

Preventing Injuries from Slips, Trips, and Falls¹

Carol J. Lehtola, Charles M. Brown, and William J. Becker²

The Problem

For 2003, the National Safety Council reported that falls resulted in over 7 million visits to emergency rooms — leading all other causes of ER visits. Over 16,000 Americans died as the result of a fall in 2003.

In the workplace, the Bureau of Labor Statistics reported 4.4 million injuries for 2003. About a third of these resulted in days away from work, and of these, over 250,000 were falls, accounting for almost 20% of disabling workplace injuries. Injuries due to falls in the workplace typically resulted in 7 to 14 days away from work. About 700 workers died from a workplace fall in 2003.

The average direct cost for one disabling workplace injury has been estimated at \$34,000. Taking into account indirect costs would make this number much higher. Estimates for indirect costs of injuries range from 2 to 5 times the direct cost. In the case of a death on the job, the average cost has recently been estimated at \$1.15 million. Add to these the personal and family costs and trauma, and it is evident that slips, trips and falls should be avoided.

A thorough analysis of falls in Florida agriculture was conducted in 1991, based on an analysis of Workers' Compensation records. Falls accounted for nearly 25 percent of all serious disabling work injuries: 17 percent were elevated falls, 8 percent were same-level falls. Elevated falls accounted for 26 percent of the injuries in fruit and vegetable production occupations. Same-level falls accounted for 12 percent in both livestock and horticultural production occupations.

In addition, 32 percent of all elevated falls in Florida agriculture were from ladders, while 25 percent were from vehicles and other mobile equipment. Same-level falls were on walking or working surfaces in 76 percent of the incidents.

The back was the most frequently injured part of the body in falls: 37 percent of the injuries were from elevated falls, while 29 percent were from same-level falls. The joints — wrist, elbow and shoulder, or the ankle, knee and hip — accounted for 32 percent of elevated falls and 47 percent of same-level falls.

Most injuries are sprains and strains: 52 percent from elevated falls, 46 percent from same-level falls. Fractures are the result of 19 percent of elevated falls

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 2. Carol J. Lehtola, associate professor and Extension Agricultural Safety Specialist; Charles M. Brown, coordinator information/publication services; William J. Becker, professor emeritus; Agricultural and Biological Engineering Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

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and 10 percent of same-level falls. Bruises and contusions account for most of the remaining injuries.

Types of Falls

Falls are of two basic types: elevated falls and same-level falls. Same-level falls are most frequent, but elevated falls are more severe.

- Same-Level Falls: high frequency–low severity
- Elevated Falls: lower frequency–high severity

Same-level falls are generally slips or trips. Injury results when the individual hits a walking or working surface or strikes some other object during the fall. Over 60 percent of elevated falls are from less than 10 feet.

Same-Level Falls

Examples of same-level falls are described below.

Slip and Fall

Slips are primarily caused by a slippery surface and compounded by wearing the wrong footwear. In normal walking, two types of slips occur. The first of these occurs as the heel of the forward foot contacts the walking surface. Then, the front foot slips forward, and the person falls backward.

The second type of fall occurs when the rear foot slips backward. The force to move forward is on the sole of the rear foot. As the rear heel is lifted and the force moves forward to the front of the sole, the foot slips back and the person falls.

The force that allows you to walk without slipping is commonly referred to as "traction." Common experience shows that dry concrete sidewalks have good traction, while icy surfaces or freshly waxed floors can have low traction. Technically, traction is measured as the "coefficient of friction." A higher coefficient of friction means more friction, and therefore more traction. The coefficient of friction depends on two things: the

quality of both the walking surface and the soles of your shoes.

To prevent slips and falls, a high coefficient of friction (COF) between the shoe and walking surface is needed (Figure 1). On icy, wet, and oily surfaces, the COF can be as low as 0.10 with shoes that are not slip resistant. A COF of 0.40 to 0.50 or more is needed for excellent traction. To put these figures in perspective, a brushed concrete surface and a rubber heel will often show a COF greater than 1.0. Leather soles on a wet smooth surface, such as ceramic tile or ice, may have a COF as low as 0.10.

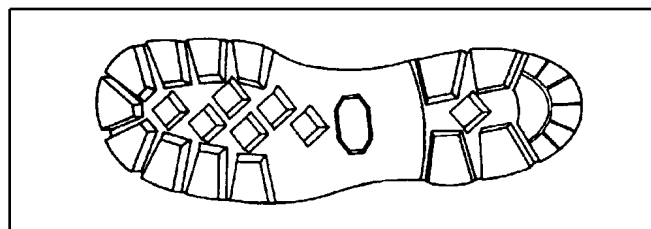


Figure 1. Shoes with soft rubber soles and heels with rubber cleats provide a high coefficient of friction (COF).

Providing dry walking and working surfaces and slip-resistant footwear is the answer to slips and their resultant falls and injuries. Obviously, high heels, with minimal heel-to-surface contact, taps on heels, and shoes with leather or other hard, smooth-surfaced soles lead to slips, falls, and injuries. Shoes with rubber-cleated, soft soles and heels provide a high COF and are recommended for most agricultural work.

In work areas where the walking and working surface is likely to be slippery, non-skid strips or floor coatings should be used. Since a COF of 0.40 to 0.50 is preferred for walking and working surfaces, we should strive for a surface which provides a minimum of 50 percent of this friction. If the working surface is very slippery, no footwear will provide a safe COF.

Trip and Fall

Trips occur when the front foot strikes an object and is suddenly stopped. The upper body is then thrown forward, and a fall occurs.

As little as a 3/8" rise in a walkway can cause a person to "stub" his toe resulting in a trip and fall. The same thing can happen going up a flight of stairs:

only a slight difference in the height of subsequent steps and a person can trip and fall.

Step and Fall

Another type of working and walking surface fall is the "step and fall." This occurs when the front foot lands on a surface lower than expected, such as when unexpectedly stepping off a curb in the dark. In this type of fall, the person normally falls forward. A second type of step and fall occurs when one steps forward or down, and either the inside or outside of the foot lands on an object higher than the other side. The ankle turns, and one tends to fall forward and sideways.

Contributing Factors

Proper housekeeping in work and walking areas can contribute to safety and the prevention of falls. Not only is it important to maintain a safe working environment and walking surface, these areas must also be kept free of obstacles which can cause slips and trips. One method which promotes good housekeeping in work environments is the painting of yellow lines to identify working and walking areas. These areas should never be obstructed by objects of any kind.

Adequate lighting to ensure proper vision is also important in the prevention of slips and falls. Moving from light to dark areas, or vice versa, can cause temporary vision problems that might be just enough to cause a person to slip on an oil spill or trip over a misplaced object.

Carrying an oversized object can also obstruct one's vision and result in a slip or a trip. This is a particularly serious problem on stairs.

Behaviors that Lead to Falls

In addition to wearing the wrong footwear, there are specific behaviors which can lead to slips, trips, and falls. Walking too fast or running can cause major problems. In normal walking, the most force is exerted when the heel strikes the ground, but in fast walking or running, one lands harder on the heel of the front foot and pushes harder off the sole of the rear foot; thus, a greater COF is required to prevent

slips and falls. Rapid changes in direction create a similar problem.

Other problems that can lead to slips, trips and falls are: distractions; not watching where one is going; carrying materials which obstruct view; wearing sunglasses in low-light areas; and failure to use handrails. These and other behaviors, caused by lack of knowledge, impatience, or bad habits developed from past experiences, can lead to falls, injuries, or even death.

Elevated Falls

Generally, elevated falls are less frequent but more severe than same-level falls in the workplace. In Florida agriculture, 17 percent of all serious injuries are from elevated levels and eight percent are from same-level falls.

Falls from ladders while harvesting oranges and grapefruit are the major cause of elevated falls in Florida agriculture, but there are also significant numbers of falls from vehicles and equipment, loading docks, buildings and other structures.

Falls from Ladders

Ladders may be fixed or portable. They may be straight- extension- or step-ladders and may be manufactured from wood, metal, plastic, or fiberglass. They can be light-, medium-, heavy-, or extra-heavy-duty.

They can be two feet high (step-stools), 18 feet for extra-heavy-duty step-ladders, and 40 feet or longer for extension-type ladders.

The materials from which ladders are constructed have advantages and disadvantages in weight, durability, flexibility, conductivity, and strength. The intended use of the ladder should determine the type purchased, and only American National Standards Institute (ANSI) approved ladders should be used. One major caution is that metal ladders should never be used in locations in which the ladder or its user could come into contact with electricity.

A ladder should be long enough so that when it rests against the upper support the user can work with waist no higher than the top rung of the ladder or above the rung at which the siderails are resting against the upper support. This means that the top three rungs of a straight ladder, or the top two steps of a step-ladder, should never be used for the feet.

The lower ends of the siderails should be equipped with slip-resistant pads, particularly if the ladder is to be used on hard surfaces. The same is true for the upper ends of the siderails if they are to rest against a surface.

Ladders should be set at, or as near, a 4:1 angle as possible (See Figure 2). That is, for each three or four feet of rise from the base to the upper resting edge of the ladder, the base should be one foot out from a vertical line from the upper resting edge of the ladder to the working surface. As an example, if a ladder is leaning against a ledge that 20 feet off the ground, the base of the ladder should be five feet back from the Preventing Injuries from Slips, Trips, and Falls 4 wall. The base of the ladder must be firmly set so that there is no possibility of slippage or settling into soft ground. The resting edge of the ladder should have both siderails in contact with the object (building or tree) it is against. When setting a ladder against a tree, set the ladder in the crotch of two limbs so that it cannot slide in either direction. Whenever there is any question as to the stability of the ladder, additional effort should be made to stabilize the ladder as it is being climbed. Tying the top of the ladder to the supporting structure can also keep the ladder from slipping or sliding.

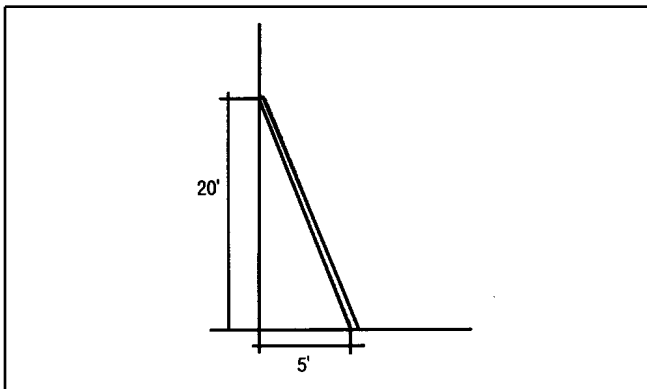


Figure 2. Use a 4:1 ratio for setting ladders.

Ladders should be inspected before use: check for cracks, loose rungs, splinters, and sharp edges. Never paint ladders, as the paint can hide potentially dangerous conditions. Wooden ladders can be coated with linseed oil or an oil-based wood preservative to keep them from drying out and cracking. Allow ladders to dry thoroughly before using them or the rungs will be slippery.

The rungs and siderails of ladders must be kept free of oil, grease, and mud; they should be kept dry. Since the shoe has limited contact with the rung or step of a ladder, it is very important that both rungs and shoes have a high COF. Only shoes with heels should be worn when climbing ladders; users should be taught that the rung or step of the ladder should be just in front of the heel, under the arch of the foot. Stepping or standing on a ladder with the front part of the shoe is inviting a slip and fall. Always face the ladder when climbing or descending.

Another frequent cause of ladder-related injuries is attempting to reach too far left or right. When working on a ladder, the person's belt buckle should never extend beyond the siderails. Reaching further can cause the ladder to slide in the opposite direction. Tying the ladder to the structure supporting it can prevent this and is a recommended practice.

Workers should have both hands free to hold the ladder's siderails, not the rungs, when climbing or descending. Small tools may be carried in a tool belt, not in the hands; but a better choice is to raise tools and supplies with a rope. Never raise or lower power tools by the cord or while they are plugged into an electrical source.

Make-shift ladders, chairs, boxes, and barrels should never be used as substitutes for a ladder — the risk is far too great.

Falls from Vehicles and Equipment

Death or serious injury is a frequent result of extra riders falling from tractors, equipment or the bed of a truck. Unless the operation requires riders, such as on certain planting and harvesting equipment where seats or protected work areas are provided, extra riders should never be permitted. Riding on tractor fenders, draw-bars on equipment, or the bed of

a truck is an invitation for a disaster. The safe way is **"NO RIDERS"**.

Far too many injuries occur in the simple process of getting in and out of trucks, on or off tractors, machinery, wagons, trailers or truck beds. When the steps are metal, there is a low COF which becomes even lower if they are wet, muddy or oily. Keep the steps clean and dry.

Whenever mounting or climbing on a vehicle or machine, have a good hand-hold before stepping up. Pulling yourself up reduces the force between your shoe and the step and reduces the danger of a slip. As with a ladder, the foot should be placed on the step or rung just in front of your heel, under the arch. Always face the vehicle or equipment when mounting and dismounting. When stepping down backward, one steps down on the ball of the foot; when stepping down forward, one lands on the heel, thus increasing the chances of falling, twisting an ankle or knee or suffering some other injury.

Practice the "Three-Point System." This system can significantly reduce the chances of injuring yourself through a slip or fall while climbing ladders or while entering or exiting a vehicle. The Three-Point System means that three of your four limbs are in contact with the ladder or vehicle at all times, either one hand and two feet, or two hands and one foot — only one limb is in motion at any one time.

One more tip that will save you from many sprains or worse: When getting off the bed of a truck or wagon or any similar level: Step down backward, never "jump" or "fall" down forward.

Falls from Loading Docks

Loading docks and ramps are dangerous areas. They are frequently congested, heavy-traffic areas, and working and walking surfaces are often wet. Metal dock plates can wear smooth and become very slippery; in particular, the edge of a dock plate invites trips and falls.

Accidental backward steps can result in a fall from the dock. Portable railings, which can be easily removed from the edge of the dock, could prevent many dangerous falls. They are removed when a

truck or tractor is at the dock, and replaced as soon as the truck or trailer leaves.

Proper housekeeping, well-designed traffic patterns and the use of abrasive, skid-resistant surface coatings will reduce the risk of slips, trips and falls.

Ramps and gang-planks have hazards similar to loading docks. The slopes should be as gradual as possible, as wide as possible, and as dry as possible. They should also have skid-resistant surfaces.

Falls on Stairs

Stairwells should be well-lighted, with sturdy handrails on both sides. Persons using the stairwell should have one hand free to be able to use the handrail.

All the steps should have the same rise and depth, with visible edges. They must be kept free of grease, oil and obstacles which could cause slips and trips. Whenever possible, avoid carrying heavy or bulky objects which obscure your vision and/or require the use of both hands. Carry smaller, lighter loads and make more trips, or obtain help with the load.

Fixed Ladders

Fixed ladders are mounted on buildings, bins and other tall structures which require workers to climb to high levels to perform some functions. Such ladders should be securely attached to the structure and be capable of supporting a minimum of 250 pounds, of concentrated live weight. The rungs should be a minimum of 16 inches wide and a maximum of 12 inches apart. There should be seven inches of toe space between the rung and the structure to which it is attached. Fixed ladders extending more than 20 feet above the ground or floor level should be surrounded by a cage, beginning at 7 to 8 feet above the ground.

If a catwalk or working area is provided at the top of the ladder, it should have a protective railing at least 42 inches high. A toe board, four-inches high, around the edge of the work area should be provided. This reduces the risk of a person stepping off the edge or having tools fall from the work area.

Workers climbing or descending a fixed ladder should have both hands free. Small tools can be carried in a tool belt; other tools and materials should be raised by rope and pulleys or some other mechanical system.

Fall Protective Devices

Workers at high elevations, such as ladders, platforms, or catwalks, should be protected from falling by some kind of fall protective device. This can be a protective cage, a lifeline, lanyard, safety belt or harness; there are numerous devices on the market. The system should provide maximum protection, but it also should be reasonably comfortable and not restrict a worker's necessary work activity. Suppliers of safety equipment can provide information on the correct system for your workplace and should provide instruction on its safe use.

Slip-Resistant Materials

Abrasive coatings can be applied to concrete, metal and wood surfaces to increase the COF and reduce the risks of slips and falls. Many of these products can be applied like paint; others can be troweled on in a thin coat. These coatings are formulated to resist grease, oil, water and a wide range of chemicals. Most paint and building supply companies handle these materials. It is important, however, to purchase the correct product for your particular problem, since some are enamels or epoxies which contain a rough, hard, gritty material with a high COF.

There are also a number of skid-resistant products that can be purchased in strips or rolls. These may have a pressure-sensitive backing or be applied with a special glue. They are designed for easy application to stair treads, ramps and other hazardous walking and working surfaces.

Another effective skid-resistant material is rubber or rubber-like mats. This material is long-wearing and skid-resistant on both the top and bottom sides. Hard rubber or hard rubber-like mats are ineffective because they have a low COF when wet.

Signs and Stripping

Safety signs to remind people of slip, trip and fall hazards are certainly always helpful, particularly where hazards cannot be removed or corrected. Such signs should be changed frequently. Recent evidence indicates that "humorous" warnings are more effective than simple warning signs. "CAUTION—WET FLOOR" is less effective than "WET FLOOR—SKATE, DON'T SLIP".

Yellow stripping to identify walking and working areas are most effective if their meaning is enforced. Striped areas should mean that no object should be placed in these areas. Dropped and spilled materials should be removed immediately.

Learning How to Fall

Naturally, the goal is not to slip, trip and fall; however, the possibility of a fall still exists. There are correct ways to fall, however, the recommended procedures are:

- Tuck your chin in, turn your head, and throw an arm up. It is better to land on your arm than on your head.
- While falling, twist or roll your body to the side. It is better to land on your buttocks and side than on your back.
- Keep your wrists, elbows and knees bent. Do not try to break the fall with your hands or elbows. When falling, the objective is to have as many square inches of your body contact the surface as possible, thus, spreading out the impact of the fall.

More about Shoes and Boots

According to the National Safety Council (NSC), there are 110,000 injuries each year to the feet and toes of United States workers, representing 19 percent of all disabling work injuries.

The most important protection is to wear the proper footwear for your work and environment. In most agricultural occupations the shoes or boots should provide three major types of protection.

- The soles and heels should be slip-resistant
- The toe of the shoe should resist crushing injuries
- The shoe should support the ankle.

ANSI sets standards for shoes and boots. Never purchase work shoes that do not meet these standards. A typical ANSI rating could be 1-75 C-25. This means the toe will withstand 75 foot pounds of impact and 2,500 pounds of compression.

Chevron or cleat-designed soles are definitely the best for slippery situations because of the suction or squeezing action they provide. The softer soles are better for slippery indoor conditions; the harder, more rugged cleat-type sole is preferred for tough outdoor use.

Leather covering the foot and ankle portion of the foot is preferred in most work environments. However, when working in wet environments or around chemicals, oils, greases or pesticides, boots made of polyvinyl chloride (PVC), a blend of PVC and polyurethane, or neoprene should be used. Rubber is satisfactory for wet conditions, but not with pesticides or petroleum products.

When purchasing work shoes or boots, it is best to purchase them from a reputable dealer who handles quality footwear. A dealer who is informed of your work and work environment will be able to provide the correct footwear for you. Quality footwear for work is expensive; but not nearly as expensive or painful as broken foot bones or other injuries from a slip, trip or fall.

Recommendations

Established policies and practices can be implemented to significantly reduce the number of injuries and deaths due to slips, trips and falls. The following recommendations are provided for your consideration:

Owners, managers and supervisors must make a commitment to prevent accidental slips, trips and falls.

Regular frequent inspections of working and walking areas should be conducted to identify environmental and equipment hazards which could cause slips, trips and falls. Special attention should be given to the working and walking surfaces, housekeeping, lighting, vision, stairways and ladders. Immediate corrective action should be taken.

Extensive safety training on the prevention of slips, trips and falls should be provided for all new employees. Regular retraining should be provided for all employees. Special attention should be given to proper walking, carrying, climbing and descending stairways, ladders, vehicles and equipment. Unsafe practices should be corrected immediately.

All workers should wear proper footwear for their work and environment whether in the office, shop, plant, feedlot or field.

No riders should be permitted on tractors, trucks or other self-powered or towed equipment unless a safe seat or workstation is provided.

All slips, trips and falls, with or without injury, should be reported, recorded and thoroughly investigated. Corrective action to prevent such a repeat occurrence should be taken immediately.

Slips, trips and falls whether on or off the job are expensive, disruptive, painful, and may be tragic.

For More Information

For more information about agricultural safety, visit the Florida AgSafe Network Web site, at: <http://flagsafe.ufl.edu>

References

Becker, William J. and Tracy A. Wood. 1992. *An Analysis of Agricultural Accidents in Florida for 1991*. Gainesville, Florida: Florida Cooperative Extension Service. Available on the Internet through the National Agricultural Safety Database: <http://www.cdc.gov/nasd>.

Bureau of Labor Statistics. *Lost-Worktime Injuries and Illnesses: Characteristics and Resulting Time away from Work, 2004*. 2005. *News*, December 13.

Dutton, Cheryl. 1988. Make Foot Protection a Hit. *Safety and Health* 138 (5): 30-33.

Ellis, J. Nigel and Howard B. Lewis. *Introduction to Fall Protection*. 1988. Des Plaines, Illinois: American Society of Safety Engineers.

Estimating the Cost of Unintentional Injuries, 2004. 2005. National Safety Council Web site: <http://www.nsc.org/lrs/statinfo/estcost.htm> (accessed: May 2, 2006).

Goldsmith, Aaron. Natural Walking, Unnatural Falls. *Safety and Health* 138 (5): 44-47.

McElroy, Frank (ed.). 1980. *Accident Prevention Manual for Industrial Operations*, 7th ed. Chicago, Illinois: National Safety Council.

Peter, Robert. 1985. Fallsafe: Reducing Injuries From Slips and Falls. *Professional Safety* 30 (10): 15-18.

Peter, Robert. 1985. How to Prevent Falling Injuries. *National Safety and Health News* 132 (4): 87-91.

Reports on Injuries in America, 2003. 2004. National Safety Council Web site: http://www.nsc.org/library/report_injury_usa.htm (accessed: May 2, 2006).

Strachta, Bruce J. 1987. Keep Fall Costs Down. *Safety and Health* 135 (4): 30-32.

Waller, Julian A. 1985. *Injury Control: A Guide to the Causes and Prevention of Trauma*. Lanham, Maryland: Lexington Books.