Occupational Knife Safety

Is a Sharper Knife a Safer Knife? Liberty Mutual Researchers Investigate

Reducing the Strain of Occupational Knife Cutting Tasks

At the Cutting Edge: Laboratory Studies Use New Technologies to Assess Knife Cutting Exposures
Laboratory Studies Use New Technologies to Assess Knife Cutting Exposures

In addition to field studies aimed at identifying worker exposures (see p. 2 article), the Liberty Mutual Research Institute conducts laboratory experiments to examine the ergonomic and physiological factors associated with occupational knife cutting tasks.

“In the laboratory,” explains Liberty Mutual Senior Research Scientist Raymond McGorry, “we’re able to apply sophisticated technologies under controlled conditions to measure the different exposures associated with occupational cutting tasks. This approach allows us to identify those job elements that pose the most significant risk, and find ways to reduce that risk.”

Force Measurement Systems Yield Insights on Ergonomic Factors

In one experiment, Institute researchers observed 12 study participants as they performed knife cutting tasks in a standardized modeling clay to simulate meat cutting. Specially instrumented knives and wrist goniometers recorded grip forces, cutting forces, and wrist posture data. The participants performed a total of 72 cutting tasks under varying conditions: three work surface orientations (horizontal, tilted 30°, tilted 60°); three work surface heights (low, medium, high); two knife blade angles (bent, straight); and two work paces (self-paced, production-paced).

The study findings, published in the journal *Ergonomics*, (Vol. 47, No. 5), suggest that the interaction between work surface height and orientation had a significant impact on wrist flexion, extension, and displacement. The “best” (i.e., most ergonomically favorable) combinations were: lowest height / 30° tilt; and highest height / 60° tilt. The next most favorable interaction was the 30° tilt at medium height. At all surface heights, the “worst” surface orientation was horizontal, because it caused the greatest wrist flexion and ulnar deviation.

There were also strong interactions between knife blade angle and surface orientation, resulting in large differences in wrist displacement (flexion or extension). The “best” combinations of blade angle and surface orientation were: bent blade / 30° tilt; and straight blade / 60° tilt, because they minimized wrist deviation from a neutral posture.

“The results suggest that providing ergonomic workstations that offer height and work surface angular adjustment would improve wrist posture during meat cutting tasks,” says McGorry. “We also found that using an angled blade in conjunction with an adjustable workstation might also improve working wrist postures, but that finding requires further investigation.”

Next, the researchers analyzed the force data from self-paced cutting tasks, in which participants selected a work pace they felt they could sustain comfortably, and production-paced tasks, in which they used a faster cutting pace, aimed at maximizing production. As a group, study participants used significantly greater torque and grip force during the production-paced tasks. This finding suggests that they exerted higher forces to achieve greater speed.

However, data also showed that the grip-to-cutting ratio was 7.6 percent greater for the production pace than for the self-selected pace. This finding suggests there may be a trade-off between performance speed and the efficiency of energy transfer from the participant to the clay, because the participant must use greater energy to produce the desired work. The relative increase in grip force suggests that participants felt the need to grip the knives tighter for better control when working at production-paced cutting tasks.

Does this finding mean companies will have to modify the pace of their industrial cutting tasks and accept lower production rates in order to reduce injury exposures? “Not necessarily,” says McGorry, who was
principle investigator for the study. According to McGorry, a slower pace would reduce the number of task repetitions per shift, but this reduction could be offset by increased efficiency. “In theory, the worker who is not as rushed will do a better job of cutting and create less waste on the line,” says McGorry. “The ideal approach would be for companies to evaluate the extent to which decreasing line speed impacts yield and reported symptoms, and make their decisions based on what they find out.”

Researchers Use Medical Technology to Explore Optimal Work:Rest Ratios

Delving deeper into the issue of task pace and injury exposure, Institute researchers recently began a new laboratory study to examine physiological responses to repetitive upper-extremity tasks such as knife cutting. The study is the first of its kind to use near-infrared spectroscopy (NIRS) to measure muscle oxygenation during repetitive upper-extremity tasks (see side article, p. 7), and the findings will be used to help define optimal work-to-rest ratios.

The 19 participants in this study performed nine half-day sessions of repetitive hand-grip tasks at three different work intensities (10, 15, and 25 percent of their maximal effort) and three different work-to-rest intervals. Research Institute scientists used NIRS to measure the participants’ muscle oxygenation and blood volume responses in the flexor and extensor muscles during the tasks. They set values for work output and time spent on each task trial according to an established experimental protocol. Before and after
Georgia Tech Taps Institute Force Measurement Expertise

Researchers at Georgia Tech Research Institute’s Agricultural Technology Research Program recently announced the development of new Ergonomic Work Assessment System (EWAS) to identify musculoskeletal exposures associated with poultry cutting tasks. As part of the development process, Georgia Tech involved subject matter experts from the Liberty Mutual Research Institute for Safety and McMaster University, Ontario. The resulting tool integrates a fiber optic position measurement system, EMG sensors, and the Liberty Mutual Instrumented Knife to measure ergonomic factors related to these tasks.

EWAS is unique in that it can simultaneously collect real-time data on arm position, muscle response, and grip force during cutting tasks performed on an actual production line. As the worker performs tasks, data is transmitted wirelessly to a laptop computer, allowing researchers to study relationships among force, exertion, posture, and repetition. The information can be used to boost work efficiency on the deboning line and to correct inefficient movements by workers performing the cutting task.

The tool is part of Georgia Tech’s broader research program aimed at helping poultry processors and ergonomists develop effective worker rotation schemes and training programs to minimize the risk of injury.

Near-Infrared Spectroscopy: What Is It?

Near-infrared Spectroscopy (NIRS) is a non-invasive diagnostic procedure that measures how efficiently human tissues use oxygen during physical activity. The procedure involves transmitting near-infrared light into the tissue and then measuring the amount of light absorbed by the tissue. An increase in light absorption indicates a high hemoglobin concentration in the tissue region, which means that the tissue is using oxygen efficiently. Inefficient use of oxygen is an early indicator of muscle fatigue.

Scientists at the Research Institute are finding that NIRS, while developed primarily for use in clinical or diagnostic settings, can be instrumental in the study of work-related upper-extremity tasks. In the laboratory, Liberty Mutual researchers apply this state-of-the-art technology to study how efficiently arm muscles (flexor and extensor) use oxygen during simulated upper-extremity repetitive work tasks. By quantifying changes in muscle oxygenation during various work tasks, researchers can compare the measured exposures to different task parameters.

This novel use of NIRS technology provides valuable information that researchers will use to develop recommendations for optimal work-to-rest ratios for high-risk, repetitive upper-extremity tasks.