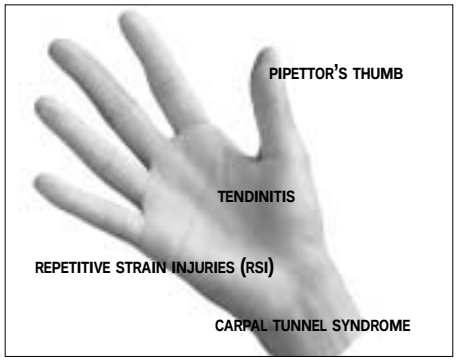
Smart Pipetting: **Using Ergonomics to Prevent Injury**

Joan Erickson
Bob Woodard

If you spend several hours a day using a manually operated pipette, you know it can be a real pain…in the neck, or the wrist or the elbow, or the thumb or just about any other part of the anatomy you care to name.



The bad news is that prolonged pipetting can lead to serious repetitive strain injuries. The good news is that there is a lot you can do to protect yourself.

Become informed. Learn all you can about pipetting injuries, risk factors, and how to prevent or reduce them. Not only will this information help you avoid injury, it will help you when choosing and using an ergonomic pipette. More and more laboratory-based scientists are becoming aware of the injuries that can result from repetitive pipetting. Many pipette manufacturers have responded with new designs that dramatically reduce end-user exposure to RSI-related injuries.

If it Hurts it's Not Necessarily Carpal Tunnel Syndrome

Most people who experience soreness or numbness in the hand or wrist from pipetting automatically assume they have carpal tunnel syndrome (CTS). In fact, CTS is just one of many repetitive strain injuries (RSIs). These injuries, also known as cumulative trauma disorders (CTDs), are characterized by damage to muscles, nerves, tendons, ligaments, joints, cartilage or spinal discs. Usually, symptoms are gradual in onset as they result from many small injuries sustained over a long period of time. It is the cumulative nature of CTDs that make them dangerous.

The Anatomy of Repetitive Stress Injury

CTDs can be divided into three groups of injuries: nerve injuries (such as CTS), muscle/tendon disorders, and joint problems. Pipetting can cause any and all of these injuries.

Nerve Injuries

Carpal Tunnel Syndrome is a disorder that can lead to permanent disability. Symptoms may include pain, weakness and/or numbness and tingling in thumb-side of the hand. CTS can occur in the laboratory when you hold the pipette so tightly that the tendons that operate your fingers swell and compress the median nerve where it passes through the carpal tunnel area. This problem can also be caused or worsened by the nerve being compressed when you bend your wrist.

Another type of nerve injury is Cubital Tunnel Syndrome. This occurs when the ulnar nerve (the "funny-bone" nerve) is compressed at the elbow—usually when the elbow is bent at 90 degrees or more. Resting your bent elbow on a hard bench top while pipetting for long periods of time is an excellent way to get Cubital Tunnel Syndrome.

Neck and Shoulder Nerve Compression injuries take place when the head and neck are bent forward for long periods of time or repeatedly turned to the side. They can also occur in the collarbone area when muscles or bony structures press on the nerves. Typically, this happens when shoulders are rounded or when the arm is held above shoulder height. These body positions can compress blood vessels and restrict blood flow, reducing the supply of nutrients to muscles and tendons.

Muscle/Tendon Disorders

Lateral Epicondylitis is the medical term for *tennis elbow*. Tennis elbow is common in the laboratory—even among those who have never picked up a racket. It is caused by overstressing the muscle/tendon units that straighten the wrist and fingers, and the symptoms include pain at the bony prominence of the elbow. If you place your tip rack too far away from you while pipetting, you have to fully extend your elbow, and often

your wrist, each time a tip is picked up, increasing your risk for this disorder. Poorly fitting pipette tips, which require you to repeatedly pound or rock the pipette shaft into the tip, can compound the problem.

Thumb Tenosynovitis, also known as deQuervain's Tenosynovitis, is one of the most common laboratory thumb injuries. In fact, a better name might be Pipettor's Thumb. Repeatedly depressing a pipette plunger or tip ejection button may lead to overuse of the muscle/tendon unit that puts the thumb into the "hitchhike" position, thus causing this injury. If you use a thumb-operated pipette, choose one with low tip ejection and plunger forces, and minimal plunger stroke length.

Joint Problems

Joint problems develop from excessive wear and tear on the joint surfaces. Clinical experience indicates that the joint most prone to wear and tear in the hand from pipetting is the carpometacarpal joint at the base of the thumb. Over time, the wearing of the joint can show up on x-ray as osteoarthritis or arthrosis of the joint.

Know Your Risk Factors

When looking at your work space and pipetting tasks, it is useful to keep certain risk factors in mind. Exposure to a combination of common risk factors[1] can greatly increase your chances of developing one of the CTDs discussed previously.

Force

Manual pipettes require relatively high levels of hand force. Tip insertion, plunger manipulations, and tip ejection require forces that have been shown to exceed recommended risk levels.[2,3] Each of these operations increases the stress to the muscles and tendons and, therefore, can increase the risk of CTD.

Repetition

According to a recent study, some laboratories perform more than 11,750 pipetting activities per day.[4] That's a lot of repetitions, and high repetitions lead to wear and tear on the tendons and joints.

Awkward Posture

Be aware of your posture. Keep your ears positioned over your shoulder, shoulders in line with your hips, and arms close to your body when possible. An awkward posture may lead to injuries. Awkward posture is commonly exhibited while working in a biosafety cabinet or when loading vertical gels.

Static Position

Tightly gripping a pipette handle tightly for extended periods of time reduces the blood flow and may put pressure on nerves. Static position is often observed when a person pipettes multiple aliquots, as he/she holds the pipette tightly for a long time. This is particularly troublesome if an awkward posture is assumed (e.g. slumped shoulders).

Extracurricular Activities

Some of these risk factors also pose a problem outside the lab. Remember, the key word here is *cumulative,* and even when you aren't holding a pipette, repetitive activities like typing, some sports, working with hand tools, and playing musical instruments present similar, if not identical, risks. That's not to say you should stop playing the harp or give up golf, but be aware of the movements involved and take care of yourself.

Practice Self Defense—Arm Yourself with a Good Pipette

One of the single best ways to reduce risk of injury is to choose the best pipette. What is the best pipette? One that eliminates risk factors. Here are a few things to think about when choosing the best pipette for you.

Watch Out for High Forces

When operating a pipette with CTD prevention in mind, a number of forces are working against you. Learn to recognize and avoid them.

Tip Insertion Force

Tip insertion force is the effort required to load pipette tips firmly on the pipette. Tips that do not seal properly require "pounding," rocking motion, or even hand tightening to seal the tips. You can decrease the amount of tip-loading force by using properly fitted pipette tips and moving the tip rack close to your body.

Tip Ejection Forces

Studies have shown that the plunger and ejection forces of a traditional manual pipette place a person at high risk of injury, especially in conjunction with high levels of repetitious pipetting.[2, 3] Next to tip insertion, tip ejection requires the most force during a pipette cycle. Tip ejection forces range from 1 kg to over 8 kg, with an average of 4 kgs.[12] And while it may be fun to have a pipette that can launch a tip across the lab, it can lead to Pipettor's Thumb.

How much is too much? Multiple studies have been conducted to determine the maximum lateral pinch strength (pipetting motion) capacity of men and women. One study noted the peak lateral pinch strength for women was 6.4 kg,[6] and another suggests 7.2 kg.[3] However, most people are unable to perform at their peak level for very long without risk of injury.

Studies recommend regular rest periods when the force is 20% to 30% of the maximum.[7, 13] Applying a 20% rule to lateral pinch strength capacity suggests that forces as low as 1.6 kg should be the maximum.

It is also important to be aware of the fact that when ejecting a pipette tip, the contact force within the joint at the base of the thumb increases about 9-13 fold compared to the force experienced at the tip of the thumb.[5]

The bottom line is that 4 kg of ejection force is too much. Choose a pipette that requires less. Your thumb will thank you for it.

Blowout can "Blowout" your Thumb

Thumb motions associated with pipetting also place a person at risk. These include depressing the pipette plunger through the blowout stroke. As in tip ejection, blowout forces can exceed 4 kg of force,[12] placing considerable stress on the many tendons, ligaments, and muscles in your hand. There is no reason to expose yourself to this level of stress. New pipette designs significantly lower the forces required for plunger activation and tip ejection.

Look for the Finger-Hook

Pipettes with a finger-hook make it easy to rest the hand before, during and after a pipette cycle. Your grip can be relaxed, reducing inflammation of the tendons and possible compression of the median nerve. This greatly reduces the risk of carpal tunnel syndrome and tendinitis.

Get a Grip

The diameter of the pipette handle is another consideration. Grant, et al found that forearm muscle activity was reduced when a smaller handle was used. The study indicates that handles with a diameter –one centimeter smaller than the user's inside grip diameter may reduce effort and potential for injury.[8]

It's all in the Wrist

The position of the wrist and hand when operating the pipette is a key factor to injury prevention. Many pipettes are designed so the wrist needs to be tilted to the side and bent in order to operate. It is important that the wrist be held in a neutral position, so that it is not bent up or down or side to side. Studies have demonstrated that when the wrist is tilted to the side, the maximum capacity of the muscles is reduced.[9] There is also a reduction in strength when the wrist is tilted down or back.[9, 10] The lateral pinch strength used when operating a thumb-operated pipette is reduced when the wrist is bent down or back or deviated to the side.[6]

Where are the Controls?

Thumb tendinitis and tenosynovitis can also be caused when the thumb is extended away from the hand. When choosing a pipette, notice where the controls are located. How far will you need to extend your thumb when operating the controls? Mital and Kumar found that the further the thumb needs to reach in performing lateral pinch the greater the strength required.[6] Choose a pipette that minimizes thumb extension.

Manual vs. Electronic

Electronic pipettes reduce two major risk factors: force and repetition. Some manual pipettes require considerable force to grip and to manipulate the plunger during the pipette cycle. Electronic pipettes use a motor to control the plunger, removing many motions and considerable physical stress on the thumb, hand, and forearm. Most electronic pipettes are also programmable, thereby eliminating many repetitive motions involved in procedures such as mixing, diluting, and dispensing multiple samples.

Automatic operation, lightweight construction, increased handle comfort, low maintenance, and high accuracy/precision—it all adds up to making electronic pipettes an attractive choice.

Ask your pipette supplier to explain the advantages of their product offering before you decide.

The Importance of Technique and Posture

Pipette design can go a long way toward preventing CTDs but your pipetting technique will also ensure you get maximum benefit from it.

Pay close attention to your posture, alternating hands when possible, taking breaks, doing stretches and varying activities throughout the day.

Keep the pipette and supplies (pipette tip racks, etc) close to your body (no more than the length of your forearm).

Put the waste container low or in a well in the bench.

If you feel pain–STOP! Your body is trying to tell you something.

Take care of your body; it's the only one you get

Pipetting is a key component of many research applications. By choosing the right pipette and paying attention to proper technique and posture, there is no reason pipetting should be painful or cause injuries. Take the time now to inform and equip yourself so you won't have to pay for it later.

Authors

***Joan Erickson**[10] is an ergonomic consultant to biomedical and research institutions in the Seattle area. She has extensive experience as an occupational therapist and certified hand therapist treating individuals with repetitive strain injuries.*

***Bob Woodard** is a freelance writer specializing in healthcare and the life sciences.*

References

1. Occupational Safety and Health Administration (OSHA), 1999, Ergonomics Program, 29 CFR Part 1910, RIN No. 1218-AB36. www.osha-slc.gov/ergonomics-standard/.

2. Bjorksten, M.G.; Almby, B; and Jansson, E.S. (1994), Hand and shoulder ailments among laboratory technicians using modern plunger-operated pipettes. *Applied Ergonomics*, Vol. 25:2, 88-94.

3. Fredriksson, K. (1995), Laboratory work with automatic pipettes: a study on how pipetting affects the thumb. *Ergonomics*, Vol. 8:5, 1067-1073.

4. McGlothin, J.D.; and Hales, T.R. (1996), "Health Hazard Evaluation Report"; HETA 95-0294; Science Applications International Corporation. Frederick, MD; NIOSH, U.S. Department of Health and Human Services, Center for Disease Control and Prevention.

5. Cooney, W.P., III; Chao, E.Y.S. (1977), Biomechanical analysis of static forces in the thumb during hand function. *Journal of Bone and Joint Surgery,* 59-A (1), 27-36.

6. Mital,S.; Kumar, S. (1998), Human muscle strength definitions, measurement and usage. *International Journal of Industrial Ergonomics,* 22, 101-121.

7. Dalahan, J.D.; Fernandez, J.E. (1993), Psychophysical frequency for a gripping task. *International Journal of Industrial Ergonomics,* Vol. 12, 219-230.

8. Grant, K.A.; Habes, D.J.; Steward, L.L. (1992) An analysis of handle designs for reducing manual effort: the influence of grip diameter. International Journal of Industrial Ergonomics, Vol. 10, 199-206.9.

9. Kattel, B.P.; Fredericks, T.K.; Fernandez, J.E.; Lee, D.C. (1996), The effect of upper-extremity posture on maximum grip strength. *International Journal of Industrial Ergonomics,* Vol. 18, 423-429.

10. Hallbeck, M.S.; McMullin, D.L. (1993), Maximal power grasp and three-jaw chuck pinch force as a function of wrist position, age, and glove type. Vol.11, 195-206.

11. Hoskins, D.B.; Erickson, J.G., (1998), Laboratory ergonomics: the wake-up call: How one company relieved stress and strain on its employees. *Chemical Health and Safety*, January/February, 20-23, 38.

12. Fox, T., A pipet with ergonomic benefits. *American Biotechnology Laboratory,* July 1999.

13. Kroemer, K. (1989), Cumulative trauma disorders: their recognition and ergonomics measures to avoid them. *Applied Ergonomics,* 20, 274-280.