AN INTERVENTION STUDY COMPARING TRADITIONAL AND ERGONOMIC MICROSCOPES

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In recent years, manufacturers have produced new microscopes with claims of "ergonomic design" for reduced musculoskeletal stress among users. To test this claim, we measured posture of the neck, back, and upper extremities, and the prevalence of musculoskeletal and visual symptoms among cytotechnologists while using traditional microscopes (baseline) and again after the introduction of ergonomically designed microscopes. Participants were five full-time cytotechnologists, who used the microscope 6-8 hours per day and had reported discomfort while using traditional microscopes. Results showed the ergonomically designed microscopes were significantly more comfortable to use than the traditional microscopes for the neck and shoulders. Significant improvement in joint angles of the elbows (flexion) and shoulders (abduction) was noted with the ergonomically designed microscopes. These results suggest that ergonomically designed microscopes may reduce some of the risk factors for musculoskeletal disorders (MSDs) and benefit individuals who use microscopes for prolonged periods of time.

INTRODUCTION

In the past, microscope designers have concentrated on improving optical performance rather than user comfort resulting in fewer ergonomic features for microscopes. The fit between a person and a microscope is not typically an issue for short-term users but becomes more critical for long-term users (James, 1995). Long-term microscope users historically report a great deal of discomfort or pain.

Putz-Anderson (1995) found typical problems associated with microscope use are head inclinations up to 45 degrees and upper back inclination as much as 30 degrees. From a biomechanics perspective, slight inclines of the head such as 30 degrees from vertical can produce significant muscle contractions, fatigue, and pain (Chaffin and Anderson, 1991).

In a regional survey of cytotechnologists 70.5 percent of survey respondents reported experiencing neck, shoulder, or upper back symptoms (Kalavar & Hunting, 1996). Fifty-six percent had an increased prevalence of hand/wrist symptoms.

Previously James (1995) identified a group of cytotechnologists in a clinical laboratory within a major medical center in the southeastern United States who reported pain, fatigue, and discomfort after using microscopes for prolonged periods of time. Through a series of focus groups and onsite ergonomic evaluations, James identified a number of awkward and static postures the workers adopted while using traditional microscopes as possible risk factors contributing to their symptoms. Subsequently, the medical center was approached by a major microscope manufacturer who agreed to provide microscopes for the purpose of conducting an intervention study. Designers of microscopes and related equipment are now beginning to consider user comfort and new microscopes have ergonomic features such as telescoping and tilting eyepieces, eyepiece height adjustability, and well-placed manual controls. Manufacturers contend these microscopes prevent awkward postures, a well-documented risk factor for musculoskeletal disorders (MSDs).

The purpose of this study was to determine if there would be a change in levels of musculoskeletal and visual discomfort, awkward postures of the upper limbs and neck after the introduction of an ergonomically designed, adjustable microscope in this same group of cytotechnologists.

METHODS

Participants

Five full time cytotechnologists, four females and one male (ages 30-51 years), participated in this study. This work group used traditional, non-adjustable microscopes to screen slides for cancer and infectious conditions six to eight hours per day.

Dependent Variables

The dependent variables of this study were musculoskeletal discomfort and the following posture measurements:

- shoulder flexion/extension and abduction/adduction;
- elbow flexion/extension;
- wrist flexion/extension and ulnar/radial deviation;
- neck flexion (defined by the angle: acromion - C7 spinous process - tragus);
- head tilt (defined by the angle: canthus of eye - tragus - true horizontal).

Equipment

Nikon Eclipse E400 clinical microscopes with the following features were selected as the "ergonomically designed" microscope: tilting and telescopic head, optional riser tubes, one-hand focus control capability, and in-line focusing (Figure 1). The traditional microscope was a Zeiss (Model NT6V-10W) that had previously been used by the participants. Digital photographs of participants were taken with an Epson Photo PC600 digital camera. The camera was fastened to a tripod set a fixed distance and height relative to each participant. The horizontal and anterior-posterior orientation of the camera was adjusted with use of a level. A board marked with one-inch squares was placed vertically behind the participants, perpendicular to the camera. Pieces of adhesive reflective tape or .5 inch diameter wooden beads covered with reflective tape were secured to the participants at the following anatomical landmarks with tape: ecto-canthus, tragus, C7 spinous process, and acromion

process. Both large and small manual goniometers were used to record shoulder, elbow, and wrist posture. Participants were supplied with their own three-ring folders containing daily discomfort surveys.

Procedures

Measurements of posture and discomfort for the neck and upper limb were collected over a two-week period while participants used traditional microscopes. The traditional microscopes were then replaced by adjustable, ergonomically designed microscopes which were fitted to participants by a Nikon, Inc. representative. Footrests were provided to participants who requested them since some chairs were elevated during the "fitting" process. No other major changes took place within the work environments. After a two-week adjustment period with the new microscopes the second phase of posture measurements were collected and daily discomfort surveys were re-administered for two weeks.

Figure 1: Microscope with ergonomic features including tilting and telescoping head, optional riser tubes, one hand focus control, and in-line focusing. (Photo courtesy of Nikon, Inc.)

Discomfort Surveys. Daily discomfort surveys (developed by the authors) were administered to participants for two weeks prior to implementing

the ergonomically designed microscopes to obtain baseline data regarding the type, frequency, and severity of musculoskeletal symptoms for specific body parts and problems associated with vision. The traditional microscopes were replaced with the ergonomically designed microscopes and participants were given two weeks to adjust to them. Daily discomfort surveys and posture measurements were repeated for a two-week period.

Posture data collection. Postural data and measurements of key joint angles (described above) were collected for each participant using a manual goniometer twice per day for each two week period with methods previously described in the literature (Norkin & White, 1995; Ortiz, Marcus, Gerr, Jones & Cohen, 1997). Participants were photographed using a digital camera with a tripod. Neck angle and head tilt were measured from the photographs using a manual goniometer.

Data Processing and Analysis

Musculoskeletal discomfort data for each body area was analyzed using a symptom factor. The symptom factor represents the product of the following values: number of symptoms (out of a possible 9), frequency of symptoms (on a 6-point scale), and severity of symptoms (on a 6-point scale).

Posture data and symptoms factors collected before and after introduction of the ergonomic microscope were compared using repeated measures analyses of variance (ANOVA). The level of significance was set at .05.

RESULTS

For the traditional microscope, most participants experienced the greatest amount of discomfort in the neck and shoulders, lower back, arm, forearms and wrists. Results of the comfort surveys revealed that participants were significantly more comfortable in the neck and shoulder regions ($p<.05$) after introduction of the ergonomically designed microscopes. Figure 2 shows subtle postural differences for a participant using the traditional microscope and using the ergonomic microscope.

Symptoms of eye fatigue and mid back discomfort decreased after introduction of the ergonomic microscopes, although the differences were not statistically significant ($p=.08$ and $p=.08$, respectively).

There were statistically significant differences in awkward joint angles with regard to right elbow flexion ($p=.01$) and right shoulder abduction (.01) while using the ergonomically designed microscopes. There were also differences in right shoulder flexion and left shoulder abduction, although the differences were not statistically significant ($p=.07$ and $p=.07$, respectively).

Figure 2: Postural differences using traditional microscope (left) and ergonomic microscope (right).

DISCUSSION

The results from the discomfort surveys are consistent with the Kalavar and Hunting survey (1996) indicating a mismatch between cytotechnologists and their work environment. Results also indicate the participants' comfort increased when they went from using traditional microscopes to ergonomic microscopes, particularly in the area of the neck and shoulders.

One of the greatest limitations of this study was the small sample size thus the power was low. Had the sample size been larger, other statistically significant differences between the two microscopes may have

emerged. The data collection methods were limited to written surveys, manual goniometry, and 2-D digital photography. The use of EMG to measure muscle activity may have provided more objective data. As with any survey of discomfort, there may be some reporting bias since participants were not unaware of the purpose of the study.

It must be noted that workstations in the laboratory were not adjustable and did not provide adequate leg clearances. However, in order to isolate the effects of a change in microscopes, other ergonomic improvements were postponed during this study. Combining the features of ergonomically designed microscopes with other ergonomic improvements such as proper seating, workflow, work organization, and workstation arrangement likely would improve individual comfort and ultimately worker productivity.

Future studies should focus on using larger populations of microscope users to determine if significant improvement in discomfort and awkward postures occur while using ergonomically designed microscopes. Similar studies should be conducted to determine if further equipment re-design is necessary. The use of EMG data, particularly in a controlled laboratory setting, might add greater depth to this type of study. Future studies are needed to identify the impact that better fitting equipment has on productivity and error rates of cytotechnologists.

In terms of usability, the participants eagerly accepted the new microscopes, and were able to use them with minimal training time.

CONCLUSIONS

By using ergonomically designed microscopes with multiple adjustments that allow for a more customized fit, participants in a cytology laboratory were able to work in more neutral postures and had fewer symptoms of discomfort. It is speculated that this reduction in risk factors for MSDs and improvement in posture may decrease injury rates. Although this study had some limitations, the results could have an impact on the many work groups that use microscopes for prolonged periods of time. Future efforts should be aimed at incorporating additional ergonomic improvements (such as workstation arrangement, chair selection, and ergonomic training) to optimize the benefits of the ergonomically designed microscopes.

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