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Kathy Grant & Dan Habes

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Summary of Studies on the Effectiveness of Ergonomic Interventions

Scott Schneider, Column Editor

Reported by Kathy Grant and Dan Habes

Introduction

In 1993, the National Institute for Occupational Safety and Health (NIOSH) prepared a summary of studies on the effectiveness of ergonomic interventions as part of its submission to the Occupational Safety and Health Administration in support of the proposed ergonomics standard. Since the effectiveness of ergonomic intervention is key to the standard, it is important to make this summary more widely available. Below is an updated version of the summary which has been prepared by Kathy Grant and Dan Habes at NIOSH. For more information you can contact them at (513) 533-8291. I hope you find it useful.

TABLE 1. Select Studies Demonstrating Effectiveness of Engineering Controls for Reducing Exposure to Ergonomic Risk Factors

Study	Target Population	Problem/Risk Factor	Control Measure	Effect
Miller *et al.* (1971)	Surgeons (bayonet forceps)	Muscle fatigue during forceps use, frequent errors while passing instruments	Redesigned forceps (increased surface area)	Reduced muscle tension (determined by EMG), fewer passing errors
Armstrong *et al.* (1982)	Poultry workers (knives)	Excessive muscle force during poultry cutting tasks	Redesigned knife (reoriented blade, enlarged handle, provided strap for hand)	Reduced grip force during use, reduced forearm muscle fatigue
Knowlton and Gilbert (1983)	Carpenters (hammers)	Muscle fatigue, wrist deviation during hammering	Bent hammer handle, decreased handle diameter	Less strength decrement after use, reduced ulnar wrist deviation
Habes (1984)	Auto workers	Back fatigue during embossing tasks	Provided cut-out in die (reduced reach distance)	Reduced back muscle fatigue as determined by EMG
Goel and Rim (1987)	Miners (pneumatic chippers)	Hand-arm vibration	Provided padded gloves	Reduced vibration transmitted to the hand by 23.5 to 45.5%
Jorgensen *et al.* (1987)	Airplane baggage loaders	Heavy musculoskeletal loads on the back and shoulders	Introduced telescopic, motor-driven transport system for loading and unloading cargo	Trapezius load reduced by 75% or more; erector spinae load reduced by up to 33%; time to load and unload cargo reduced by 14%; energy consumption decreased by 11%
Wick (1987)	Machine operators in a sandal plant	Pinch grips, wrist deviation, high repetition rates, static loading (legs and back)	Provided adjustable chair and armrests, angled press, provided part bins	Reduced wrist deviation, compressive force on L5/S1 disc (from 85 to 13 lbs)
Little (1987)	Film notchers	Ulnar deviation, high repetition rates, pressure in the palm of the hand imposed by notching tool	Redesigned notching tool (extended, widened, and bent handles, reduced squeezing force)	Reduced force from 12–15 to 10 lbs, eliminated ulnar wrist deviation, increased productivity by 15%
Johnson (1988)	Power hand tool users	Muscle fatigue, excessive grip force	Added vinyl sleeve and brace to handle	Reduced grip force as determined by EMG
Fellows and Freivalds (1989)	Gardeners (rake users)	Blisters, muscle fatigue	Provided foam cover for handle	Reduced muscle tension and fatigue buildup as determined by EMG

(*continued*)

TABLE 1. (Continued)

Study	Target Population	Problem/Risk Factor	Control Measure	Effect
Andersson (1990)	Power hand tool users	Hand-arm vibration	Provided vibration damping handle	Reduced hand-transmitted vibration by 61 to 85%
Radwin and Oh (1991)	Trigger-operated power hand tool users	Excessive hand force and muscle fatigue	Extended trigger	Reduced finger and palmar force during tool operation by 7%
Freudenthal *et al.* (1991)	Office workers	Static loading of back and shoulders during seated tasks	Provided desk with 10 degree incline, adjustable chair and table	Reduced moment of force at L5-S1 by 29% and at C7-T1 by 21%
Powers *et al.* (1992)	Office workers	Wrist deviation during typing tasks	Provided forearm supports and a negative slope keyboard support system	Reduced wrist extension
Erisman and Wick (1992)	Assembly workers	Pinch grips, wrist deviation	Provided new assembly fixture	Eliminated pinch grips, reduced wrist deviations by 65%, reduced cycle time by 50%
Magnusson (1992)	Butchers	Awkward postures, repetitive motions	Developed height-adjustable table with tilted surface and provided meat hook	Awkward postures reduced
Luttmann and Jager (1992)	Weavers	Forearm muscle fatigue	Redesigned workstation (numerous changes)	Reduced fatigue buildup as indicated by EMG, improved quality of product
Fogleman *et al.* (1993)	Poultry workers (knives)	Excessive hand force, wrist deviation	Altered blade angle and handle diameter	Wrist deviation reduced when angled blade was used
Lindberg *et al.* (1993)	Seaming operators	Awkward static neck and shoulder postures, monotonous work movements, high work pace	Automated seaming task	Head postures less flexed, more varied during automated seaming; loads in trapezius were reduced and more varied (as indicated by EMG) during automated seaming; perceived exertion was reduced
Nevala-Puranen *et al.* (1993)	Dairy farmers	Whole-body fatigue, bent and twisted back postures, static arm postures	Installed rail system for carrying milking equipment	Heart rate decreased; bent and twisted back postures decreased by 64%; above-shoulder arm postures decreased by half; mean milking time per cow decreased by 24%
Degani *et al.* (1993)	Construction workers, landscapers (shovels)	Whole-body and local muscle fatigue	Modified shovel handle (mounted second shaft on handle)	EMG in the lumbar paraspinal muscles reduced; ratings of perceived exertion reduced
Gallimore and Brown (1993)	VDT operators	Visual fatigue and body discomfort due to static postures	Fitted VDT screen with device to move image further from the eye	Glare reduced, awkward neck postures reduced for bifocal wearers
Wick and Deweese (1993)	Shipping clerks	Wrist deviations, high force pinch grips, awkward shoulder, neck, and back postures	Lowered and tilted the workstation, raised storage racks, provided a cutting device for wrapping materials	Reduced awkward wrist, shoulder, back, and neck postures; cycle time reduced by 12%
Peng (1994)	Assemblers (percussive rivet tools)	Vibration	Modified rivet hammer (numerous changes), introduced "recoilless" bucking bar	Vibration at the bucking bar and rivet hammer handle reduced

TABLE 2. Select Studies of the Effectiveness of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study Group	Intervention Method	Summary of Results	Additional Comments
Snook *et al.* (1978)	Various (insurance company survey)	200 companies	Selection of workers, training in lifting technique, design of lifting tasks to fit worker capabilities	Selection, training not effective, matching job demands to worker capabilities reduced injuries by 67%	Authors also conclude that 33% of low back injuries will occur no matter what hazard control approach is used
Itani *et al.* (1979)	Film manufacturing	124 film rollers in two groups	Reduced work time, increased number of rest breaks	Reduction in cervicobrachial disorder and low back complaints, improved worker health	Postintervention productivity 86% of preintervention levels
Luopajarvi *et al.* (1982)	Food production	200 packers	Redesigned packing machine	Decreased neck, elbow, and wrist pain	Not all recommended job changes implemented; workers still complain
Drury and Wick (1984)	Shoe manufacturing	Workers at six work sites	Workstation redesign	Reduced postural stress, increased productivity	Trunk and upper limbs most affected by changes
Westgaard and Aaras (1984, 1985)	Cable forms production	100 workers	Introduced adjustable workstations and fixtures, counter-balanced tools	Turnover decreased, musculoskeletal sick leave reduced by 67% over 8-year period, productivity increased	Reductions in trapezius muscle load verified by EMG
McKenzie *et al.* (1985)	Telecommunications equipment manufacturing	6600 employees	Redesigned handles on powered screwdrivers and wire wrapping guns, instituted plant-wide ergonomics training program	Incidence rate of repetitive trauma disorders decreased from 2.2 to 0.53 cases/200,000 work hours; lost days reduced from 1001 to 129 in 3 years	Data inadequate for rigorous statistical evaluation
Echard *et al.* (1987)	Automobile manufacturing		Redesigned tools, fixtures, and work organization in assembly operations	Reduced long-term upper extremity and back disabilities; CTS surgeries reduced by 50%	
Lutz and Hansford (1987)	Medical products manufacturing	>1000 workers	Introduced adjustable workstations and fixtures, mechanical aids to reduce repetitive motions, job rotation	Medical visits reduced from 76 to 28 per month	Results based on two departments with 33 employees; company enthusiastic about exercise program
Silverstein *et al.* (1987)	Investment casting plant	136 workers	Specific ergonomic changes not identified	No relationship between ergonomic changes and prevalence of hand-wrist CTDs	Ergonomic changes did not reduce the risk of studied jobs
Kilbom (1988)	Various (reviews intervention programs in various industries)	14 companies		Concludes that job redesigns are most effective, but as the physical environment improves, work organization and psychosocial factors become more important	

(*continued*)

TABLE 2. (Continued)

Study	Industry	Study Group	Intervention Method	Summary of Results	Additional Comments
Jonsson (1988)	Telephone assembly, printed circuit card manufacturing, glass blowing, mining	25 workers	Job rotation	Job rotation in light duty tasks not as effective as in dynamic heavy-duty tasks	Measured static load in trapezius muscle with EMG
Geras *et al.* (1988, unpublished)	Rubber and plastic parts manufacturing	87 plants within one company	Ergonomics training and intervention program introduced; added material handling equipment, workstation modifications to eliminate postural stresses	Lost time at two plants reduced from 4.9 and 9.7/200,000 hours to 0.9 and 2.6, respectively, over 4-year period	Success attributed to increased training, awareness of hazards, and improved communication between management and workers
Tadano (1990)	Office	500 VDT operators	Provided training, redesigned workstations, and incorporated additional breaks and exercises into the work schedule	CTD cases reduced from 49 in the 6 months preceding the intervention to 24 in the 6 months following the intervention	
Hopsu and Fouhevaara (1991)	Office	Eight female cleaners	Provided training and greater flexibility in their work and eliminated strictly proportioned work areas and time schedules	Average sick leave decreased from 20 days/year before the intervention to 10 days/year 2 years after intervention	Mean maximum VO2 rate increased, mean heart rate decreased after the intervention
La Bar (1992)	Household products manufacturing	800 workers	Introduced adjustable workstations, improved the grips on hand tools, improved parts organization and work flow	Reduced injuries (particularly back) by 50%	Company also had a labor management safety committee to investigate ergonomics-related complaints
Orgel *et al.* (1992)	Grocery store	23 employees	Redesigned checkstand to reduce reach distances, installed a height adjustable keyboard and trained workers to adopt preferred work practices	Decreased self-reported neck, upper back, and shoulder discomfort; no change in arm, forearm, and wrist discomfort	Study lacked a control group
Rigdon (1992)	Bakery	630 employees	Formed union management CTD committee; made workstation changes, tool modifications; improved work practices	CTS cases dropped from 34 to 13 in 4 years; lost days reduced from 731 to 8	Union advocated more equipment to reduce manual material handling
Garg and Owen (1992, 1994)	Nursing home	57 nursing assistants	Implemented patient transferring devices	Incidence rate of back injuries decreased from 83 to 43 per 200,000 work hours following the intervention; no lost or restricted work days during the 4 months following the intervention	

(*continued*)

TABLE 2. Select Studies of the Effectiveness of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study Group	Intervention Method	Summary of Results	Additional Comments
Halpern and Davis (1993)	Office	90 office workers	Adjusted workstations according to user's anthropometric dimensions	Body part discomfort decreased; perceived efficiency and usability of the equipment increased	
Narayan and Rudolph (1993)	Medical device assembly plant	316 employees	Redesigned workstation to reduce reach distances, provided adjustable chairs and foot rests, provided fixtures and pneumatic gripper to eliminate pinch grips	Plant-wide CTD incidence rate reduced from 13.7 to 11.3 per 200,000 worker hours after intervention. Plant-wide severity rate reduced from 154.9 lost-time days to 67.8 lost time days per 200,000 worker hours	Not all jobs in plant affected by changes
Parenmark *et al.* (1993)	Chain saw assembly plant	279 workers	Increased number of workers and tasks, provided training, reduced work pace, adopted new wage system and flexible working hours	Sick leave rate dropped from 17 to 13.7 days annually; labor turnover dropped from 35 to 10%; assembly errors reduced by 3 to 6%; total production cost reduced by 10%; productivity not impacted	Difficult to pinpoint which factor had biggest impact
Shi (1993)	County government (various occupations represented)	205 workers	Education, back safety training, physical fitness activities, equipment/facility improvements (e.g., additional material handling equipment)	Back pain prevalence declined modestly; significant improvement in satisfaction and a reduction in risky behavior were reported; a savings of $161,108 was realized, giving a 179% return on the investment	
Wickstrom *et al.* (1993)	Ventilation equipment manufacturing plant	800 employees		Low back pain due to work decreased from 56% in 1986 to 35% in 1988 to 29% in 1990	
Reynolds *et al.* (1994)	Apparel manufacturing	18 operators	Introduced height-and tilt-adjustable work stands, additional jigs, antifatigue mats, and automatic thread cutters	Body part discomfort reduced in shoulders-arms and hands-wrists; no injury costs incurred in 5 months following intervention	Used participative approach; productivity significantly increased after intervention
Aaras (1994)	Telephone exchange manufacturing; office	96 workers (divided into 4 groups)	Provided adjustable workstations and additional work space; tools were suspended and counterbalanced	Significant reduction in intensity and duration of neck pain reported after intervention	Reductions in static trapezius load after intervention were confirmed via EMG

(*continued*)

TABLE 2. (Continued)

Study	Industry	Study Group	Intervention Method	Summary of Results	Additional Comments
Moore (1994)	Automotive engine and transmission manufacturing	Five workers	Eliminated manual flywheel truing operation by implementing a mechanical press	29% decrease in musculoskeletal disorders, 78% decrease in upper extremity CTDs, 82% reduction in restricted or lost work time	Used participatory (team) approach to select intervention method
NIOSH (1994)	Red meatpacking	Three beef/pork processing companies	Implemented participatory (labor management) ergonomics program	Results varied: only two teams able to introduce changes to address identified problems; some evidence that incidence/severity of injury was reduced following introduction of an ergonomics program	Additional follow-up needed to evaluate intervention effectiveness

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EDITORIAL NOTE: Kathy Grant and Dan Habes are industrial engineers in the Applied Psychology and Ergonomics Branch of the Division of Biomedical and Behavioral Sciences at the National Institute for Occupational Safety and Health.