Ergonomic benefits of LTS pipettes

The risks of pipetting

Pipetting has been identified as a cause of injury. A study conducted on laboratory technicians found that technicians who pipetted for over 300 hours a year were at greater risk of repetitive strain injuries than their peers who pipetted less than this amount.[1] This will come as no surprise to corporations and universities whose workers have been incapacitated and put out of work by cumulative trauma disorders. Cumulative trauma disorders (CTDs) encompass a variety of musculoskeletal disorders involving the tendons, muscles, nerves and bones of the upper extremities. CTDs such as tendinitis, tenosynovitis, and carpal tunnel syndrome can be excruciatingly painful and very expensive, as medical and indemnity claims can exceed $25,000 for a single injury.

Although hand injuries stemming from pipetting are of primary concern, simple cases of tendinitis or even hand fatigue can result in a significant loss in pipette accuracy and precision. Scientists who depend on a precision liquid handling instrument in their research cannot tolerate user-dependent errors such as hand fatigue.

Ergonomic risk factors

Why is pipetting a potentially dangerous activity? There are two primary risk factors. First are the high hand forces required to operate most traditional mechanical pipettes. One pipetting cycle, which consists of: 1) depressing the plunger, 2) aspirating sample, 3) dispensing sample, 4) blowout, and 5) tip ejection, can require up to 12 kilograms of cumulative force.

Pipetting is also a repetitive activity. Ergonomic job analysis of sample preparation activities at NIH revealed that lab technicians were performing between 6,000 and 12,000 pipetting repetitions per day.[2] Studies suggest that technicians performing over 1,000 daily repetitions are at greater risk of CTDs.[3]

There is a limit to the amount of force that workers can safely exert. Human strength limitations for pinching motions (such as pipetting) average 10 kg for males and 7 kg for females.[4] For repetitive activities such as pipetting, ergonomists recommend that force exertions do not exceed 30% of a worker's strength limit: 3 kg for a male or 2.1 kg for a female.[5]

To minimize the risks which lead to pipetting-related hand stress, pipettes which minimize force and/or repetition are crucial.

Pipetting forces: Traditional air-displacement pipettes

A study and comparison of the most widely used mechanical pipettes reveals that approximately 50% of pipetting forces results from heavy aspiration and blowout springs while the remaining 50% is due to heavy tip ejection forces.[6]

Figure 1 illustrates the average forces encountered in the most commonly used air-displacement pipettes. Tip ejection is the highest single force. The force required to eject a manufacturer-recommended tip can range from 2 to 8 kilograms with an average of 4 kilograms.

The next highest force is due to heavy blowout springs. Blowout forces average 2.25 kg and can easily exceed 4 kg, well above the recommended strength limitation for many laboratory workers.

The remaining significant pipetting forces illustrated in Figure 1 are aspiration spring forces (which average one kilogram) and static or holding forces (which average slightly less than one kilogram).

In traditional mechanical pipettes, the pipetting cycle is started by depressing the plunger against the aspiration spring (medium force) until it encounters the blowout spring (heavy force). This heavy spring defines the beginning of the pick-up stroke (zero point). For the exact volume to be picked up, the blowout spring must be substantially heavier than the aspiration spring.

Figure 2 depicts the force required to depress the plunger of a typical mechanical pipette. Initially, the thumb overcomes the aspiration spring which averages about one kilogram. A sharp increase in force occurs when the thumb reaches the blowout spring. At the point where blowout begins, is the "zero-point". The force at this point is the holding force: the amount of static force the contracted thumb continually applies while holding the plunger in the downward position prior to sample aspiration. Finally, the thumb overcomes the blowout force, the heaviest spring force in pipetting.

Figure 3 illustrates the peak pipette spring forces of aspiration and blowout for the three most common commercial pipettes.[7] The high ratio between the aspiration and blowout springs provides more resistance at the zero point and a higher sense of control and accuracy. Unfortunately, the need for this high force ratio results in higher pipetting forces and ultimately, risk of injury.

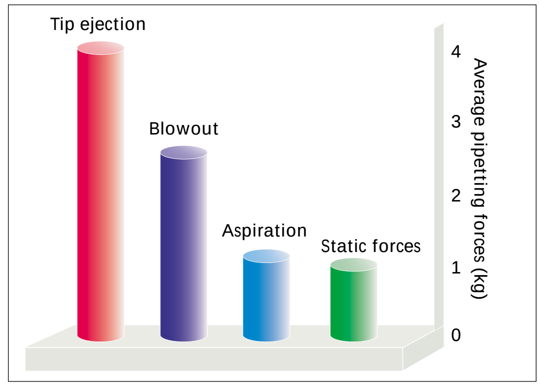

Figure 1 Average forces encountered in most commonly used air-displacement pipettes.

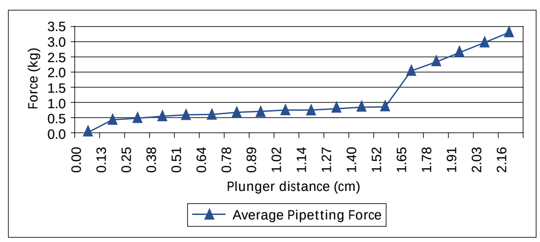

Figure 2 Force required to depress the plunger of typical mechanical pipettes.

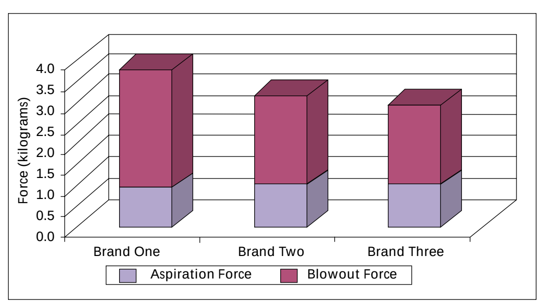

Figure 3 Comparison of peak pipette spring forces of aspiration and blowout for three common commercial pipettes.

Tip ejection force

Large tip ejection forces are caused by inadequacies of a conical pipette tip/shaft design which has not changed in over thirty years. In this conical system, the user is never quite sure when the seal between shaft and tip is made and therefore applies excessive force when attaching the tip. This produces a seal over a large surface area with very high friction. While the whole arm is used to attach this tip, only the smaller weaker thumb is used to eject it.

LTS: A new ergonomic solution for tip ejection

LTS™ LiteTouch™ Tip Ejection System was developed to reduce tip ejection forces. Both LTS tips and shafts are cylindrical rather than conical. These new tips are thin-walled and incorporate a small, well-defined seal and a positive stop. The stop allows the user to feel exactly when the seal is made and prevents over-insertion of the pipette shaft into the pipette tip. ***(Figure 4).***

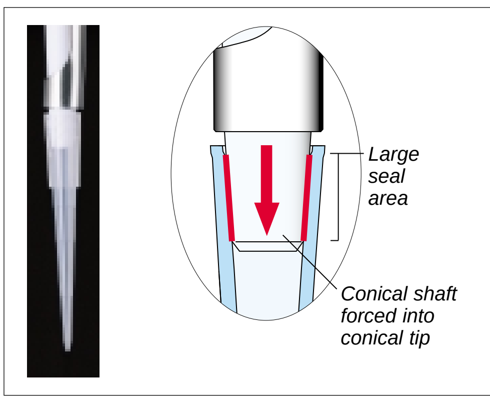

Figure 4-1 illustrates traditional conical shaft and conical thick wall tip system. Note the larger seal area.

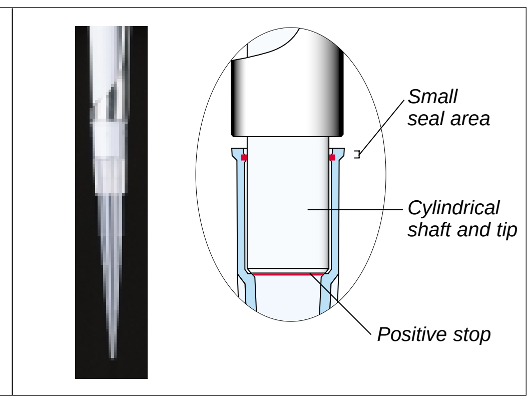

Figure 4-2 illustrates new LTS cylindrical tip/shaft system. Note thin wall construction with small, lower-friction seal area and positive stop.

Figure 5 illustrates the dramatic force reduction achieved with LTS compared to traditional conical tip/shaft designs. Average ejection forces are reduced from 4 to 0.6 kilograms. A force reduction of over 90% is possible using LTS.

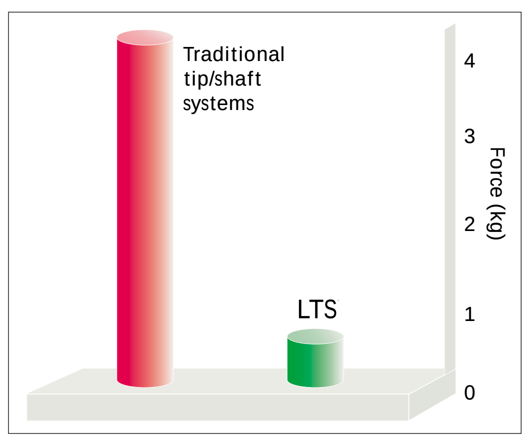

Figure 5 Ejection forces in LTS cylindrical tip/shaft system compared to traditional pipettes.

Rainin has designed three new ergonomic pipettes which incorporate the new LTS tip ejection system. These LTS pipettes can reduce total pipetting forces by 65% to 95% over traditional air-displacement pipettes.

Pipet-Lite, Pipet-Plus, and EDP3 with LTS

Pipet-Lite™ Magnetic-Assist Pipette with LTS
Up to 65% less pipetting force

Pipet-Plus® Latch-Mode™ Pipette with LTS
Up to 85% less pipetting force

EDP3™ Electronic Pipette with LTS
Up to 95% less pipetting force

Pipet-Lite with Magnetic-Assist

Pipet-Lite has the same feel and operation as the traditional air-displacement pipettes used by many scientists. But Pipet-Lite incorporates a magnet to help sense and hold the piston at the zero or home position before sample is drawn into the pipette. The combination of magnetic-assist and LTS tips result in an average force reduction of 65% over traditional mechanical pipettes.

Pipet-Plus Latch-Mode pipette

Pipet-Plus is a mechanical pipette that incorporates a magnetic latch and a trigger release to reduce the variables inherent in traditional pipettes. The magnetic latch holds the plunger in the down position, ready for sample pickup, until sample is aspirated by pulling the trigger. The tip is then filled at the speed set by an aspiration rate controller. Pipet-Plus with Latch-Mode eliminates 50% of the required thumb strokes[8] and with LTS reduces up to 85% of the overall force.[9]

EDP3 Electronic Pipette with LTS

EDP3 incorporates a lightweight, linear actuator stepper motor and high-capacity lithium-ion battery. Weight is 150 grams – similar to many mechanical pipettes. EDP3 is designed for one-handed (right or left) operation using dual “mouse” triggers with an actuation force of only 10 grams. With LTS, EDP3 reduces pipetting traditional pipetting forces by as much as 95%.

Pipetting Force Comparisons

Figure 6 shows comparisons of pipetting forces encountered in one pipetting cycle: 1) depressing plunger, 2) holding plunger at “home” position, 3) aspirating sample, 4) dispensing sample, 5) blowout stroke, and 6) ejecting tip, for traditional pipettes and LTS pipettes.

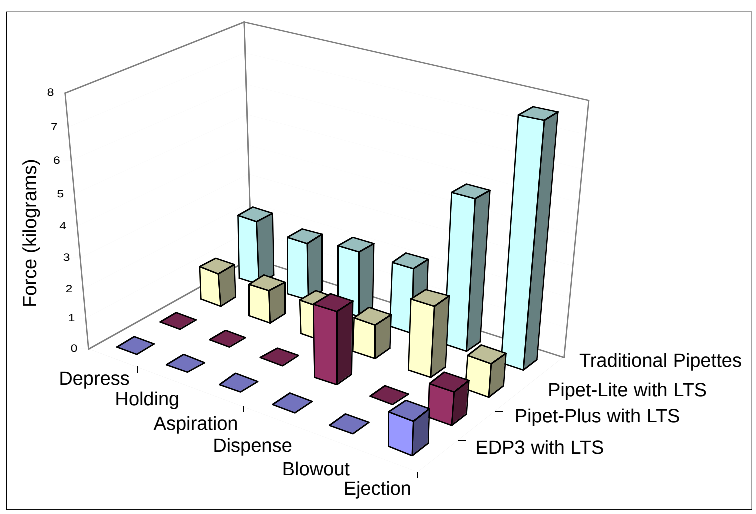

Figure 6 Forces encountered in one pipetting cycle: traditional and LTS pipettes.

Improving Pipette Ergonomics

LTS is a unique new pipette and tip system that has been shown to reduce tip ejection forces by as much as 90%. Used in conjunction with magnetic-assist, latch-mode, and microprocessor-controlled pipettes, LTS enables pipette users to experience a force reduction of 65 to 95%. The use of LTS pipettes can dramatically reduce the occurrence of cumulative trauma disorders among laboratory personnel.

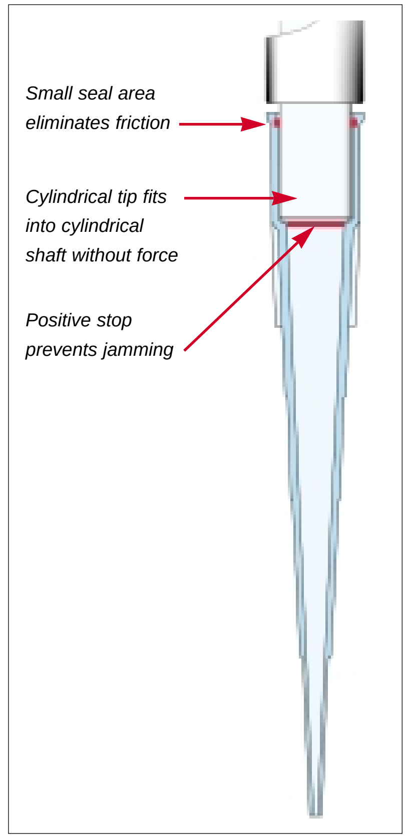

Figure 7 LTS: cylindrical shaft and cylindrical thin-walled tip, resulting in light ejection force

References

1. Bjorksten, M., *et al; Applied Ergonomics 1994;* **25(2)**: 88-94.
2. McGlothlin, J., Hales, T.; *NIOSH Health Hazard Evaluation Report 95-0294-2594.*
3. Bjorksten, M., *et al; Applied Ergonomics 1994;* **25(2)**: 88-94.
4. Woodson; W. E. 1981, *Human Factors Design Handbook*, 774.
5. Kroemer; K. H. E.; *Applied Ergonomics 1989;* **20(4)**: 274-280.
6. Pipetting forces were measured using an AccuForce Cadet force gage, with a range of 1 to 9 kilograms, calibrated using NIST traceable standards. Force/displacement measurements were taken using the AccuForce Cadet gauge and a Mitutoyo micrometer, also calibrated using NIST traceable standards. Measurements were repeated 10 times, and the mean value was used in each case.
7. The most universal 200 microliter pipettes are: Gilson Pipetman®, Eppendorf® Research, LabSystems® Finnpipette®.