

T A B L E 14.9

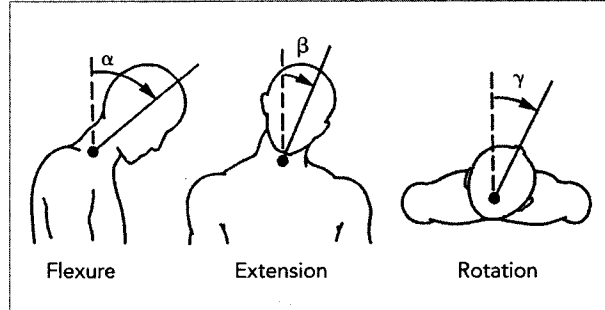
Sample checklist for upper extremity cumulative trauma disorders (Lifshitz and Armstrong, 1986). A "no" indicates a risk factor. Checklist was tested only in an automobile final assembly plant.

NO	YES	RISK FACTORS
Physical Stress		
<input type="checkbox"/>	<input type="checkbox"/>	1. Can the job be done without hand/wrist contact with sharp edges?
<input type="checkbox"/>	<input type="checkbox"/>	2. Is the tool operating without vibration?
<input type="checkbox"/>	<input type="checkbox"/>	3. Are the worker's hands exposed to temperatures > 70° F (21° C)?
<input type="checkbox"/>	<input type="checkbox"/>	4. Can the job be done without using gloves?
Force		
<input type="checkbox"/>	<input type="checkbox"/>	1. Does the job require exerting less than 10 lbs (4.5 kg) of force?
<input type="checkbox"/>	<input type="checkbox"/>	2. Can the job be done without using a finger pinch grip?
Posture		
<input type="checkbox"/>	<input type="checkbox"/>	1. Can the job be done without wrist flexion or extension?
<input type="checkbox"/>	<input type="checkbox"/>	2. Can the tool be used without wrist flexion or extension?
<input type="checkbox"/>	<input type="checkbox"/>	3. Can the job be done without deviating the wrist from side to side?
<input type="checkbox"/>	<input type="checkbox"/>	4. Can the tool be used without deviating the wrist from side to side?
<input type="checkbox"/>	<input type="checkbox"/>	5. Can the worker be seated while performing the job?
<input type="checkbox"/>	<input type="checkbox"/>	6. Can the job be done without a clothes-wringing motion?
Workstation Hardware		
<input type="checkbox"/>	<input type="checkbox"/>	1. Can the worksurface orientation be adjusted?
<input type="checkbox"/>	<input type="checkbox"/>	2. Can the worksurface height be adjusted?
<input type="checkbox"/>	<input type="checkbox"/>	3. Can the tool location be adjusted?
Repetitiveness		
<input type="checkbox"/>	<input type="checkbox"/>	1. Is the cycle time longer than 30 s?
Tool Design		
<input type="checkbox"/>	<input type="checkbox"/>	1. Are the thumb and finger slightly overlapped in a closed grip?
<input type="checkbox"/>	<input type="checkbox"/>	2. Is the tool handle span between 2 and 2.75 inches (5 and 7 cm)?
<input type="checkbox"/>	<input type="checkbox"/>	3. Is the tool handle made from material other than metal?
<input type="checkbox"/>	<input type="checkbox"/>	4. Is the tool weight below 9 lbs (4 kg)? Note exceptions to the rule.
<input type="checkbox"/>	<input type="checkbox"/>	5. Is the tool suspended?

Source: Adaptation of Table 1 in "A Design Checklist for Control and Prediction of Cumulative Trauma Disorder in Hand Intensive Manual Jobs" by Yair Lifshitz and Thomas J. Armstrong, in *Proceedings of the Human Factors Society 30th Annual Meeting*, 1986. Thomas J. Armstrong, Dept. of Environmental and Industrial Health, University of Michigan, 1205 Beal Ave., Ann Arbor, MI 48109-2117; 734/763-3742, fax 734/764-3415; tja@umich.edu. Copyright © 1986 by the Human Factors and Ergonomics Society. All rights reserved.

F I G U R E 14.8

Neck postures (Hidalgo et al., 1992). For flexion, neutral is $-15^\circ \leq \alpha \leq 15^\circ$; moderate is $15^\circ \leq \alpha \leq 45^\circ$; severe is $\geq 45^\circ$. For extension, neutral is $\beta \leq 15^\circ$; moderate is $\geq 15^\circ$. For rotation, neutral is $\gamma < 15^\circ$. See also Table 14.10.



Source: J. Hidalgo, A. Genaidy, R. Huston, and J. Arantes, "Occupational Biomechanics of the Neck: A Review and Recommendations." *J. of Human Ergology*, Vol. 21, pp. 165-81. Copyright © 1992 by Center for Academic Publications, Tokyo. Reprinted with permission.

Can feet or torso be repositioned to reduce stretching? Welders have many shoulder problems because they hold a relatively heavy object in a precise location (i.e., static load). Consider a balancer for the welding equipment. If a guard must be lifted, can it be counterbalanced?

When push or pull movement is needed, push or pull below the shoulder and above the hip, because in this range the muscles are strongest. When cutting with a knife, have the cutting edge down. Cutting away from or toward the body has twice the strength of cross-body motions.

Valves require a torque to open and close. Therefore, determine whether the moment arm can be increased so the force is less; don't ignore valve maintenance to reduce required torque.

Note that even if the hand is empty, an arm is about 4.9% of body weight. Consider supporting this weight. For example, can the arm rest on a support when using a VDT mouse?

Shoulder symptoms probably will differ for static and dynamic work (Torner et al., 1991).

Reduce dynamic loads by using the guidelines in Chapter 15, Manual Handling. Can motors instead of muscles furnish the power? Can two surfaces be the same height so sliding replaces lifting? Can a short section of gravity roller conveyor bridge the gap between the workstation and a powered takeaway conveyor—thus permitting sliding instead of lifting? Sometimes force requirements can be reduced by maintenance, such as sharpening equipment (drills, knives) and properly lubricating equipment. (hand-tools, valves) or product (to reduce sticking).

T A B L E 1 4 . 1 0

Posture checklist (Keyserling et al., 1992) for neck, trunk, and legs. A zero indicates insignificant risk. An X indicates a potential risk. An asterisk indicates a significant risk.

Job Studied	PERCENT TIME POSTURE USED IN JOB		
	Never	<1/3	>1/3
Neck			
1. Mild forward bending (>20°)	0	0	X
2. Severe forward bending (>45°)	0	X	*
3. Backward bending (>20°)	0	X	*
4. Twisting or lateral bending (>20°)	0	X	*
Trunk			
5. Mild forward bending (>20°)	0	X	*
6. Severe forward bending (>45°)	0	*	*
7. Backward bending (>20°)	0	X	*
8. Twisting or lateral bending (>20°)	0	X	*
General body/legs			
9. Standing stationary (no walking or leaning)	0	0	X
10. Standing, using footpedal	0	X	*
11. Knees bent or squatting	0	X	*
12. Kneeling	0	X	*
13. Lying on back or side	0	X	*
Total X = _____	Total * = _____		

Comments:

Source: M. Keyserling, M. Brouwer, and B. A. Silverstein, "A Checklist for Evaluating Ergonomic Risk Factors Resulting from Awkward Postures of the Legs, Trunk, and Neck." *Int. J. Industrial Ergonomics*, Vol. 9, pp. 283-301. Copyright © 1992 by Elsevier Science, Amsterdam, Netherlands. Reprinted with permission.

For the neck, the load typically is static (e.g., microscope or VDT work). Waersted and Bjorklund (1991) pointed out that mental effort increases muscle tension, adding to the biomechanical force requirements. Helander et al. (1991) gave suggestions for improving microscope work.

3.2.2 Administrative solutions See Section 1.3.2.

4 BACK

4.1 Problem Musculoskeletal disorders of the back occur primarily from manual material handling, although some problems arise from body

movement without a load. Back problems also can occur from lack of movement, such as from sitting.

Khalil (1991) gave some statistics:

- On any given day, 6,500,000 people in the United States are in bed with back pain.
- 75,000,000 Americans have back pain problems.
- In industrialized societies, 80% of working adults will develop back pain during their career.
- In the United States, only colds cause more physician visits than back pain. An estimated 50% of all chiropractor visits are due to low-back symptoms.

In 1988, estimated total compensable cost of low-back disorders in the United States was \$15.3 billion. In 1988, 35% of all Liberty Mutual workers compensation claim costs were for low-back disorders. About 1/3 of the costs were for medical treatment and 2/3 for lost wages. The cost distribution is quite skewed, with 25% of the cases accounting for 95% of the costs: average cost/claim = \$7,400, while median cost = \$360 (Snook, 1991). (*Statistical note:* For the median, the sum of the deviations of individual values from the median equals zero. For the mean, the sum of the deviations squared is a minimum; the exponent of 2 emphasizes "outliers.")

Snook (1991) pointed out a hierarchy of low-back problems:

1. low-back **pain**
2. low-back **impairment** (reduced ability to perform various musculoskeletal activities)—experienced by about 11% of U. S. working population
3. low-back **disability** (time lost from the job or assignment to restricted duty)—experienced by about 2% of workers each year
4. low-back **compensation** (reimbursement for medical costs and lost wages)—about .75 claims presented each year/100 workers with approximately a 10-1 range from the best to worst industry

4.2 Risk Factors Khalil (1991) gave risk factors for low-back pain (LBP):

- individual physical factors (e.g., weight, physique, age, gender, flexibility)
- psychological factors (e.g., depression, anxiety, job dissatisfaction)
- task demand factors (e.g., posture, speed, repetition, twisting, prolonged sitting or standing)
- environmental factors (e.g., workplace design, slippery floors, distractions, bulky containers)

For another review of risk factors, see Pope et al. (1991).