# Avoiding Injury While Using Tools

# Part I: Tool Design

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Home improvement projects and repairs are almost inevitable whether you own a house or not! Unless you want to spend a fortune on painters, appliance repairs, plumbers, and carpenters, most people learn to tackle at least some of these projects. Home improvement can be fun and challenging; the sense of pride and accomplishment is unmatched. In many cases, projects can keep you mentally and physically sound. However, there is a high level of risk for Cumulative Trauma Disorder if the injury threshold is crossed. Injuries occur when "weekend warriors" don't use proper tools, when they use tools improperly, or when they underestimate the time required and have to do a whole project in one day or one weekend.

Injury prevention involves a complex interaction between users and their tools. Using the wrong tool, using the right tool incorrectly, or using poorly designed tools can cause injuries to muscles, tendons, joints and nerves.[1] Therefore, we want to help you approach things armed with the correct tools, knowledge, and attitude so that you don't injure yourself in the process. This series of articles will discuss proper tool design, introduce you to some user-friendly tools, and suggest ways to accomplish simple tasks to avoid injury.

Developing a single standard for hand tool design is challenging due to the size differences of tool users, so product development continues to evolve.[2] No hand tool is perfect for every job or every user.[2] A good tool feels like an extension of the body.

To avoid injury while using tools, the following goals need to be met.[2] The best tool will:

- Decrease the force or grip strength.
- Decrease repetitive motion.
- Decrease awkward body postures or wrist positions.
- Decrease vibration transmitted to the hand and wrist.

<u>Force or grip strength</u>
There are several factors that affect the amount of force and grip strength needed when using a tool: the type of handles and grips, how the tool is maintained, and the balance and weight of the tool.

1. *Handles and grips*
The most important consideration is to avoid tools that are difficult to use or hold.

In general, tools with **longer handles** require less force.[2,3] A hand tool with a longer handle allows the user to generate more leverage with a smaller force at a greater distance.

A handle should extend across the entire breadth of the palm to avoid the end of the handle digging into the palm. [1] The preferred length is 5.5 inches, although it may need to be longer if the user is wearing gloves. [1] The handle span for crushing, gripping or cutting tools, such as pliers or tongs, is 3 inches for both male and female users. [1]

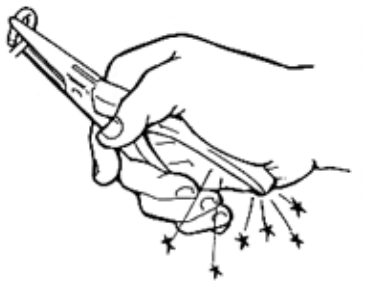


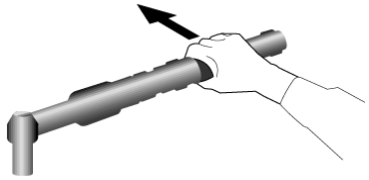
Illustration courtesy of Reference 4

In addition, tools such as pliers and wrenches with slightly **wider handles** distribute grip force and contact stress over a larger surface, thus reducing the required grip strength.[2]

A **thicker handle** allows more surface for grasping; however, the handle must be the right size for the hand. For example, a screwdriver with a thicker handle has increased torque which reduces the overall required force.[2] But if the handle is too thick, it will cause greater strain for someone with smaller hands [2] To determine the optimum **grip diameter**, make the "okay" sign using the thumb and index finger, then measure the diameter of the "O" formed by the thumb and index finger. [2] If a tool grip size is wrong, it should be customized for the best fit. [2]

Handles with molded **finger grips** provide improved slip resistance.[2] In the case of custom-molded finger grips, the tool should only be used by the person for whom the tool was customized.[2]

Tools with **straight** handles are good for tasks where the force is exerted perpendicular to the straightened forearm and wrist.[1] **Bent** handles are effective when most tasks are performed in the same plane and height as the arm and hand. [1]



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Avoid tools that require finger or pinch grip. A **power grip** allows the operator to align the fingers so they work together to maximize hand strength.[1] The occasional exception is during precision work when a pinch grip allows better finger control for minute manipulations with the tool.[1]

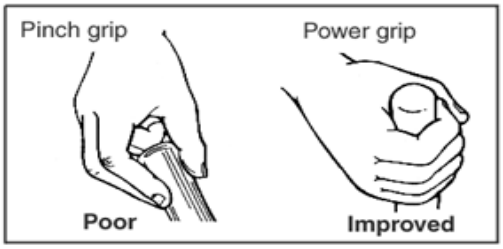



Illustration courtesy of Reference 4

Handles and grips should be cylindrical or oval in shape.[1] The range of diameters for a power grip is 1.2-1.8 inches. The range of diameters for precision pinch-grip tools (eg. Tweezers) is 0.3-0.5 inches.[1]

A tool designed with a **pistol grip** may require less gripping force than an in-line tool handle.[2] Pistol grips are preferred when the force is exerted in a straight line in the same direction as the straightened forearm and wrist, especially when the force must be applied horizontally.[1] However, if the wrist is not straight, pistol grips put more force on the wrist and forearm.

Select tools with **switches** that allow use of all four fingers to operate.[3] In other words, avoid tools that require trigger-finger action.[3] Triggers should be at least 1 inch in length to allow more than one finger to activate them, reducing force and strain on one finger.[1] The switch location and style is very important for power tools.

**Cushion grips** provide better tool comfort and slip resistance, as well as reduced grip force.[2] Compressible materials on grips are better than metal or hard plastic.[3] Beware of tools marketed as having a slip-resistant handle, however, because in many cases the material will not stand up to the tasks and environments required of the tool.[2] Handles made of plastics or compound rubbers are recommended for applications involving electricity or temperature extremes that get conducted to the hand through the metal. [1]

A variety of materials can be used to customize tool handles and grips.[2] These materials include Magic Wrap, Plastic Dip, Heat Shrink Tubing, Tool Wrap, Plastazote, and pipe insulation.[2] Gloves with slip resistant material on the palm and fingers are also available.[2] Thick materials that can be used to create custom molded finger grips are My Grip, Thermoplastic, or epoxy putty. [2]

Note: If you wear **gloves**, make sure they fit.[3] Tight gloves put pressure on the hands; loose gloves require more grip force to hold tools.[3] Gloves can affect dexterity and the ability to grip.[3]

2. *Tool maintenance*
Worn out or poorly maintained tools require more force, such as worn drill bits and saw blades.[2] Teflon coated saw blades may improve tool efficiency, which reduces force needed to use the tool.[2] These blades require regular maintenance.

Proper power tool maintenance may reduce vibration. [1, 2,6]

3. *Tool balance and weight*
The weight of the tool and distribution of the load within the tool affects the way the user holds the tool.[1] It is best to limit the weight of the tool to 2.5 to 3 pounds for tools operated with one hand. [1, 5] Precision tools should weigh less than 1 pound. [1]

A tool's balance can sometimes make a heavier tool feel lighter. A well-balanced tool is easier for the user to hold, fits the hand better, and feels more natural.[7]

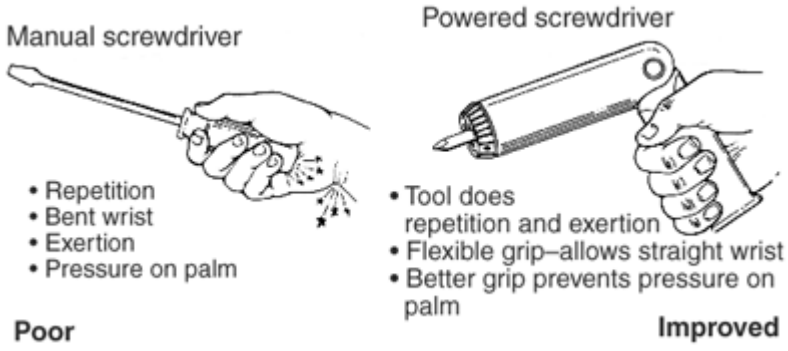
The distribution of weight should align the tool's center of gravity with the center of the gripping hand. [1, 5] For example, drills that are front-heavy require more effort to balance. [1, 5]

Advances in electronics and tool materials affect tool weight: [7]
1) Some tool manufacturers have recently introduced Lithium Ion (Li-Ion) batteries for cordless tools.[8, 9] This type of battery weighs less than the NiCd batteries, has a much longer run time, and is much smaller.[8, 9] Therefore, the tool is more compact and easier to use.

2) Housings made with plastic/fiberglass compounds or magnesium reduce overall weight.[7]

Repetitive motion
There are a number of ways to decrease repetitive motion associated with tool use.

1. Avoid tools that require repetitive motions and bending or twisting of the wrist. The greater the force exerted and the more the hand must twist to use it, the greater the risk of injury.[1] When possible, replace hand tools that require frequent and repetitive force with power tools.[1] For example, use power screwdriving tools rather than handheld screwdrivers.

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Power tools increase efficiency as well. However, in some cases, switching to power tools may cause other risks such as vibration.[2] It is important to consider all options when selecting a tool.

2. Use hand tools that have adjustable spring-loaded returns, such as pliers and scissors.[2]

3. Look for other innovations that can reduce repetitive motions, such as saw blades that cut faster.[2]

4. Use proper operating methods to eliminate unnecessary force and repetition. For example, make pilot holes for drilling.[2]

5. If a task has sufficient clearance, use tools with gears or a ratcheting mechanism.[2]

When it is not possible to reduce the repetitive motions due to the nature of the task, take some time to plan or redesign the work or task itself.[2]

Awkward postures and wrist positions

Poor wrist positioning can lead to repetitive strain injuries.[2] Some hammers and pliers are designed with a bent or curved handle to maintain a more natural wrist position. Some gardening tools and paintbrushes can be modified with an add-on pistol grip that facilitates a straight wrist.[2]

A general rule is "bend the tool, not the wrist", so use tools with angled or bent handles when appropriate.[1]

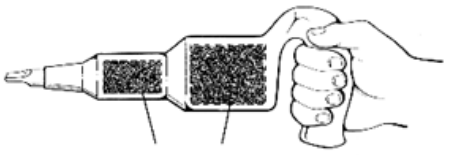
Photo courtesy of Tomboytools.com

Vibration

Vibration may be the largest concern with power tools.[2, 3] Exposure to large amounts of vibration in a localized area, such as the hand, may increase the risk of chronic disorders of the muscles, nerves, and tendons.[2] The amount of vibration transmitted by a power tool can be influenced by the tool's weight, design, and various attachments.[2] Poor design is often responsible for unnecessary vibration.[6]

The goal is to create as much distance as possible between the tool vibration and the user.[1] Tool covers and anti-vibration gloves can help achieve this distance, although their effectiveness varies.[1, 2]

Power tools designed with anti-vibration materials or anti-vibration mounts/handles have had limited success in reducing the amount of transmitted vibration.[2]

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If you must use vibrating power tools for prolonged periods of time, try to redesign the process, redistribute the work, or use some kind of external support to handle the power tool.[2]



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