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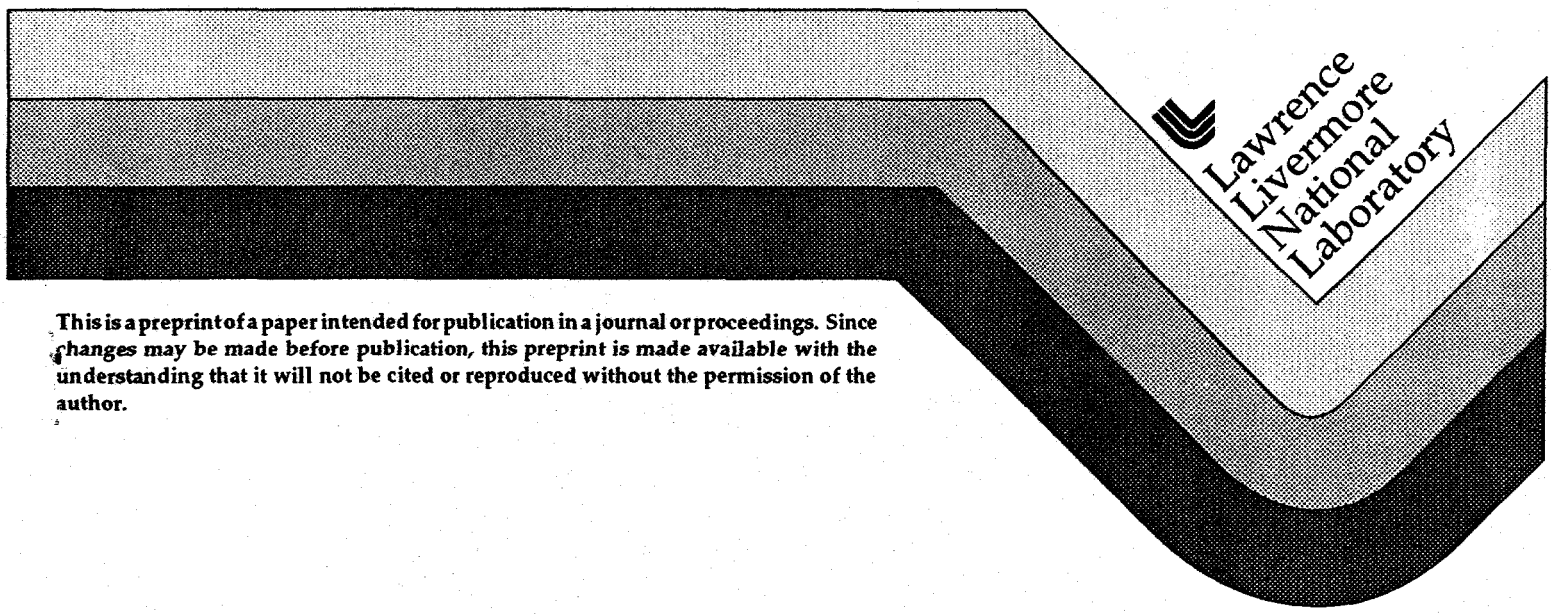

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ERGONOMICS PROBLEMS AND SOLUTIONS IN BIOTECHNOLOGY LABORATORIES

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The multi-functional successful ergonomics program currently implemented at Lawrence Livermore National Laboratory (LLNL) will be presented with special emphasis on recent findings in the Biotechnology laboratory environment. In addition to a discussion of more traditional computer-related repetitive stress injuries and associated statistics, the presentation will cover identification of ergonomic problems in laboratory functions such as pipetting, radiation shielding, and microscope work. Techniques to alleviate symptoms and prevent future injuries will be presented.

BACKGROUND

In the "old days", the administrative jobs involving prolonged or unusual postures caused modest numbers of strains and pains. Today computer workstations are generally credited with being a significant cause of repetitive stress injuries (RSI), such as carpal tunnel syndrome. As a result, we hope we are becoming smarter in learning how to cope with ergonomics problems in other work areas. However, it is likely that the magnitude of the computer usage injuries has caused us to overlook laboratories as a possible high-risk environment for RSI.

The LLNL ergonomics program, focusing on prevention, requires a partnership of Health and Safety professionals, management, and those performing the tasks to actively seek out high-risk job situations before the injury statistics define them as problems. The challenge is to identify those tasks that contain the commonly reported risk elements wherever they are. (Ulin and Armstrong 1992). This is an account of a program just implemented in LLNL's Biology Biotechnology Research Program laboratories. The facility employs 167 employees who work in laboratories and offices. 112 of these employees perform tasks that could contain risk factors for RSI. 84 employees were evaluated and 19 presented physical problems resulting from the work they performed.

A previous reactive study in the Animal Research Facility of BBRP revealed repetitive stress and other ergonomic problems in the areas of cage cleaning, bottle washing, and material handling (lifting and carrying cages, bottle racks and sacks of food). Job task analyses were performed, administrative and mechanical changes made, and training conducted which, so far, has prevented further RSI's.

PROBLEMS

Several tasks have been identified that have caused or could cause repetitive stress injury problems in the biotechnology labs. They involve pipetting, radiation shielding, microscopes, and finally, computer use as a contributing factor (e.g., a situation where periods of repetitive lab work result in physical damage). Other related factors, which are probably not unique to LLNL, appear to be the self-driven over-achiever, the "tough kid" image, limited time and high-expected output of some students, and the competitive atmosphere among parts of the organization.

Pipetting

Many pipetting tasks are highly repetitive and demand hours of continuous effort. The most common pipette is a thumb

and finger-operated mechanical instrument for measuring and dispensing liquids. Extremely small quantities (milliliters) are drawn up into this syringe-like device, then dispensed into small micro-centrifuge vials which are typically opened and recapped with the opposite hand. Finally the pipette tip is ejected and a stabbing motion installs a fresh tip for the next sample. The ejection motion requires the most exertion. It can take hours to complete thousands of samples. Details of the equipment and experiments vary widely, but usually contain similar motions. Our study found that it is not unusual for an employee to repeat the motions with the pipette at least 1,000 times a day.

Depending on the design of the pipette, the operator may have difficulty maintaining fingers and wrists in a neutral position. Some experimenters believed that taking a rest break before completion could introduce mistakes or ruin the entire experiment, wasting other peoples' time and money as well. An occasional pause may be the only break taken until the task is done. Because this tedious work often requires use of both hands, only ambidextrous persons would be comfortable switching hands to relax stressed muscles. Medical diagnosis of these employees includes "right thumb flexor tendinitis".

Radiation Shielding

Because some of the liquids must be "labeled" with radioactive materials used as tracers in experiments, many biotechnology scientists are working at shielded workstations. Shielding can take the form of Plexiglas screens, pipette shields, and Lucite boxes. Shields can be applied to the source material, the samples, and waste containers.

Some typical problems caused by shielding include the need to assume exaggerated or unnatural postures to work around the screens. Shields with openings for arms located to fit average heights will be too tall or too low for some users, creating strained positions. Shielding also clutters already congested lab bench or hood workspace and requires more manipulation of containers. Also, added weight and disturbed balance are present when shielding is added to the pipette. These problems worsen the normal fatigue of prolonged standing or sitting.

Microscope work

Microscope work often involves prolonged sitting, eyestrain and repetitive movement of stage and focus controls. Focus controls may be bilateral, allowing hands to be switched, but stage controls are typically unilateral. Even when another microscope with reversed controls is available, it's use may not be feasible. It may be difficult to coordinate microscope switching with other users, and some prefer their "personal" microscope or one they consider to be better quality. If furniture is not adjustable, all users have to tolerate the set height of a table or bench.

Since the emphasis has historically been on computers, many microscope users did not realize repetitive stress applied to them. We found that some users were staying at the job two and three hours at a time. Reasons given for long hours included schedule deadlines, and, especially for students, limited time to complete lab work. Symptoms included sore hands from manipulating the controls and sore necks and shoulders from awkward positions.

Computers

Office environments have been heavily evaluated within recent years for properly adjusted chair heights and back positions, work surface levels, and foot rests. But we found that those hard-learned lessons also need to be taken into the laboratories to ensure comfortable work postures.

Computer usage by lab personnel seems to us to be an indirect contributor to laboratory ergonomic problems. Perhaps the best way to visualize this condition is to relate it to a cumulative damage model. Fingers and wrists, stressed by hours of keyboard and mouse use, may be contributing to the fatigue of lab work, even when the computer work station is properly set up. Even though the lab work may qualify as alternative work and provide a break from computers, repetitive stress occurs in the laboratory. Computers are also found in the labs and may not be set up with the same attention they would receive in an office. There is usually less suitable space available in a lab for the proper placement of a computer.

INVESTIGATIONS AND PROTOCOL DEVELOPMENT

Evaluations can occur as follow-up to an injury, in response to an invitation or inquiry, or they can be solicited as part of a proactive program to actively evaluate targeted work areas. Other than computer users, only the animal research workers had been targeted as a group. Based on the experience gained in the previous analyses, the Safety Officer in BBRP decided to use the proactive approach. A summer intern was trained to canvas BBRP office and lab work areas. At that time there were indications that pipette users might be a high-risk group.

Evaluations consisted of lab visits and personal interviews. Results were documented and compiled. Observations and complaints implicated radiation shielding and microscope work as additional stress factors.

The form used to document computer workstation evaluations was employed in the lab setting, as it was general enough to gather relevant data. Occupational therapists from the LLNL Medical Department participated and were invaluable as they offered their expertise and ideas. Their presence also clearly indicated the connection between ergonomic problems and the medical community.

Of the 84 employees evaluated, the following cases were significant: three cases related to pipetting; two cases related to microscope work; two cases related to radiation shielding; and twelve cases related to computer use. Of these, one pipette, one microscope, and three computer use cases reported to the Medical facility due to severity of discomfort. In the other cases, changes were made which reduced or alleviated the symptoms, and it was recommended that employees report to LLNL Medical facilities.

SOLUTIONS ENACTED OR PROPOSED

Solutions can take the form of alternate methods or proposed changes in equipment. It is an important observation that "outsiders" such as safety professionals can suggest solutions and options, but fixes must meet workers' acceptance to ensure complete success. And, once properly informed, self-correcting and reporting of problems by the lab workers themselves is a desirable outcome.

Pipettes

We found that there were usually good reasons why the single pipettes were being used rather than reducing or eliminating the number of manual operations by the use of multi-channel pipettes or robots. The smaller volumes needed, the viscous nature of some liquids, and high costs of lengthy calibrations or loss of experiment all contributed heavily to experimenters' judgment about which pipette is chosen. Speed, accuracy, and equipment expense/availability were also factors. On the personal level, rework is costly and embarrassing and sometimes it was just an individual's preference to choose one pipette over another.

After consultation with physical/occupational therapists and reviewing all available pipette designs and other literature, the perfect pipette remains to be invented. Two were identified as being improvements over current designs. One has a side mounted thumb lever which succeeds in keeping the wrist and fingers in a neutral position. The other has a low-stress tip release function which appears will be a better solution than a tip removal bracket we designed but have not yet tested.

The pipette that combines both low stress and easy tip removal would be a nearly perfect choice. However, repetitive work with even perfect tools still requires periodic rest breaks or alternate work. We have purchased several of the improved pipettes for trial by heavy users in the hope they will be accepted as a definite improvement over the present equipment. We hope the emerging trend of manufacturer's interest in the ergonomic design of their pipettes continues.

Radiation Shielding

We surprised several isotope handlers by offering to remove, cut down or relocate beta radiation shielding that was doing a great job of keeping their already low doses lower, but contributing seriously to fatigue and discomfort. We modified arm placements and offered customized shielding to all who wanted it. (This is a judgment that must be made only with a clear knowledge of current and projected exposures). Fortunately we had none of the pipette shielding devices that enlarged the grip diameter, as that would surely have aggravated hand-wrist fatigue for even small jobs. The light-weight "shadow shield" plate near the tip is a very effective way to reduce hand doses.

At least one individual was unable to sit at the workbench during pipetting because the leg space was used as a storage area for (shielded) radioactive waste. Temporarily we recommended a foot rest to ease the standing until a new waste storage location is found. Other shielding can be customized by adding arm holes at the correct height.

Microscope Work

As mentioned before, an effective work-rest protocol may be the most effective tool for dealing with microscope users' wrist fatigue since there are no easy mechanical modifications. However, it is recommended that a replacement stage be considered if one can be found with controls in a more neutral position or with multiple position controls.

Also, there are electrically- and manually-controlled variable height tables that can be installed to accommodate multiple users.

Computers

As there are countless references related to computer workstation improvements and techniques, we will only say that it is important to realize that the conditions of computer over-use can be easily translated into the laboratory setting. Employees should remember that extended periods of performing the same task in the same body position has the high potential to lead to repetitive stress injury.

Other candidates for alternate methods are any improvements that result in a more comfortable position. Sometimes the search for dramatic causes for problems causes us to overlook simple causes like the quality and adjustments of chairs and work surface heights. We found some of these problems in our labs and designed a prototype foot rest and a slide out bench that would allow leg room and closer positioning to the work surface. Old style lab chairs were replaced by more adjustable ones.

SUCCESSFUL ENDPOINT

The future we envision is one where we have enabled the biotechnology workers to identify ergonomic problem situations in their work areas and get help solving them before they cause serious injuries. We want them to break out of the belief that repetitive motion injury only happens to computer operators in offices. If they are experiencing pain, it's not "whining or wimping" to tell someone and recognize it for the warning sign it is.

By sharing our workplace evaluation results with the workers (in a non-embarrassing way), training classes take on more personal relevance. When those involved in this process are working on our team to select options, order new equipment and modify existing tools, we gain powerful partners in preventing ergonomic injuries. Self-reporting, problem recognition, early intervention, reduced injuries and lost time are the payoffs we're after. Relevant training will be our best key to an aware and informed workforce.

In biotechnology laboratories, we are generating cost-effective options: providing tools that are adequately designed for the application and modifying existing equipment where possible in an economic approach that should more than pay for itself. In BBRP, management allocated funds to meet the recommendations to improve existing conditions and provided additional funding for further research and study. We believe the statistics will show our program to be effective.

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