Dear Readers

Computer technologies have revolutionized our ability to capture, process, communicate, and manipulate information, but along with these efficiencies have come increased reports of upper-extremity musculoskeletal discomforts. Although research has not proven the existence of a causal link, extensive evidence suggests that computer use can be harmful to workers’ well-being and performance. Our research into office ergonomics interventions attempts to address these issues.

Many things can impact worker safety during computer use—input devices, furniture, postures, visual environments, task design, and organizational and psychosocial factors. Our findings have provided compelling evidence that appropriate workstations, combined with comprehensive, interactive ergonomics training and management support, can reduce musculoskeletal discomfort among computer users. Next, we will look at developing computer-based training to examine safety concerns in non-traditional settings, such as telework.

As always, we welcome your feedback and suggestions.

Ian Noy, Ph.D.
Vice President and Director

Letter from the Director
In the early 1980s, personal computing technology began a rapid migration into the workplace and began transforming the way Americans work. Today, there are tens of millions of computers in use in workplaces across the United States on any given day. Not surprisingly, society’s growing dependence on computers has seen a concurrent rise in reports of work-related musculoskeletal discomforts of the upper extremities and neck—especially in computer-intensive jobs such as data processing, software programming, word processing, and customer service.

Although there is general agreement that pain and discomfort associated with computer use can negatively impact worker well-being and performance, a definite causal link between computer use and musculoskeletal injuries has eluded scientists. “My own view is that, among some intensive computer users, there is a progression from discomfort to pain,” explains Marvin Dainoff, Ph.D., director of the Research Institute’s Center for Behavioral Sciences (CBS). “Our research looks at various factors related to office ergonomics and seeks ways to help workers work more comfortably and efficiently, thus avoiding that progression to pain.”

Office ergonomics research examines the nature of the “fit” between the worker and the workspace in an effort to understand and address the worker’s physical comfort. “We need to examine what kinds of adjustability are needed to allow workers—who vary widely in body dimensions—to maintain comfortable working postures. It is clearly not a one-size-fits-all science,” explains Dr. Dainoff, who goes on to point out that addressing the physical aspects of the work is only part of the solution to discomfort.

“The research tells us that simply providing adjustable furniture is not effective,” notes Dr. Dainoff. “Ergonomic furniture should be accompanied by well-designed and tested interventions and training.” He adds that it is critical that the employer understand the organizational context within which ergonomic interventions and training are implemented. “This context is best understood through a sociotechnical systems approach that jointly considers the people, technology, work processes, and management structure necessary to achieve overall safety goals,” he explains.

Over the years, CBS researchers have conducted several field studies, as well as an extended laboratory study, to examine the use and impact of flexible workspaces and systematic training among large groups of office workers. Unlike most research in this area, the CBS studies involved both intervention and non-intervention (control) groups, allowing for comparisons of findings among the two groups. In addition, researchers followed workers over extended time periods (ranging from 12 to 18 months) and collected data both pre- and post-intervention. This longitudinal research approach, unlike the more common cross-sectional approach, allowed researchers to investigate and better understand the long-term, cumulative effects of interventions.

“As we gain insights into physical, social, and organizational factors that affect computer users in the workplace, we will continue to refine ergonomic recommendations to help ensure optimal outcomes in terms of worker comfort, safety, and performance,” concludes Dr. Dainoff.
Do Training and Equipment Help Reduce Musculoskeletal Symptoms?

As early as the 1930s, US government and military personnel were using computers to perform census counts and defense work. Of course, those highly specialized “dinosaurs” had little resemblance to the streamlined, mass-produced, multi-functional computers that more than half of US workers routinely use on the job today. Over the past few decades, computers have dramatically changed the way we work, while at the same time prompting increased reports of computer-related physical discomfort. The change has spawned significant research aimed at understanding and addressing these new health and safety concerns.

In the late 1970s and early 1980s, researchers focused on how computers were changing physical demands and job tasks in the workplace. Studies in the late 1980s linked physical symptoms (that is, musculoskeletal and visual discomforts) with intensive computer use and compelled scientists to begin to explore ways in which to manage risks in computing work environments. In the 1990s, researchers began to examine the effects of office ergonomics interventions (such as adjustable equipment, flexible/moveable workspaces, rest breaks, and training) on worker health and performance.

In 2000, the Liberty Mutual Research Institute for Safety began a long-term, in-depth research program to evaluate various office ergonomics interventions. With the University of Houston and, later, with the Institute for Work and Health (Toronto, Canada), Liberty Mutual researchers began a series of controlled, longitudinal field intervention studies involving more than 600 intensive computer users (defined as those who performed more than four hours of computer work per day).

“Unlike most office ergonomics intervention studies, we applied a systems approach, both to study the problem and to design the workplace interventions. We considered not just physical factors, but also environmental, organizational, and job-related factors,” says Michelle Robertson, Ph.D., CPE, a research scientist for the Institute’s Center for Behavioral Sciences (CBS).

CBS researchers designed a unique investigative approach that can be replicated in various organizational settings. A central component of this approach involves a comprehensive office ergonomics training program that is designed to impart technical knowledge and increase workers’ understanding of the risks associated with computer work. The training incorporated background data about companies’ ergonomics programs and the role of management and included practice sessions and periodic follow-up communications to remind workers of what they had learned. “Our goal was to give workers instruction on how to appropriately use their workplace setup, and to help them understand why they should be motivated to implement the ergonomic changes,” explains Dr. Robertson. “We hypothesized that, when people are engaged in and learn from the training, they will change their computing behaviors in ways that positively impact safety and performance.”

Field Study I

In 2008, Applied Ergonomics published the first of several papers from the study series. The paper reported the long-term effects of flexible workspaces and comprehensive ergonomics
training among 197 intensive computer workers in a public-sector accounting firm. For this study, researchers assigned one of three conditions to the study participants: 121 were given a flexible workspace only; 31 received both a flexible workspace and ergonomics training; and a control group of 45 received no intervention. The researchers conducted pre- and post-intervention workspace and postural assessments for each group, interviewed key management staff in order to evaluate the company’s commitment to ergonomic changes, and conducted a business process analysis of all of the groups studied. Two months prior to the study, and three and six months after the study, the workers completed a Web-based survey assessing work environment design, psychosocial factors (such as job demands, supervisory support, and job control), worker health, organizational practices, and performance.

Analyses of the observational data and outcomes indicated that body postures for both intervention groups improved significantly compared to the control group; however, the group that received the combination workspace + training intervention showed greater improvements. This group also reported fewer overall body musculoskeletal symptoms (such as discomfort in the neck, back, legs, shoulders, wrists/hands) than the workspace-only and control groups at six months post-intervention. These results indicate that the combination of workspace change and training had a positive and significant effect on symptoms and that these improvements were stronger at the six-month post-intervention period. (See Chart 1). Furthermore, the fact that the workspace + training group exhibited significant decreases in symptoms compared to the control and workspace-only groups suggests that training provides employees with the requisite knowledge to successfully adjust their workstation to fit their postures and workflow needs, thereby reducing the risk of musculoskeletal discomfort. Meanwhile, the observation that the workspace-only group reported a greater decrease in overall body discomfort relative to the control group indicates that the provision of ergonomic furniture alone may be somewhat beneficial; however, pairing training with the new workstations was shown to result in greater overall health benefits.

Both the workspace-only and the workspace + training groups also demonstrated positive psychosocial effects from the interventions. For example, the workspace + training group

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**CHART 1**

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<td><a href="chart1">Graph showing changes in musculoskeletal discomfort over time for control, workspace only, and workspace + training groups.</a></td>
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Means of the overall musculoskeletal discomfort outcome variable for each group over the three study periods.

*Significant differences between the workspace-training group compared to the workspace-only and control group.
displayed a significant increase in ergonomics knowledge and reported greater control over the physical work environment, indicating that they applied the training in order to adjust and set up their workspaces appropriately. In addition, over the course of the study, objective performance measures for the workspace + training group showed a 10.5 percent improvement, compared to a 5.62 percent improvement for the workspace-only group and a mere 0.46 percent improvement for the control group.

“These results illustrate that a carefully designed systems approach to office ergonomics—one that provides flexible workspaces as well as comprehensive training—can have very positive and continued effects on both worker safety and performance,” notes Dr. Robertson.

Related Papers


Field Study II

In 2009, Applied Ergonomics published findings from the second field study of the series. For this study, researchers investigated the combined effects of ergonomics training and the use of a highly adjustable chair among 216 employees of a public-sector company. Researchers assigned study participants to one of three groups and observed them over a 16-month period: 96 people received a combination of training + adjustable chair; 63 were involved in training only; and a control group of 57 experienced no intervention. The systematic training program focused on motivating employees to conduct self-evaluations and to reorganize their workspaces and adjust their chairs as needed. All trained participants received periodic e-mails regarding healthy computing habits and working postures, as well as reminders about the ergonomics principles that corporate resources discussed during training. Researchers documented workspace setups prior to and after the intervention and observed body postures as employees worked at the computer. They also administered online work environment and health surveys to participants at two months and one month pre-intervention and again at two, six, and 12 months post-intervention.

The findings were similar to the previous study; the training + adjustable chair group reported fewer musculoskeletal symptoms over the course of the workday than workers in the training-only and the control group. The training + adjustable chair group’s performance also improved by nearly 17 percent over the year, as the group members used their workspaces more effectively. Both training groups (the one with and the one without an adjustable chair) demonstrated a significant increase in overall ergonomics knowledge and perceived greater control over the physical work environment than did workers in the control group. Furthermore, average pain levels over the workday decreased for both training groups. “We learned from this study that workers who received ergonomics training and a highly adjustable chair were able to successfully translate the knowledge from the training into appropriate behaviors,” explains Dr. Robertson.

Field Study III

A third field study, which was recently accepted for publication (Applied Ergonomics, 2012), replicated the previous public-sector study; this time, however, the researchers examined workers at a private-sector organization over a 16-month period. Again, the findings indicated a significant reduction in musculoskeletal symptom growth for the training + adjustable chair group compared to the training-only and control groups.
In addition, both training groups experienced fewer visual symptoms than the control group. This private-sector study validated the generalizability and effectiveness of the interventions studied.

Considered together, the combined findings from all three field studies indicate the following compared to non-ergonomic interventions:

- Workers who received a single office ergonomics intervention (either a flexible workspace or training alone) experienced moderate reductions in work-related musculoskeletal and visual symptoms;
- Workers who received a combination of an adjustable chair or flexible workspace and training had much greater reductions in work-related musculoskeletal and visual symptoms; and
- Workers who received the combination of interventions (adjustable chair/flexible workspace and training) demonstrated improved performance outcomes.

“These combined findings suggest that a systems approach involving adjustable workspaces/equipment, ongoing comprehensive training, and management support can help reduce computer-related musculoskeletal and visual symptoms with the added benefit of improving performance outcomes,” explains Dr. Robertson.

**Lab Study Validates Field Study Findings**

In 2008, CBS researchers launched a laboratory study in order to test the findings from the field studies. “The laboratory setting allowed us to study the same interventions, but in a controlled environment where we could study the effects of specific experimental variables,” notes Dr. Robertson.

The laboratory study included four pre-experimental task-training days and 15 eight-hour experimental days, during which participants performed typical call center work. Researchers recruited 22 healthy participants and randomly assigned half of them to a group that would receive ergonomics training and the other half to a group that would receive minimal training. Both groups were given state-of-the-art ergonomic equipment. This included adjustable workstations, which allowed participants to alternate between sitting and standing while working. Some research suggests that such changes in posture can reduce overall levels of discomfort. The ergonomics-trained group took part in 1.5 hours of classroom instruction. On days seven through 12 of the experiment, this group was given the mandatory instruction to stand for periods of five or 20 minutes out of every 50 minutes; on days

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four through 15, members also received reminders either to rest or to readjust their furniture and posture. In contrast, the minimally trained group received only a brief orientation to the workstation features, with no further directions or reminders during the experiment.

All participants completed a baseline questionnaire at the start of the experiment, along with seven hourly questionnaires a day throughout the 15-day study. The questionnaires asked participants to rate their levels of musculoskeletal pain/discomfort across 57 body regions. Chart 2 presents the results for the seven body regions most commonly associated with computer work discomfort.

As described in a recent publication (Applied Ergonomics, 2012, online), the ergonomics-trained participants reported minimal musculoskeletal and visual discomfort over the course of the 15 days, while also demonstrating more varied computing postures and higher performance. By comparison, the minimally trained group experienced a significantly higher number of symptoms. Participants in the ergonomics-trained group demonstrated a significant increase in office ergonomics knowledge and were given sufficient time to practice these skills during the training session. As indicated in Chart 3, these practice periods and reminders influenced their behaviors; thus, for example, they stood more often and for longer periods of time after the practice periods (on days 13–15) than they had at the beginning of the experiment (days 1–6).

“Our laboratory study findings strongly support the results found in our field studies,” concludes Dr. Robertson. “We know that simply providing flexible work equipment, while important, is not a silver-bullet solution. To be effective, ergonomic equipment must be part of a systems-based approach that includes ongoing, comprehensive training and a long-term management commitment. When all these necessary elements are in place, workers gain a higher sense of control over their workspace, and all levels of the company—workers, supervisors, and upper management—become part of a process that can have a tremendously positive impact on safety as well as performance.”
Today's office workplaces look radically different from those of the 1960s, '70s, and '80s. Computers have replaced typewriters, and flexible workstations and ergonomic chairs have replaced the rigid wood or metal chairs and desks of the past. Ergonomics has become a critical consideration for computer-dependent industries and the cornerstone of safety programs designed to keep computer workers more comfortable and build efficiency.

For 30 years, researchers have been studying office ergonomics and applying their findings to the development of more flexible equipment and workspaces. But, as the Institute’s CBS field study findings have pointed out, adjustable furniture, computers, and work surfaces are only one part of an effective office ergonomics program. “Most people think only about equipment when they consider ergonomic design—but our research shows that organizational factors such as work systems and training, as well as psychosocial factors and management involvement, are just as important,” says Wayne Maynard, CSP, CPE, ALCm, Manager of Technical Services and Product Development for Liberty Mutual’s Loss Control Advisory Services.

Mr. Maynard advocates a broad approach to ergonomic design that looks at both the micro aspects of equipment design and the macro view of organizational and psychosocial factors. Micro-ergonomics focuses on physical design only, with the underlying belief that providing the right accessories (keyboard, mouse, and screen) or furniture (adjustable chairs and workstations) will fix the problem. Macro-ergonomics considers the design of the whole work system, which extends beyond equipment to also include management relationships, work organization, company policies, and rest breaks. “The CBS research showed that an ergonomics strategy that addresses both micro and macro elements can yield significant improvements in worker performance, efficiency, and safety.”

The research findings suggested that comprehensive, interactive, and ongoing training is a core element of any successful office ergonomics strategy. “We have known for a long time that training people how to use adjustable furniture is important, but the study findings showed us that the way we train people is also critical,” notes Mr. Maynard. For example, interactive approaches to office ergonomics provide an opportunity to use the workstation assessment as training. Workers can be trained in how to properly adjust the ergonomic furniture and equipment so that they, not the assessor, appropriately adjust the equipment.

“We need to make sure employees understand that ergonomics is not just about the chair, keyboard, and mouse, but also about their body’s tolerance for performing jobs and tasks that require long-duration keyboarding and clicking or dragging of the mouse. They need to know why sustained repetitive work without periodic breaks is not good for them, and understand the physical benefits of ‘neutral’ postures, while recognizing that frequent changes of posture for comfort are beneficial,” says Mr. Maynard. “If workers are included in a participative discussion of ergonomic safety, they are more likely to accept and apply new and safer behaviors,” he adds.

Ongoing communication between supervisors/managers and workers is another critical component of sound office ergonomics. According to Mr. Maynard, a systems approach requires that the manager and supervisor provide a supportive environment that allows workers to take regular breaks and report discomfort promptly. “The supervisor-to-worker relationship is huge. When something hurts, workers should not be hesitant to report symptoms, and they should know that there are ways...”
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“Quite simply, when workplaces are optimally designed with an approach that includes both the micro and macro elements of ergonomics, people perform at a higher rate, efficiency is improved, and workers are safer.”

“Ergonomics is all about design—but over the years we have learned that it’s not just about equipment design, but rather, the design of the whole work system,” notes Mr. Maynard.

“to address discomfort. It is equally important that supervisors are receptive to worker reports of pain or discomfort,” says Mr. Maynard, adding that periodic follow-up and training refreshers are key elements for promoting this awareness.”
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