Computer Ergonomics Programs

Risk-based approaches maximize their impact

By Hank McDermott, Kimberly Lopez and Brett Weiss

USING RISK-BASED ERGONOMICS PROGRAMS, an employer can target interventions toward workers who are in higher risk categories rather than toward the entire employee population. Such programs also optimize the allocation of ergonomic resources. Valid risk assessment tools are available for computer users—ranging from workstation survey forms to web-based applications. These tools can help determine relative risk from factors such as workstation setup, workload, behavioral issues, history of ergonomic problems and other confidential nonmedical information.

The risk assessment step is usually one element of an overall computer ergonomics program and serves to drive the other components. Once the individual's risk category (low, moderate or high) is known, appropriate follow-up measures can be implemented depending on the extent of ergonomics hazards. In some cases, the risk category is used mainly to identify which workstations should be evaluated by a professional ergonomist. In workplaces with a history of computer-related RSIs or where high risk factors are present, aggressive preventive measures can be implemented based on an employee's risk category. These measures include risk-specific training, ergonomic-friendly equipment and software, and preventive wellness referrals for strengthening and limbering plans. Low-risk category employees may not require any follow-up, except perhaps ergonomics awareness training.

Experience has shown that a risk-based program is effective in reducing repetive stress injuries (RSI) risk (with significant reduction in the number of employees in the high- and moderate-risk categories after 15 months of follow-up interventions); reducing workers' compensation (WC) costs; and in targeting preventive resources. In one company, initial results (over two years) showed a significant reduction in RSI-related WC costs per case and lost workdays per case where a comprehensive risk-based program was fully implemented. Additional benefits included improved awareness of ergonomic risks and fostering a culture in which employees report discomfort immediately; this allowed the employer to respond quickly with appropriate specialists and supervisory support to resolve the discomfort before an injury developed.

Risk-Based Programs

SH&E professionals recognize the value of risk-based preventive programs. In situations in which relative risk to specific employees or employee groups from a "potential hazard" can be quantified, those at higher risk can be targeted with more rigor-

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ous protective measures than can be justified for the entire employee population.

The hearing conservation program required by OSHA standards is an example of a risk-based approach. Employers must evaluate the noise dose of employees exposed to noise above 80 dB, with protective measures keyed to the measured dose (Table 1) (OSHA). Many driving safety programs are also based on relative risk. Fleet and high-mileage drivers with high "exposure" may receive intensive behind-the-wheel training with periodic "check rides" by a driver trainer or supervisor, while employees who use company vehicles infrequently may receive awareness and accident avoidance training during a safety meeting or in a classroom session.

Table 1

Risk-Based Actions Required by OSHA's Hearing Conservation Standard

Relative Risk of Occupational Hearing Loss		
Low(<85 dBA)	**Moderate(≥85-90 dBA)**	**High(>90 dBA)**
•Remonitor exposures if noise levels increase.	•Annual training. •Annual audiograms to detect hearing loss. •Voluntary use of hearing protectors.	•Install feasible engineering controls. •Annual training. •Annual audiograms to detect hearing loss. •Mandatory use of hearing protectors.

Risk-based programs help to optimize use of resources, and also avoid the "one size fits all" perception that often fails to engage employees and management when everyone receives the same follow-up—regardless of risk. For example, using the driving safety scenario, if all employees were to receive the intensive training required for high-exposure drivers, available resources would likely be diverted from other safety efforts that have more impact on protecting people. In addition, the occasional drivers and their supervisors might display a lackluster commitment to the intensive training if they feel it is a poor use of their time.

In some situations, a risk-based approach is not a good choice: 1) where no valid method to measure relative risk exists; and 2) when the cost of tracking employees by risk category and implementing different levels of controls is not justified by the savings offered by a risk-based program.

Risk-based programs can be successfully applied in preventing RSIs from computer use. These musculoskeletal injuries are due to conditions such as awkward postures, repetitive motions, contact stress, forceful exertion and excessive task duration (see "Computer-Related" sidebar on pg. 36). Although the extent of these injuries among computer users is a controversial topic, it is clear that the conditions of many computer-intensive jobs can lead to RSIs unless adequate protective measures are in place.

Risk Assessment Tools

Risk assessment tools can help determine risk from factors such as workstation setup, workload, behavioral issues and history of ergonomic problems. Most of these tools are derived from a survey technique called rapid upper limb assessment (RULA) that was developed at the University of Nottingham's Institute of Occupational Ergonomics (McAtamney and Corlett). RULA assesses an individual's exposure to postures, forces and muscle activities that have been shown to contribute to RSIs, with particular attention to the neck, trunk and upper limbs. Reliability studies conducted on groups of computer users and sewing machine operators confirmed the validity of this technique. A RULA results in a "relative risk" score—a higher score signifies greater levels of apparent risk. It is important to note that RULA is a screening tool; a low score does not guarantee that the work environment is free of ergonomic hazards. Additionally, most risk assessment tools automatically place the worker in the high-risk category if s/he reports significant discomfort from computer use even if the screening score for other risk factors is low.

Computer risk assessment tools vary in complexity—from workstation survey forms that contain a risk scoring system to be completed by the employee, a trained observer or an ergonomic professional, to sophisticated web-based applications completed by employees online (NIOSH). Figure 1 is an excerpt from a typical survey form; the entire survey evaluates the risk factors listed in Table 2.

With a survey form, a simple scoring system involves adding the rating for each item to yield a total score, while computer-based systems can apply more complex algorithms based on the interaction of multiple risk factors. Web-based tools offer powerful features in addition to the basic risk assessment function:

•ergonomic injury risk assessment (initial and periodic);

•instructions to employees on proper workstation adjustment;

•initial training on ergonomic principles and risk factors;

•links to outside training modules and resources;

•tailored communications and reminders to employees and supervisors;

•data management to track resolution of issues and recalculate risk category.

In addition, employees may be granted access to web-based applications from their home computers so they can assess the adequacy of their home offices, which may reduce the risk of off-the-job injuries; this also allows family members to participate in this safety awareness and intervention initiative.

The final risk assessment (whether through a survey form or a web application) places the employee in a relative risk category (low, moderate or high) after easy-to-handle workstation adjustment and similar issues have been resolved. These broad risk categories are sufficient for the purposes of the assessment, which are to focus preventive follow-up measures, effectively allocate resources and heighten awareness among employees of the risk factors impacting RSIs.

Computer-Related Repetitive Stress Injuries

Repetitive stress injuries (RSIs) are musculoskeletal disorders due to an accumulation of very slight traumas to bone, muscle, connective tissues and nerves that eventually cause pain, numbness, loss of motion, weakness, swelling and other symptoms. The body parts most commonly involved are the fingers, wrists, elbows, shoulders, neck, spine, knees and ankles.

Although excessive and/or repetitive forces are the best known causal factors, reduced blood circulation due to poor posture, stress-induced muscle tension or sustained muscle contraction (static position) also play a role. Reduced blood flow prevents oxygenation of cells and the removal of waste products from cell biological activity. Static position can also prevent lubrication of joints that normally occurs from adjacent tissue.

Common repetitive stress injuries associated with computer use include:

- **Bursitis:** Inflammation of the lubrication-tissue lined sac that facilitates motion of tendons, usually near a joint. It can occur in most joints, but commonly in the elbow and shoulder due to compression of the bursa sac due to mousing, keying and tasks involving overhead work. It can also be caused by an adjacent irritated tendon (see tendinitis).
- **Carpal Tunnel Syndrome:** Tingling, pain or numbness in thumb and first three fingers due to compression of median nerve as it passes through a bony "tunnel" in the wrist. Caused by tasks such as typing, keying, mousing, assembly work, hand tool use, playing musical instruments, hammering and meat cutting.
- **Cubital Tunnel Syndrome:** Tingling, pain or numbness radiating into ring and little fingers due to compression of the ulnar nerve below the notch of the elbow (i.e., at the "funny bone"). Caused by resting the forearm on a hard edge or surface.
- **Epicondylitis (tennis elbow):** Irritation of the tendons attaching the upper arm bone at the elbow. Caused by tasks such as mousing, typing, playing musical instruments, hammering and assembling small parts.
- **Tendinitis:** Irritation of a tendon (fibrous component of muscle tissue), often where it attaches to a bone. The tendon may become thickened, frayed or hardened. This condition has specific names depending on the location (e.g., rotator cuff syndrome in the shoulder). Caused by tasks that require continuous tension, motion and bending of upper extremities such as mousing, keying, using pliers, and assembly work. Rotator cuff syndrome is associated with continuous effort to keep the arm elevated such as overhead painting or welding.
- **Thoracic Outlet Syndrome:** Arm numbness and restricted muscle activity due to reduced blood flow caused by compression of nerves and blood vessels between the collarbone and first two ribs. Caused by tasks such as mousing, keying, materials handling, carrying heavy loads with extended arms and using power hand tools.

Risk-Based Computer Ergonomics Program

As noted, the risk assessment step is usually one element of an overall computer ergonomics program and serves to drive the other components. The scope of the ergonomics program can vary greatly depending on extent of hazards and other factors. In some cases, the risk category is used mainly to determine which workstations need to be evaluated by a professional ergonomist, with any subsequent actions following the ergonomist's recommendations. In other workplaces, particularly those with history of computer-related RSIs or high risk factors, aggressive preventive measures can be implemented depending on an employee's risk category.

The components of a comprehensive program typically encompass the following (Figure 2):

- **Risk assessment and initial training.** All workers who use a computer complete the risk assessment and receive initial training on RSI risk factors and prevention, and repeat the risk assessment module periodically to detect any change in risk factors.
- **Risk-based training.** Additional risk-specific training can be provided to people in the high- and moderate-risk categories for tasks such as software applications that require extensive mouse use, and use of a laptop computer in various settings.
- **Ergonomic controls.** Feasible engineering, administrative and work practice preventive measures can be applied depending on risk category and their relevance to the employee's job duties (see "Typical Aggressive" sidebar on pg. 38).
- **Behavioral safety process.** "Behavioral safety" means use of a structured process that applies sound behavioral principles (e.g., setting people up to perform safely and providing immediate positive reinforcement) in order to identify key workstation behaviors; ensure that all individuals understand these behaviors; and provide positive reinforcement for safe behaviors and helpful coaching for at-risk actions (Daniels). These processes can increase awareness of RSI factors, encourage safe workstation behaviors and promote employee involvement (Krause).

If warranted by the extent of the computer ergonomic hazards, these processes are often implemented for computer users in facilities that have experience with behavioral safety for operations, crafts and other "field" jobs. The risk assessment tool can provide a tailored list of key behaviors for each employee such as taking adequate mini-breaks; performing recommended stretching exercises; using minimum keystroke pressure; and proper use of ergonomic aids such as a document holder.

- **Early discomfort reporting and rapid interventions.** A critical component of RSI prevention is the ability to quickly identify and provide additional corrective measures for computer users who experience even minor discomfort. In many workplaces, employees tend to "wait and see" or work through discomfort. The importance of reporting initial discomfort must be stressed. Employees better recognize this when they understand the cumulative nature of these injuries and the need to take immediate preventive action, and when supervisors and managers respond promptly to reports of initial discomfort.

The "rapid intervention" phase includes all of the coordinated actions that occur once an employee reports discomfort or a more serious condition. The primary goal of this phase is to resolve discomfort before it progresses into injury. Since discomfort automatically places the employee in the high-risk category, many steps during this phase mirror the risk-based measures described under earlier elements, with an added sense of urgency to perform further evaluation and to implement additional corrective measures. Throughout the rapid intervention phase, consistent follow-up is essential to gauge progress in resolving employee discomfort. If discomfort increases or is not significantly resolved, the employee is referred to a qualified healthcare professional for further evaluation and possible medical treatment. During this phase, all applicable workers' compensation rules, occupational safety and health regulations, and medical confidentiality requirements must be carefully followed.

•**Metrics and process evaluation.** A mix of process (implementation) metrics and outcome (result) measures can be valuable in showing the impact of the program. Incidence rates for RSIs and breakdown of employees in each risk category can be tracked along with process measures such as number of employees at different stages of program implementation; number of resolved ergonomic issues; and output from the behavioral safety process. Many data elements tracked by a web-based risk assessment tool can represent potentially powerful metrics as identified issues are corrected and as employees move to a lower risk category. Experience shows that emphasizing process metrics rather than outcomes during initial program implementation may be beneficial, since RSI incidence rates may increase over prior periods as people with existing discomfort or symptoms are identified.

Periodically evaluating the overall RSI prevention process is critical to ensuring that it is effectively addressing specific ergonomic hazards and efficiently achieving the desired results. Evaluation can involve surveying a sample of employees; reviewing process elements to ensure that they are functioning effectively; and verifying that the implementation and outcome objectives are being attained. The occurrence of an RSI does not in itself mean that the program is ineffective, but a root-cause analysis of RSI cases can help identify early trends or possible gaps in the program or its implementation.

Figure 1

Excerpt of Workstation Risk Assessment Tool

Computer Ergonomics Risk Assessment

Directions: check the box next to the observation or condition:

1) Do you have any discomfort in your body such as shoulders, arms, wrist, hands, etc., when working on the computer?

❏ Yes ❏ No

2) On a typical day, how many hours do you work on the computer?

❏ < 2 hours (0 points) ❏ 2 to 6 hours (3 points) ❏ > 6 hours (5 points)

3) How often do you get up from your desk (e.g., walk to a meeting, go to a fax/copy machine, etc.) or alternate tasks (e.g., from computer work to phone work or handwriting, etc.) during a typical workday?

❏ At least once every hour (0 points)
❏ Once every two hours (3 points)
❏ Once every three hours (5 points)

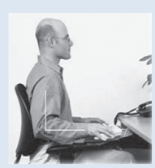
4) Do you commonly cradle the telephone between your ear and shoulder?

❏ Yes (5 points) ❏ No (0 points)

5) Do you commonly type from documents that lie flat on the desk?

❏ Yes (5 points) ❏ No (0 points)

6) Which picture best describes your arm position while working at the computer:



❏ (0 points) ❏ (3 points) ❏ (5 points)

•**Supporting processes** highlight the need to align groups such as computer resources, workstation designers, medical services, human resources, safety and industrial hygiene, training, wellness and workers' compensation to support the RSI prevention effort. This can be a fruitful area to examine since many organizations with effective RSI prevention efforts have a high degree of standardization and integration of supporting processes.

Managing the Cost of Ergonomic Interventions

Although protecting people is the primary reason for all SH&E programs, SH&E professionals must consider costs and budget constraints. Risk-based concepts can help the SH&E professional protect people while carrying out their financial management responsibilities. Low-risk category employees may need no further attention, so in workplaces with low ergonomic hazards the risk assessment can verify the absence of hazards and need for additional expenses. Risk assessment results can also help prioritize actions for those in the moderate- and high-risk categories, and help identify alternate intervention strategies that result in comparable risk reduction. For example, if chair-related issues contribute to higher risk for many employees, the detailed risk assessment data can be used in preparing an affordable multiyear plan involving ergonomic accessories such as lumbar support cushions and footrests, as well as programmed purchase of ergonomic chairs.

Case Study: Successful Application of a Risk-Based Ergonomic Program

From 1995 to 1999, a multinational petroleum firm found that computer-related RSIs accounted for more than 25 percent of total recordable cases among some 25,000 U.S. employees. The company recognized the need to prevent these injuries, since they represented both a major safety risk to office-based employees and a threat to the corporate strategy of being a recognized safety leader. Many of the firm's business units had made conscientious efforts to implement office ergonomic programs during this period with mixed results. In 2001, a companywide risk-based ergonomic program was implemented using the elements

Table 2

Factors Impacting Risk Category

Factor	Lower Risk	Higher Risk
Existing discomfort or stiffness?	No	Yes
Time/day at computer	<2 hours	>6 hours
Frequency of mini-breaks during day	>1 per hour	<1 per 2 hours
Is phone cradled between ear and shoulder?	No	Yes
Type from documents lying flat on desk?	No	Yes
Is head positioned over spine?	Yes	No
Do elbows form 90-degree angle?	Yes	No
Are wrists in neutral position on keyboard?	Yes	No
Is keystroke pressure gentle?	Yes	No
Do knees form 90-degree angle?	Yes	No
Do back of knees touch seat pan?	No	Yes
Position of spine	Vertical	Leaning
Is head tilted when viewing monitor?	No	Yes, upward
Bifocal or trifocal use that results in head tilt?	No	Yes
Is monitor directly to front?	Yes	No
Do feet rest on comfortable surface?	Yes	No

shown in Figure 2. While local business units had flexibility on how to implement the program, employees who used a computer at work were to complete a risk assessment and apply preventive measures from the sidebar below. These measures were:

•required for high-risk category employees if the measure was relevant to their job duties;

•mutually decided by worker and supervisor based on RSI risk factors for those in moderate-risk category;

•optional depending on available resources or not applied for low-risk category workers. Under the program, such employees did not require follow-up after completing the risk assessment/initial training step, except to periodically repeat the assessment to ensure that risk factors had not increased.

To maximize impact of the initiative, supervisors held one-on-one meetings with each moderate- or high-risk category worker to determine the appropriate preventive measures for that individual. The agreed-upon action steps were included in the employee's annual work plan used for performance evaluation and salary action where appropriate.

Data for a cohort of about 700 employees in computer-intensive jobs show:

•**Reduced RSI risk.** Figure 3 shows the breakdown by risk category for the 700 employees. The initial risk category breakdown (first bar) was almost an equal split between the three risk categories. After one year of preventive follow-up steps, employees in high- and moderate-risk categories dropped to about 21 percent each, while 58 percent were at the low-risk level (middle bar, Figure 3). After 15 months of follow-up (latest data available), the risk levels dropped further, with about 17 percent in each of the high- and moderate-risk categories, and two-thirds of the employees in the low-risk category.

•**Reduced WC costs.** For cases that did develop in the cohort which implemented the program, the average WC cost per claim was less than or equal to 40 percent that of groups which had not yet begun implementation, while the average number of lost workdays per case among the cohort was less than half that of other groups. The absolute number of recordable cases in the cohort also dropped compared to earlier years, but the incidence rate was considered a less-reliable indicator of program impact at this point than WC data, since incidence rates fluctuated as people with existing symptoms were identified during initial program implementation.

•**Targeted preventive resources.** Companywide, nearly 21 percent of employees fell in the high-risk category and required aggressive interventions. About 22 percent were in the moderate-risk category, and required focused follow-up based on relevant risk factors. The 57 percent in the low-risk category were included in ongoing awareness efforts plus other measures as resources allowed. To illustrate potential cost savings, excluding low-risk employees from follow-up workstation surveys could save more than $500,000 (assuming a cost of $50 per evaluation by a contract ergonomist), compared to a program in which all employees received an on-site workstation ergonomics evaluation.

•**Engaged employees.** In a "satisfaction" survey, 91 percent of employees felt that the program helped

Typical Aggressive Ergonomics Interventions

•Workstation evaluation by an ergonomics professional, with recommendations implemented.

•Ergonomics aids such as alternate keyboards and secondary input devices, footrests, lumbar support and document holders.

•Special laptop computer accessories (full-size keyboard, etc.) for laptop computers used away from a docking station.

•Use of "break" reminder software.

•Ergonomic-friendly software, including voice-activated applications.

•Use of programmed macros to reduce the number of "point and click" steps.

•"Computer" prescription eyewear if eye strain is an issue.

•Preventive referral to wellness specialist for strengthening or limbering plan.

them to work more comfortably at their computer.

In addition to these tangible results, company supervisors, managers and SH&E professionals found that the risk-based program:

•Helped elevate RSI risks to the same level of awareness and response as other serious safety or health risks, such as chemical overexposure or confined space entry.

•Fostered a culture in which employees report discomfort immediately (rather than waiting for significant discomfort or pain). Company experience showed that early intervention was a critical factor in preventing development of an RSI.

•Allowed the company to respond rapidly with appropriate specialists and supervisory support when discomfort was reported to prevent development of an RSI.

•Reinforced proper behaviors through behavioral safety techniques and line-management accountability to engage all individuals in preventing RSIs. Personal responsibility and positive reinforcement were recognized as key contributors to success in this area.

Figure 2

Risk-Based Computer Ergonomics Program

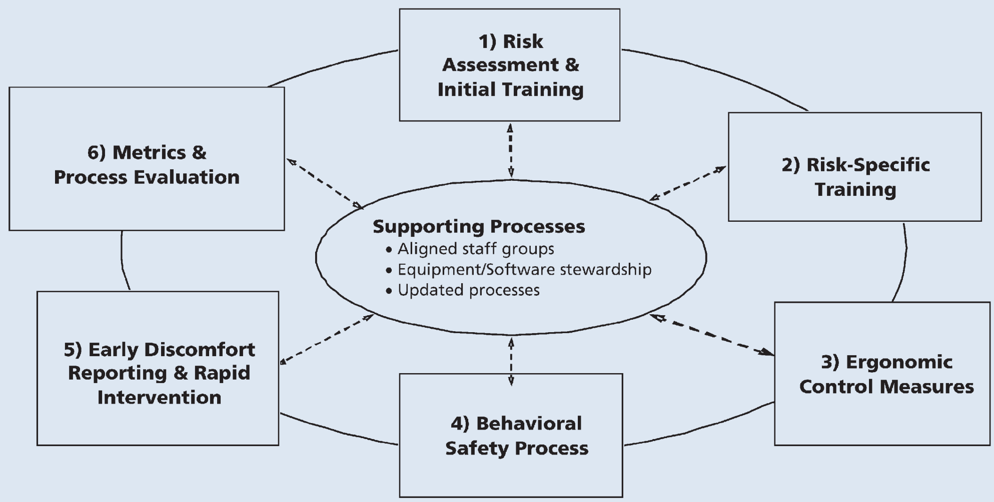
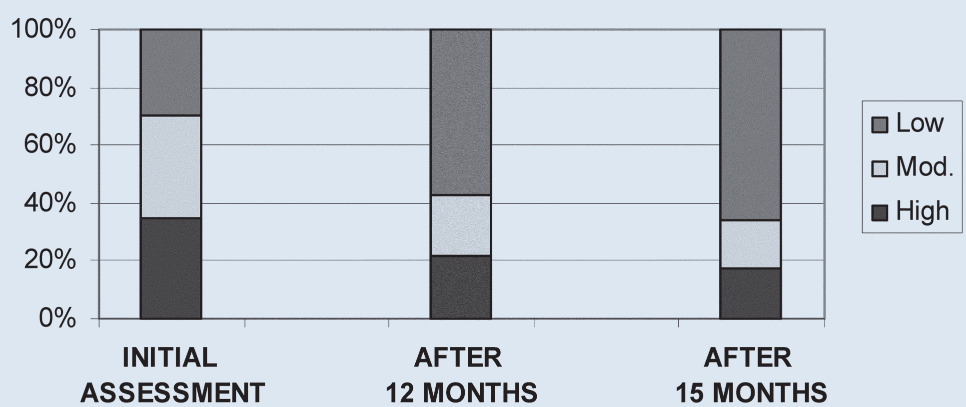


Figure 3

Employee Risk Category Over Time



Conclusion

Risk-based programs that target preventive measures toward individuals at higher relative risk result in efficient allocation of resources, and allow more rigorous protective measures for higher-risk individuals than can be justified for the entire employee population.

Valid risk assessment tools exist for computer-related ergonomic risks that range in complexity from workstation survey forms to web-based applications. When used as part of a comprehensive computer ergonomics program, the risk assessment tool drives many components of the program to realize the benefits detailed in this article. Web-based tools offer other powerful features in addition to an advanced risk assessment function, including instructions to employees on proper workstation adjustment; initial training on ergonomic principles and risk factors; links to outside training modules and resources; tailored employee communications and reminders; and data management capability to track issue resolution and automatically adjust each employee's risk category. ■

References

Daniels, A.C. *Bringing Out the Best in People.* New York: McGraw Hill, 2000.

Krause, T.R. *The Behavior-Based Safety Process.* New York: Van Nostrand Reinhold, 1997.

McAtamney, L. and E.N. Corlett. "RULA: A Survey Method for the Investigation of Work-Related Upper Limb Disorders." *Applied Ergonomics.* 24(1993): 91-99.

NIOSH. "Elements of Ergonomic Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders." DHHS (NIOSH) Publication No. 97-117. Cincinnati: NIOSH, 1997.

OSHA. "Occupational Noise Exposure." 29 CFR 1910.95. Washington, DC: U.S. Dept. of Labor, OSHA.