combined	Combined	Combined	Combined	Combined	Combined	Combined	Combined
Extreme posture	Combined	Significant differences between males and females	Combined	Combined	Combined	Combined	Combined	Õ
Vibration	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ

See footnotes at end of table

(Continued)

Appendix C Table C-5b. Summary table for evaluating work-related hand/wrist tendinitis

Components of study	Amano 1988	Armstrong 1987a	Byström 1995	Kuorinka 1979	Kurppa 1991	Luopajärvi 1979	McCormack 1990	Roto 1984
Risk factors (combined)	Right index finger flexor: 3.67 (1.85-7.27) Left index finger flexor: 6.17 (2.72-13.97)	Comparison between low R/low F and high R/high F: 4.8 (0.6-39.7) 5.5 (0.7-46.3) 17.0 (2.3-126.2)	De Quervain's tendinitis among among auto assembly workers vs. general population: 2.5 (1.00-6.23)	Scissor makers vs. shop assistants: 1.38 (0.76-2.51)	Meat cutter compared to office workers: risk ratio: 14.0 (5.7-34.4); Meat packers compared to office workers: risk ratio: 38.5 (11.7-56.1); sausage makers compared to office workers: risk ratio: 25.6 (19.2-77.5)	Assembly line workers vs. shop assistants: 4.13 (2.63-6.49)	Textile workers compared to non-office workers: 3.0 (1.4-6.4) Overall group exposed: 1.75 (0.9-3.39)	Meat cutters vs. construction workers: 3.09 (1.43-6.67)
Physical workload	Õ	Õ	Õ	Õ	Õ	Õ	Õ	Õ
Psychosocial factors	Õ		Analyzed by Fransson-Hall et al. 1995		Õ	Õ	Õ	Õ
Individual/ other factors considered	Õ	Õ	Õ	Pieces handled over the years: a nonsignificant trend with increasing number of pieces handled	Õ	NS for age, hobbies, or housework	Female gender significant for tendinitis at *p*=0.01; job category significant at *p*=0.001	Rheumatoid arthritis found not to be a confounder
Duration of employment	Õ	Õ	Õ	Õ	Õ	No association	Õ	Õ
Dose/response	Õ	With increasing combination of R and F	Õ	Õ	Õ	Õ	Õ	Õ

Õ Not studied.
CS Cross-sectional
EMG Electromyography.
F Force.
HAVS Hand-arm vibration syndrome
NR Not reported.
NS Not statistically significant.
PE Physical examination.
R Repetition.
S Symptoms.
Y Considered (yes).

Appendix C Table 5c. Summary table for evaluating hand-arm vibration syndrome

Components of study	Bovenzi 1988	Bovenzi 1994	Bovenzi 1995	Brubaker 1983	Brubaker 1987	Dimberg 1991	Kivekäs 1994	Koskimies 1992	Letz 1992	McKenna 1993
Study type	CS	CS	CS	CS	Cohort	CS	Cohort	Cohort	CS	CS
Participation rate $70%	NR	Y	Y	Y	N	Y	Y	Y	Y	NR
Outcome	S and PE; cold provocation	S and PE	S and PE; cold provocation	S and PE; cold provocation	S and PE; cold provocation	S	S and PE	S and PE	S	S and PE; cold provocation
Exposure	Observation; measurements of the tool	Observation, interview, measurements of the tool	Questionnaire, observation, measurements of the tool	Question-naire data	Observation; measurements of the tool	Questionnaire	Questionnaire	Measurement of the tools	Questionnaire, measurements of the tool used from previous studies	Questionnaire
Covariates considered	ò	Age, smoking, alcohol consumption, upper limb injuries; leisure activities, systemic diseases	Age, smoking, drinking habits, cardiovascular, neurologic, previous musculoskeletal injuries, use of medicines	Smoking, age, height, weight	Age, gender, psychosocial scales	ò	Age	ò	Age, race, smoking, alcohol, medical conditions	Age, smoking, only males studied, those with injury to the neck, upper limbs excluded.
Investigators blinded	NR	N	Y	NR	NR	NR	Y	NR	No	N
Repetition	ò	ò	ò	ò	ò	ò	ò	ò	ò	ò
Force	ò	ò	ò	ò	ò	ò	ò	ò	ò	ò
Extreme posture	ò	ò	ò	ò	ò		ò	ò	ò	ò

See footnotes at end of table (Continued)

Appendix C Table 3c. Summary table for evaluating hand-arm vibration syndrome

Components of study	Bovenzi 1988	Bovenzi 1994	Bovenzi 1995	Brubaker 1983	Brubaker 1987	Dimberg 1991	Kivekäs 1994	Koskimies 1992	Letz 1992	McKenna 1993
Vibration	Stone drillers and cutters vs. quarry and mill workers: 6.06 (2.0-19.6)	Stone workers vs. polishers and machine operators: 9.33 (4.9-17.8)	Forestry workers and 2.6% in ship-yard referents: OR = 11.8 (4.5-31.1) For workers only using antivibration saws: OR = 6.2 (2.3-17.1) For those using non-antivibration saws: OR = 32.3 (11.2-93)	NR	15% of fellers reported new symptom s of VWF from 1979 to 1985; 28% increase in prevalenc e of VWF in workers using antivibrati on chain-saws	Vibrating tool use sig. Correlated with HAVS symptom prevalance	Lumberjack es vs. referents: for 1978: 3.4, (1.7-6.9) Cumulative incidence HAVs (7-years) 14.7% vs. 2.3%: 6.5 (2.4-17.5)	Decrease in prevalence in forest workers from 1972 to 1990, attributed to reduction in weight of saws, increase in vibration frequency, reduction in acceleratio n	Full-time vibration workers vs. referents: 5.0 (2.1-12.1) Full-time vibration workers vs. Controls: 40.6 (11-177)	Riveters vs. referents: 24 (3.1-510)
Risk factors (combined)	ō	ō	ō	ō	ō	ō	ō	ō	ō	ō
Physical workload	ō	ō	ō	ō	ō	ō	ō	ō	ō	ō
Psychosocial factors	ō	ō	ō	ō	ō	ō	ō	ō	ō	ō
Individual/ other factors considered	ō	See “Covariate s considered ” above	See “Covariates considered” above	Age significantl y different between cases and controls, height and weight were not.	ō	Vibrating tool use significantl y correlated with HAVS symptoms prevalence	ō	ō	Smoking Sig.	ō
Duration of employment	ō	ō	ō	ō	ō	ō	No differece in lumberjack s with <15 years of exposure, but then increased with duration of exposure	ō	ō	ō
Dose/respon se	ō	ō	Y, between increasing vibration exposure and “vibration white finger”	ō	ō		Increased HAVS with duration of exposure	ō	Sig. for reported exposure to vibratory tools in workers with <17,000 hours of exposure	ō

See footnotes at end of table. (Continued)

Appendix C Table 5c. Summary table for evaluating hand-arm vibration syndrome

Components of study	Mirbod 1992a, 1994	Mirbod 1992b	Miyashita 1992	Musson 1989	Nagata 1993	Nilsson 1989	Saito 1987	Shinev 1992	Starck 1990	Virokannas 1995
Study type	CS	CS	CS	CS	CS	CS	Cohort	CS	CS	CS
Participation rate $70%	NR	NR	NR	N	NR	Y for platers; NR for office workers	N	NR	NR	NR
Outcome	S	S and PE	S	S	S and PE	S and PE	S and PE	S and PE	S	S and PE
Exposure	Questionnaire; interviews, measurements of the workers and the tools	Questionnaire; measurements of the workers and the tools	Job Title	Postal questionnaire, measurement of representative tools	Based on years of exposure since employment	Questionnaire, measurement of tool, exposure time	Questionnaire	Measurement of tool	Measurement of tools	Interview
Covariates considered	Age	õ	õ	Age, height, weight, smoking, time pressure, working posture	Age	Age	Follow-up of cohort	Age, cigarette smoking, industry, education VDT training	N	Age, duration of employment
Investigators blinded	NR	N	N	NR	N	NR	NR	NR	N	NR
Repetition	õ	õ	õ	õ	õ	õ	õ	õ	õ	õ
Force	õ	õ	õ	õ	õ	õ	õ	õ	õ	õ
Extreme posture	õ	õ	õ	õ	õ	õ	õ	õ	õ	õ
Vibration	Male chain saw operators vs. referents: 3.77 (2.1-6.8)	Symptom severity positively correlated with exposure duration	Male Construction workers compared to male office workers: 0.5 (0.1-11.8)	Exposure duration not related to HAVS symptoms	For >20 years vibration exposure: 7.1 (2.5-19.9)	Office workers with no vibration exposure to former exposure: 14 (5-38) Office workers with no exposure: 85 (15-486)	NR	Percussive vibration had a greater effect on muscle and bone pathology than constant high-frequency vibration	High prevalence of HAVS among workers using vibrating tools	NR

See footnotes at end of table

(Continued)

Appendix C Table 5c. Summary table for evaluating hand-arm vibration syndrome

Components of study	Mirbod 1992a, 1994	Mirbod 1992b	Miyashita 1992	Musson 1989	Nagata 1993	Nilsson 1989	Saito 1987	Shinev 1992	Starck 1990	Virokannas 1995
Risk factors (combined)	ö	ö	ö	ö	ö	ö	ö	ö	ö	ö
Physical workload	ö	ö	ö	ö	ö	ö	ö	ö	ö	ö
Psychosocial factors	ö	ö	ö	ö	ö	ö	ö	ö	ö	ö
Individual/ other factors considered	ö	ö	ö	ö	ö	ö	Age Sig. Correlated to recovery rates from 1978 to 1983	ö	Poor correlation between vibration exposure and HAVS when tools were highly impulsive	ö
Duration of employment	ö	ö	ö	ö	ö	ö	ö	ö	ö	ö
Dose/response	ö	HAVS symptom severity positively correlated with exposure duration	ö	ö	ö	OR increased by 11% for each year of exposure	ö	ö	ö	ö

ö Not studied.
CS Cross-sectional.
CTS Carpal tunnel syndrome.
EMG Electromyography.
F Force.
Hrs Hours.
NCS Nerve conduction studies.
NR Not reported.
NS Not statistically significant.
OR Odds ratio.
PE Physical examination.
R Repetition.
S Symptoms.
Sig Statistically significant.
VPT Vibration perception threshold.
Y considered (yes).

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Åstrand 1987, 1988	Bergenudd 1988	Bigos 1991b	Bongers 1988	Bongers 1990	Boshuizen 1990a, 1990b
Study type	1987: CS; 1988: Cohort	Cohort	Cohort	Retrospective cohort	CS	CS Cohort
Participation rate $ 70%	Y	N	N	Y	Y	Y
Outcome	S and PE	S	S	Physical exam from disability records	S	CS: S Cohort: records
Exposure	Questionnaire	Questionnaire	Questionnaire; For jobs with >19 workers: job analysis	Job title and records; vibration measurements obtained but not used	Questionnaire; vibration measurements	Questionnaire; vibration measurements
Covariates considered	Education level, psychosocial factors (including neuroticism)	Years of education, psychosocial factors	Medical history, previous episodes of back pain, "individual" factors, psychosocial factors (from MMPI)	Nationality, shift-work, age, and calendar time	Age, height, weight, climate, bending forward, twisted postures and feeling tense at work	Duration of exposure, age, height, smoking, awkward postures, and mental workload
Investigators blinded	N	NR	NR	NR	NR	NR
Heavy physical work	Combined	Workers in moderate and heavy physical demand work groups vs. light physical demand group: 1.8 (1.2-2.7)	No association	ô	ô	ô
Lifting and forceful movements	Combined	ô	ô	ô	ô	ô

See footnotes at end of table. (Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Åstrand 1987, 1988	Bergenudd 1988	Bigos 1991b	Bongers 1988	Bongers 1990	Boshuizen 1990a, 1990b
Awkward postures	ô	ô	ô	ô	ô	ô
Whole body vibration	ô	ô	ô	All back disorders: 1.32 (0.84-2.1); Intervertebral disc disorders: 2.00 (1.1-3.7); Disc degeneration by years of exposure: 5.7 (for highest exposure category)	LBP in exposed vs. referents: 9.0 (4.9-16.4), Sciatica: 3.3 (1.3-8.5); LBP by total vibration dose: ORs=12.0, 5.6, 6.6, 39.5 LBP by hours of flight time per day: 5.6, 10.3, 14.4;	LBP by vibration dose category: ORs=19.1, 29.4, 28.0, 38.1; By vibration dose: ORs=1.80, 1.78, 2.8; years of exposure: 3.6 (1.2-11)
Static work postures	ô	ô	ô	ô	ô	ô
Risk factors (combined)	Mill workers vs. clerical workers: 2.3 p=0.002	ô	ô	ô	ô	ô
Psychosocial factors	Neuroticism and back pain: 2.8 (1.4-5.4)	Those with back pain less satisfied with working conditions; no difference in social support	MMPI: tend towards somatic complaint or denial of emotional distress and reporting injury: 1.37 (1.1-1.7)	ô	ô	ô
Individual/other factors considered	ô	ô	Does not enjoy job tasks and reporting injury: 1.7 (1.3-2.2)	ô	ô	ô
Duration of employment	Duration of employment and back pain: 1.2 (1.0-1.5)	ô	Prior back pain and reporting injury: 1.7 (1.2-2.5)	ô	ô	ô
Dose/response	ô	ô	ô	ô	ô	ô

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Boshuizen 1992	Bovenzi 1992	Bovenzi 1994	Burdorf 1990	Burdorf 1991	Burdorf 1993
Study type	CS	CS mail survey	CS	CS	CS	CS
Participation rate $70%	Y	Y	Y	N	Y	Y
Outcome	S	S	S	S	S	S
Exposure	Questionnaire; vibration measurements	Questionnaire, measurement of WBV	Questionnaire, measurement of vibration levels	Questionnaire, job title, and expert knowledge	Questionnaire, task analysis and OWAS	Questionnaire, measurements of WBV, Postures assessed with OWAS
Covariates considered	Mental stress, years lifting >10 kg and twisting spine, height, smoking, looking backwards, hours sitting	Age, awkward posture, duration of exposure, BMI, mental load, education, smoking, sport activities and previous jobs at risk for back pain	Age, BMI, education, sport activity, car driving, marital status, mental stress, climatic conditions, back trauma, and postural load (or total vibration dose)	Age, height, and weight	Age, height, and weight	Age, history of heavy work, exposure to WBV, work requiring prolonged sitting, cold, drafts, working under severe pressure, job satisfaction, height, weight, duration of total employment
Investigators blinded	NR	NR	NR	NR	N	NR
Heavy physical work	õ	õ	õ	Heavy work: 4.02 (0.76-21.2)	Heavy physical work sig in univariate but not multivariate model	õ
Lifting and forceful movements	õ	õ	õ	Frequent lifting: 5.21 (1.10-25.5)	No association	õ
Awkward postures	õ	õ	õ	õ	Postural Index and LBP: 1.23 *p*=0.04	õ
Whole body vibration	Total vibration dose and back pain: 0.99 (0.85-1.2); In younger workers: vibration in past 5 years and lumbago, 3.1 (1.2-7.9)	Low back: Previous 12 months prevalence of LBP, bus drivers vs. controls: 2.57 (1.5-4.4) Multivariate: LBP symptoms in previous. 12 months: and total vibration dose: OR's= 1.67, 3.46, 2.63	LBP in the past year: OR=2.39 (1.6-3.7) Postural load category: OR=4.56 (2.6-8.0) (for the highest exposure category)	WBV: 0.66 (0.14-3.1)	WBV and LBP, 3.1 *p*=0.001	Combined

See footnotes at end of table. (Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Boshuizen 1992	Bovenzi 1992	Bovenzi 1994	Burdorf 1990	Burdorf 1991	Burdorf 1993
Static work postures	ð	ð	ð	For univariate analysis: sedentary postures in crance operators: 0.49 (0.11-2.2)	Posture index based on time spent in a working posture with the back in a bent and/or twisted position: 1.23 *p*=0.04	ð
Risk factors (combined)	ð	ð	ð	Job title: 3.6 (1.2-10.6)	ð	Crane operators vs. office workers: 3.29 (1.52-7.12) Straddle-carrier drivers vs. office workers: 2.5 (1.2-5.4)
Psychosocial factors	ð	ð	ð	ð	ð	ð
Individual/other factors considered	ð	ð	ð	ð	Postural load, bending, and twisting are causal factors. Standing and sitting are not found to be risk factors.	ð
Duration of employment	ð	ð	ð	ð	ð	ð
Dose/response	ð	Univariate analysis, total vibration dose: lifetime LBP symptoms: 4.05 (1.8-9.3); 12 months LBP symptoms: 3.25 (1.5-7.0).	Dose/response of combined effects to total vibration dose and postural load, highest combination of categories: 4.58.	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Chaffin 1973	Clemmer 1991	Deyo 1989	Heliövaara 1991	Hildebrandt 1995	Hildebrandt 1996
Study type	Cohort	CS	CS	CS	CS	CS
Participation rate $70%	NR	Y	NHANES-II data	Y	Y	Y, but varied from 60% to 80% by department
Outcome	S	Injury report	Data base (LBP)	S and PE	S	S
Exposure	Observation and measurement	Job title	Data base (smoking, obesity, personal characteristics)	Questionnaire	Questionnaire	Questionnaire
Covariates considered	Age, weight, stature, number of prior back episodes, isometric lifting strengths	Age, job, length of employment	Age, gender, smoking, obesity, exercise level, employment status	Age and gender	Age and gender	Age
Investigators blinded	NR	NR	N	N	N	N
Heavy physical work	ŏ	Roustabouts vs. control room operator: 4.3 (no confidence limits)	ŏ	Combined ORs=1.9, 2.5	Heavy physical work vs. sedentary work: 1.2, *p*<0.05	Nonsedentary steel workers vs. referents: No association
Lifting and forceful movements	Approx. 5	ŏ	ŏ	ŏ	ŏ	ŏ
Awkward postures	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ
Whole body vibration	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ
Static work postures	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Chaffin 1973	Clemmer 1991	Deyo 1989	Heliövaara 1991	Hildebrandt 1995	Hildebrandt 1996
Risk factors (combined)	Lifting of loads in positions which create a Lifting Strength Rating $ was considered potentially hazardous to some people	Job was best predictor of lost time.	ô	LBP and physical stress: 2.5 (1.4-4.7)	ô	NS, Reference group had high exposure to adverse working conditions
Psychosocial factors	ô	ô	Ever smoked vs. LBP: 1.13, Sig. 50 pack years vs. LBP: 1.47, Sig. Body mass index vs. LBP: 1.70, Sig.	Stress load index: 2.4 (1.7-3.5)	ô	ô
Individual/ other factors considered	Age, weight, and stature did not correlate with increased incidence of LBP	75% of back strains precipitated by pushing, pulling, or lifting.	ô	Body mass index, alcohol , work-related driving, parity, height not associated with LBP. Smoking sig in both older and younger males, but only older females. Prior traumatic injury increased risk of LBP: 2.5 (1.9-3.3); and sciatica: 2.6 (2.1-3.1)	Rates of LBP: construction: 35%; truckers: 31%; plumbers: 31%	ô
Duration of employment	ô	ô	Smoking risk increases steadily with cumulative exposure and with degree of maximal daily exposure. There is a steady increase in LBP with increasing obesity.	ô	ô	ô
Dose-response	ô	ô	ô	ô	ô	ô

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Holmström 1992	Huang 1988	Johanning 1991	Johansson 1994	Kelsey 1975b	Kelsey 1984	Knibbe 1996
Study type	CS	CS	CS mail survey	CS	Case control	Case control	CS
Participation rate $70%	Y	Y	N	Y	Y	Y	Y
Outcome	S; (A sample had PE for purposes of validation)	S	S	S	Medical records: S and PE required	S and PE	S
Exposure	Postal questionnaire	Ergonomic assessment including NLE	Job title, measured WBV in exposed group but results not presented	Questionnaire	Questionnaire	Interview and questionnaire	Questionnaire
Covariates considered	Daily traveling time, leisure activity, height and weight	Age, height, length of employment, olecranon height, weight	Age, gender, job title, employment duration	Age and gender. Non work-related S could have an effect masking result, if not identified.	Age, gender	Age, gender, medical service	Age
Investigators blinded	Y	NR	NR	NR	NR	NR	N
Heavy physical work	ô	ô	ô	Blue collar workers vs. white collar workers: no association	ô	ô	ô
Lifting and forceful movements	One year prevalence of BP and manual materials handling: 1.3 (1.2-1.4); Lifting frequency: >1 per 5 min vs.<1 per 5 min: 1.12, *p*<0.001	The workers in the center with higher rates had greater lifting compared to the referent center: no risk estimate	ô	No association	Lifting vs. herniation: 0.94, *p*=0.10	Lifting >25 lb or more, without twisting the body: 3.8 (0.7-20.1)	Registered nurses vs nursing aides: Unadjusted OR=1.2, *p*=0.04; after adjusting for hr worked, aides had higher rate: 1.3
Awkward postures	Stooping and kneeling with severe LBP compared to no stooping: 2.6; in comparison to no kneeling: 3.5	More awkward postures found in center A than B, *p*=0.05.	ô	Extreme work postures sig associated with outcome in blue collar workers	Combined	Twisting without lifting: 3.0 (0.9-10.2)	ô
Whole body vibration	ô	ô	WBV and sciatica pain: 3.9 (1.7-8.6)	ô	Combined	ô	ô

See footnotes at end of table. (Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Holmström 1992	Huang 1988	Johanning 1991	Johansson 1994	Kelsey 1975b	Kelsey 1984	Knibbe 1996
Static work postures	No association	ô	ô	ô	Sedentary work and disc herniation for workers 35 years and older: 2.4, *p*=0.01; for those < 35 years, 0.81	ô	ô
Risk factors (combined)	ô	ô	ô	ô	Time sitting, >35 years old: 2.4 *p*=0.01; More than half time driving vs. herniation: 2.75, *p*=0.02; Truck driver vs. herniation: 4.67, Chi-sq.=5.88, *p*=0.02	Lifting >25 lb >5 times per day, and twisting the body half the time: 3.1 (1.3-7.5); Simultaneous lifting and twisting with straight knees: 6.1 (1.3-27.9)	Physically demanding work vs. lifetime LBP, prevalence: 87%; 1-year LBP, prevalence: 67%; 1-week LBP, prevalence: 21%; Prevalence of sick leave due to back pain in previous 3 months: 9.7%
Psychosocial factors	High stress and LBP: 1.6 (1.4-1.8); high anxiety: 1.3 (1.1-1.4).	ô	Blue collar workers were less satisfied with “influence on and control of work, supervisor climate, stimulus from work itself, and relations with fellow workers	In blue-collar workers, 10 of 15 psychosocial job factors sig; in white-collar workers, none of the five psychosocial factors sig	ô	ô	ô
Individual/other factors considered	Severe LBP related to smoking; construction tasks such as brick laying, carpentry, etc. did not affect LBP.	ô	Gastrointestinal problems: subway train operators vs. referents: 1.6 (1.1-2.5)	ô	ô	Carrying >11.3 kg, 5-25 per day: 2.1 (1.0-4.3) Carrying >11.3 kg , >25/day: 2.7 (1.2-5.8)	ô
Duration of employment	ô	ô	ô	ô	ô	ô	ô
Dose/response	ô	ô	ô	ô	ô	ô	ô

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Leigh 1989	Liles 1984	Magnusson 1996	Magora 1972, 1973	Marras 1993, 1995	Masset 1994	Partridge 1968
Study type	CS	Cohort	CS	CS	CS	CS	CS
Participation rate $70%	Y	NR	NR	NR	NR	Y	Y
Outcome	S	Records	S	S	Records review	S	S and PE
Exposure	Questionnaire (job title)	Observation, use of records	Questionnaire, vibration measurements	Observation, interview, questionnaire	Observation, measurements	Interview, self-reports	Questionnaire, job title
Covariates considered	Gender, race, obesity, height, and repetitious work	ô	ô	ô	ô	Gender (males only), age (all participants younger than 40). General health status, social, demographic, psychologic factors	Age
Investigators blinded	NR	N	NR	NR	NR	NR	N
Heavy physical work	Self reporting: "Job requires a lot of physical effort": 1.5 (1.0-2.2)	ô	ô	ô	ô	No association	Combined
Lifting and forceful movements	ô	Injury rate for highest job severity index category vs lowest : 4.5	Heavy lifting: 1.86 (1.2-2.8) Frequent lifting: 1.55 (1.01-2.39)	1973: Sudden maximal efforts and LBP: 1.65 (1.3-2.1)	Combined	Heavy efforts of the shoulder, 1.62, *p*<0.01	ô
Awkward postures	ô	ô	ô	No association: highest rate of back pain found in the "rarely/never bend" category	ô	Univariate analysis showed trunk torsions associated with LBP in steel workers; no association seen in multivariate	ô
Whole body vibration	ô	ô	Bus and truck drivers compared to referents: 1.8 (1.2-2.8)	Bus drivers compared to bankers: 1.2 (0.8-1.7)	ô	Vehicle driving: 1.2 (*p*<0.001)	ô

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Leigh 1989	Liles 1984	Magnusson 1996	Magora 1972, 1973	Marras 1993, 1995	Masset 1994	Partridge 1968
Static work postures	ð	ð	ð	No association	ð	Seated posture: 1.5, *p*<0.09	ð
Risk factors (combined)	High vs. low physical demands: 1.68 (1.05-2.90)	ð	Driving: 1.79 (1.16-2.75) Vibration plus frequent lifting: 2.1 (0.8-5.7) Vibration plus heavy lifting: 2.06 (1.3-3.3)	Sudden maximal physical efforts; prolonged sitting or standing, inability to sit during the working day, and poor lifting technique related to LBP	Max. load moment, max. lateral velocity, ave. twisting velocity, lifting frequency, and max. sagital trunk angle related to high-risk LBP groups: 10.7(4.9-23.6)	ð	Rheumatic S: dockers vs. civil servants: 1.2 (0.98-1.64); LBP: dockers vs. civil servants: NS
Psychosocial factors	ð	ð	ð	ð	ð	Negative perception of the work environment: NS.	ð
Individual/other factors considered	Smoker vs. nonsmoker and LBP: 1.48 (1.0-2.19)	ð	ð	ð	Maximum load moment: 73.65 Nm vs. 23.64 Nm: 5.17, (3.19-8.38); Sagittal mean velocity: 11.74 degrees/sec. vs. 6.55 degrees/ sec: 3.33 (2.17-5.11); Max. weight: 104 N vs. 37 N: 3.17 (2.19-4.58)	Physical work load (no objective measurement) and repetition were NS. Final logistic model included "whole set of variables from general health status, social, demographic, and psychologic characteristics."	ð
Duration of employment	ð	ð	ð	ð	ð	ð	ð
Dose/response	ð	ð	ð	ð	ð	ð	ð

See footnotes at end of table. (Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Punnett 1991	Riihimäki 1989a	Riihimäki 1989b	Riihimäki 1994; Pietri-Taleb 1995	Ryden 1989	Schibye 1995	Skov 1996
Study type	Case referent (retrospective)	CS mail survey	CS	Prospective	Case control	Cohort	CS
Participation rate ≥70%	Y	Y	Y	Y	Y	Y	N
Outcome	S and PE	S	X-ray confirmed	S	Records	S	S
Exposure	Observation and measurements, Videotape analysis	Job title and questionnaire	Questionnaire and job title	Postal questionnaire	Work injury reports and self-reports	Questionnaire	Questionnaire, self-reports
Covariates considered	Gender, age, length of employment, recreational activity, medical history, and maximum weight lifted in study job	Age, previous back accidents, awkward postures at work, and annual car driving	Age, self-reported back accidents, body mass index, height, and smoking	Age, gender (only males were studied, previous history of back accidents, mental distress, general state of health, smoking, lifestyle factors, education	Age	Subjects served as their own controls	Age, gender, height, weight, smoking, work-related psychosocial variables, lifting, leisure time sports activities
Investigators blinded	Y	NR	Y	NR	NR	NR	NR
Heavy physical work	õ	Combined	õ	õ	Combined	õ	õ
Lifting and forceful movements	Lift 44.5 N: 2.16 (1.0-4.7)	õ	õ	õ	õ	õ	õ
Awkward postures	Time in non-neutral postures, mild or severe bending: 8.09 (1.4-44)	Sciatica and twisted or bent postures: 1.5 (1.2-1.9)	õ	Association found between twisted and bent postures with sciatica in univariate, but not multivariate analysis	õ	õ	õ

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Punnett 1991	Riihimäki 1989a	Riihimäki 1989b	Riihimäki 1994; Pietri-Taleb 1995	Ryden 1989	Schibye 1995	Skov 1996
Whole body vibration	ð	Longshoremen and earthmovers compared to referents: 1.3 (1.1-1.7)	ð	No association	ð	ð	In Danish salespeople, the annual driving distance for highest category: 2.8 (1.5-5.1)
Static work postures	ð	ð	ð	ð	ð	ð	Sedentary work (% of worktime): 2.45 (1.2-4.9)
Risk factors (combined)	Time in non-neutral posture: 8.09 (1.5-44.0)	Sciatic pain and machine operators: 1.3 (1.1-1.7) Sciatic pain and carpenters: 1.0 (0.8-1.3)	Concrete vs. painting work and disc space narrowing: 1.8 (1.2-2.5); Spondylophytes: 1.6 (1.2-2.3)	Machine operators vs. office workers: 1.4 (0.99-1.87); carpenters vs. office workers: 1.5 (1.1-2.1)	Job title or shifts requiring heaviest physical efforts: 2.2 (1.28-3.89)	No sig differences in back pain in garment workers versus other employment group upon follow-up	Annual driving distance: 2.79 (1.5-5.1)
Psychosocial factors	ð	ð	ð	Monotonous work, problems with co-workers or supervisors, and high paced work were NS.	ð	ð	ð
Individual / other factors considered	Age: 0.96 (0.09-1.0) back injury: 2.37 (1.3-4.3)	ð	Age and disc space narrowing: 6.5 (1.7-26.0) Spondylophytes: 14.9 (2.3-95.0)	Physical exercise >1 time per week vs. 1 time per week: 1.26 (1.0-1.6) Smokers vs. non-smokers: 1.29 (0.98-1.7) Severe back pain and later sciatica: 4.5 (2.7-7.6)	Previous back injury: 2.13 (1.07-4.24); Working day shift: 2.23 (1.28-3.89); Self-reported LBP: 1.25 (1.25-4.12); Self-reported slipped disc: 6.20 (2.64-14.57)	Of 82 workers with another job in 1991, 20% reported MSDs a s the reason for change.	ð
Duration of employment	Analysis controlled for length of employment.	ð	ð	ð	ð	Sig	ð
Dose/respon se	A strong trend found for increasing length of exposure and risk of back disorders to both mild and severe trunk flexion.	Dose/response is observed for twisted or bent postures (see above)	ð	ð	ð	ð	Dose/response is observed for annual driving and sedentary work (see above)

See footnotes at end of table. (Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Skovron 1994	Svensson 1989	Toroptsova 1995	Undeutsch 1982	Videman 1984	Videman 1990	Walsh 1989
Study type	CS	CS (retrospective)	CS	CS	CS	CS and lab study	CS
Participation rate $70%	Y	Y	Y	NR	Y	NR	Y
Outcome	S	S	S; then S and PE	S and PE (Clinical orthopaedic exam given to 134 of the 366 subjects)	S	X-ray confirmed	S
Exposure	Interview	Questionnaire	Interview	Interview and questionnaire	Postal questionnaire	Questionnaire, Reports from family members	Postal questionnaire
Covariates considered	Age and gender	Age, gender (only females studied), level of education, psychosocial factors, work breaks, demand on concentration	Analysis did not control for confounders	Age, height, weight, nationality, years of experience in transport work	Age, gender (only females studied), menstruation, pregnancy, exercise	Age, gender (only male cadavers used) physical exercise, heaviness of occupation	Age, year of onset of symptoms, gender
Investigators blinded	NR	NR	NR	NR	NR	NR	NR
Heavy physical work	ð	No association	ð	ð	Sig. difference in heavy occupational workload category among ages 20-29 year olds but not other age groups: 1.1	Heavy vs. mixed work: 2.8 (0.3-23.7) Heaviest work category: 12.1 (1.4-107)	ð
Lifting and forceful movements	ð	Lifetime incidence of LBP and Lifting: 1.2, *p*<0.01 found in univariate analysis but not in multivariate analysis	Frequent lifting and LBP: 1.43, *p*<0.05	Combined	No association - no sig difference between qualified nurses and nursing aides	ð	Lifting in jobs just prior to injury: 2.0 (1.1-3.7)
Awkward postures	ð	LBP and bending forward: 1.3, *p*<0.05 in univariate; not sig in multivariate analysis	Trunk flexion and LBP: 1.7 *p*<0.01	ð	ð	ð	ð

See footnotes at end of table.

(Continued)

Appendix C Table C-6. Summary table for evaluating back musculoskeletal disorders

Components of study	Skovron 1994	Svensson 1989	Toroptsova 1995	Undeutsch 1982	Videman 1984	Videman 1990	Walsh 1989
Whole body vibration	ő	ő	No association	ő	Combined	ő	Driving on job held prior to symptoms in males: 1.7 (1.0-2.9)
Static work postures	ő	"Standing" associated with LBP: 1.3 in univariate analysis, not sig in multivariate	No association	ő	ő	Sedentary work and disc degeneration: 24.6 (1.5-409)	Sitting and LBP: females: 1.7 (1.1-2.6)
Risk factors (combined)	Occupation: NS	ő	ő	In workers with present S, they occurred most frequently while lifting loads and while in bended postures: no risk estimate	ő	Driving vs. Mixed work: 2.3 (0.8-6.2)	Driving and LBP: males: 1.7 (1.0-2.9)
Psychosocial factors	Work dissatisfaction: 2.4, $p=0.02$	LBP and worry and fatigue at end of work day: $p<0.0001$ Dissatisfaction with work tasks: $p<0.05$	ő	ő	ő	ő	ő
Individual / other factors considered	Female gender: 2.16, $p=0.001$; increasing age: 2.0, $p=0.001$	LBP and standing: $p<0.01$	NS for sitting, standing, walking, or repetitive work	Current back S positively correlated with height and age.	ő	ő	
Duration of employment	ő	ő	ő	Current back S positively correlated with length of experience in transport work.	ő	ő	ő
Dose/response	ő	ő	ő	ő	ő	ő	ő

ő Not studied.
ADL Activities of daily living.
CS Cross-sectional.
F Force.
Hrs Hours.
LBP Low-back disorders.
LBP Low-back pain.
LBS Low-back symptoms.
MMPI Minnesota Multiphasic Personality Inventory.
MS Musculoskeletal.
N No.
NHANES National Health and Nutrition Examination Survey.
NR Not reported.
NS Not statistically significant.
OWAS OVAKO working posture analysis system.
PE Physical examination.
R Repetition.
S Symptoms.
Sig. Statistically significant.
WBV Whole body vibration.
Y Considered (yes).