**CASE STUDY ERGONOMICS**

## A Biopharmaceutical Breakthrough

A study involving manual pipettors eased a persistent risk for repetitive strain injuries.

*by Joan G. Erickson and Anthony V. Smith*

Pipette selection is seldom a well-thought-out decision. Rather, it has more to do with the individual preference of the person responsible for ordering or the right salesperson’s being there at the right time with the lowest price. However, pipette selection is becoming more critical due to the high cost of work-related injuries and the impact the absence of a scientist can have on a research project.

The National Institute for Occupational Safety and Health identified repetitive pipetting as the most common contributory factor with regard to developing repetitive strain injuries in the laboratory. In Washington State from 1994-2002, 5 percent of all Labor & Industry claims were due to injuries of the hand or wrist (SHARP 2004). This represented an average time loss of 185 days and a total cost of $504.7 million. The yearly rate for hand and wrist injuries in Washington State is approximately one per 600 full-time employees (SHARP 2004).

We experienced this problem firsthand when a large biopharmaceutical firm had four employees who required consultation and evaluation by a physician because of pipette-related thumb and wrist injuries. This was a significant increase from the previous year’s report.

Upon ergonomic evaluation of the four employees, it was determined that the one common factor among all four people was the use of an older, high-force plunger pipette. We knew from reviewing the literature and from our experience working with several biopharmaceutical companies that the relationship between pipetting and arm or shoulder pain, particularly when high force is required to operate the pipette, was not isolated to this biopharmaceutical company. We set out to determine what would be the best pipette to replace the high-force pipettes, in order to reduce the risk of additional repetitive strain injuries.

The literature clearly indicates that pipette use increases the risk of developing repetitive strain injuries, particularly in the arm and hand. Bjorksten, Almby, and Jansson (1994) found working with a pipette more than 300 hours per year increased the risk of developing repetitive strain injuries. Fredriksson (1995) identified that thumb symptoms increase with the amount of time spent pipetting and with age. David and Buckle (1997) reported the frequency of hand problems was higher in the pipette user population than in their control group. Moore (1997) noted high activity of specific thumb muscle groups could lead to the development of thumb tendinitis. These are the same muscles that are used during pipetting with a thumb-operated plunger pipette (Asundi, Bach & Rempel, 2005).

Once we identified that high-force pipettes had a direct impact on repetitive strain injuries, we went about looking for a pipette with a lower plunger force and other ergonomic features. In our review of the literature, we found that articles focused on what features should be included in pipette design rather than on looking at a comparison of existing pipettes (Lee & Jiang, 1999; Asundi, Bach & Rempel, 2005). A study that did compare the force required to operate pipettes did not include the pipettes we were considering as a replacement pipette (Lu & Sadhakaran, 2005).

We set out to determine the key factors that need to be considered in pipette selection. Our evaluation was based on current literature and personal experience. Research undertaken a few years ago at a leading ergonomics institute (David and Buckle, 1997) has provided valuable information about pipette features and gave us a good basis for the selection criteria we used...
in our pipette evaluation. David and Buckle (1997) reported improvements were needed to make plunger operation easier, improve tip ejection and heavy cumbersome grip design, reduce weight, and improve volume adjustment. Therefore, we included these factors in our pipette selection criteria. Lee and Jiang (1999) noted that a low plunger force, light weight, and a well-balanced feel were important design attributes, so balance was included in our evaluation. We also included factors based on our extensive experience with ergonomics and pipetting. We did not weigh all of the factors equally but placed a bias toward the factors associated with thumb force because this also was supported by the work of Asundi, Bach, and Rempel (2005); Cooney and Chao (1977); and Fredriksson (1995).

In-House Study
We wanted to identify a method for evaluating the pipettes that could easily be replicated in any laboratory setting with limited time, equipment, and cost. We felt this was important in order to have a way to evaluate and compare a new pipette at any time and demonstrate to the laboratory employees firsthand why the pipette was selected. We chose the following factors in our pipette evaluation and established our goal for each category. All are noted in the following section.

Factors Evaluated in Pipette Comparison
Pipetting and Tip Ejection Force
Forces were evaluated subjectively and were supported by infor-

<table>
<thead>
<tr>
<th>Weight in grams</th>
<th>Length in inches</th>
<th>Force</th>
<th>Balance</th>
<th>Fit small hand</th>
<th>Fit large hand</th>
<th>Ease in reading</th>
<th>Ease to adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipette A</td>
<td>74.6 g</td>
<td>222.25 mm (8.75&quot;)</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Pipette B</td>
<td>91.7 g</td>
<td>222.25 mm (8.75&quot;)</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pipette C</td>
<td>104.6 g</td>
<td>234.95 mm (9.25&quot;)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pipette D</td>
<td>118.7 g</td>
<td>234.95 mm (9.25&quot;)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

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The forces evaluated were first position, blowout, and tip ejection. In addition, we found that by placing the tip ejection button against the tip ejection button of another pipette and applying force, we could compare ejection forces between the two pipettes. We also could compare plunger forces by placing the plunger button against the plunger button of another pipette and applying force. The goal was to identify the pipette with the least amount of force required to operate it, because increased force is correlated with an increased risk of developing repetitive strain injuries (Armstrong, et al. 1987).

Weight
Pipettes of similar volume were individually weighed on an electronic scale. The goal was to identify the lightest pipettes because they would require less muscle force to hold up during use. Decreased weight has been recommended in many studies to decrease the risk of developing repetitive strain injuries (Armstrong et al, 1987; Lee and Jiang, 1999).

Length
The pipettes were individually measured from the top of the plunger button set at 50µl to the bottom of the pipette. The goal was to identify the shortest pipette, because Fredriksson reported there was a better shoulder position for those who use shorter pipettes (Fredriksson, 1995).

Balance
The way the pipette felt balanced in the hand was evaluated subjectively. The goal was to find a pipette that felt balanced when holding and operating. It has been shown that the resulting torque to the wrist is lower with improved center mass (Lee and Cheng, 1995).

Fit
The two evaluators subjectively evaluated how the pipette fit in the user’s hand. The goal was to find the pipette that fit easily and comfortably in both small and large hands. Grip size influences the muscle force required and potential for injury (Grant, Habes and Steward, 1992).

Ease to Adjust the Volume
The force and motion required to adjust the volume on the pipette were evaluated subjectively. The goal was to identify a pipette with easy-to-adjust volume. Volume adjustments were identified as having a high level of muscle activity (Asundi, Bach & Rempel, 2005).

Ability to Read Volume
Ease in reading the volume both while adjusting and using was evaluated. The goal was to identify a pipette with the easiest-to-read volumes. We knew from our experience that users would assume awkward positioning to read the volume setting if needed.

Evaluation of Pipettes
Our study included four leading pipettes from three major pipette manufacturers commonly found in many biopharmaceutical settings. We wanted to include pipettes that we thought would be easily accepted as replacement pipettes by the laboratory technicians. The pipettes were chosen based on manufacturers’ literature.
and previous experience working with pipettes.

A comparative analysis among available pipettes was performed using the identified factors to determine which pipettes should be considered for our company. An outside ergonomic consultant and an environmental health and safety specialist performed the evaluation. The evaluators were a woman with a small hand and a man with a large hand. We chose to rate the factors on a subjective scale of 1-4, with 1 being the best and 4 the worst. We did a side-by-side comparison of four leading pipettes of similar volume. We looked at each pipette individually and rated each based on our pre-established criteria.

Summary of Findings
Our most significant finding was the importance of discontinuing use of the old high-force pipettes and replacing them, over time, with lower-force pipettes. Our comparative in-house study found Pipette A was overall the best pick. We reached this conclusion because Pipette A had the lightest weight of the pipettes of similar volume, was one of the shortest in length, fit both the small and large hands the best, was the easiest to read, was the easiest to adjust volume, and for the volume we looked at had the lowest force requirements for both plunger depression and tip ejection. (We thought the low tip ejection may be due to the OptiLoad™ feature.)

We also asked several scientists to try out Pipette A to make sure we had not overlooked anything that would come up during typical usage. We received positive feedback about Pipette A, including statements about the locking feature such as, “The volume being taken up is locked in place. It is easy to accidentally change the volume on other pipettes” and “The locking mechanism ensures accurate repeatability between samples.” This type of feedback from end users is important when considering any new pipette.

We believe we were successful in identifying a pipette to replace the older, high-force plunger pipette. Additionally, we achieved our goal of identifying a method to evaluate pipettes that could easily be replicated in any laboratory setting with limited time, equipment, and cost. Future research is needed to look at the role of tip selection and ejection force, as well as the force requirements of pipettes of different sizes and the length of the duty cycle. However, for the present, we are confident we have made a significant step toward improving the health of the workers of one large biopharmaceutical company.

Joan G. Erickson (206-465-9771 or ergon@mindspring.com) of Seattle, Wash., is an independent ergonomics consultant specializing in laboratory ergonomics. Anthony V. Smith is EH&S specialist at ZymoGenetics in Seattle. ZymoGenetics is a biopharmaceutical company that specializes in the development of therapeutic proteins to treat disease. Smith can be reached by phone at 206-442-3074 or by e-mail at smitht@zgi.com. OptiLoad is a registered trademark of Biohit OY.

Bibliography