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How To Manage Friction Blisters

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Friction blisters are fairly common among athletes, hikers and the military. They can lead to pain and infection, and complications such as cellulitis and sepsis if they are not managed in a timely, appropriate manner. Accordingly, this author offers a thorough review of the literature and provides insights on the pathomechanics and treatment of this condition.

The most common foot injury in sport remains poorly understood and treatment of this condition still follows the tradition established over 30 years ago. Yet the incidence and disability from this seemingly benign injury continues at rates higher than any other condition affecting the human foot.

Every year, over 400,000 people participate in a marathon distance running event in the United States. It has been estimated that up to 39 percent of marathon runners experience a blister during the race.1 In military training, friction blisters will affect over 40 percent of soldiers while over 50 percent of active backpackers and hikers will be hampered by this condition.2,3 Friction blisters can lead to significant disability from either pain or infection or both. Complications include cellulitis, sepsis and even toxic shock syndrome.4,5

With such a high incidence and potential for disability, one would think that the prevention of friction blisters would be better understood. Yet few research studies have been published on this subject in the past 20 years. As a result, many myths continue to be propagated regarding the prevention and treatment of friction blisters.

Understanding The Pathomechanics Of Friction Blisters

A blister occurs when a tear or cleavage occurs between the top three layers of the epidermis (stratum corneum, stratum lucidum and stratum granulosum) and the underlying stratum spinosum. The lower layers, including the basal cells and dermis, stay intact. A cleft forms and subsequently fills with fluid from the capillaries due to hydrostatic pressure. Blister fluid is similar to plasma but has a lower protein level.

The tearing of skin at the level of the stratum spinosum is due to repeated shear stresses caused by frictional forces applied to the skin. This frictional force develops when the skin of the foot is in contact with an object such as a sock, an insole, a shoe or the ground itself. Frictional force resists movement of the skin when an external force is acting on the foot to push it in a forward-backward or medial-lateral direction. These forces are known as shear forces. These forces cause the skeletal segments of the foot to move out of synch with the overlying soft tissue and components of the shoe.

Shear forces are applied to the human foot during walking and running because of the mechanics of foot alignment during contact and propulsion. The foot approaches the ground at a tangential angle (not a purely vertical angle) and then pushes off in a similar tangential direction. The foot must skid to a stop and then push into the ground to propel forward. The skidding will occur in both an anterior-posterior and medial-lateral direction, depending on the activity and demands of the sport. Researchers have shown that athletes with a history of friction blisters have greater plantar pressure and shear stress magnitudes than a control group.6

A certain amount of frictional force is necessary on the plantar surface of the foot in order to develop traction and stability for propulsion. The integument of the human foot can withstand a certain amount of frictional force and vertical force for a limited number of repetitions. There is evidence that the foot can slowly adapt to these stresses and withstand a larger number of stress repetitions before blistering occurs. However, there will be a threshold where frictional force combined with vertical pressure applied in high frequency will cause the skin to tear at the upper levels of the epidermis.

One can increase frictional force by applying moisture to the skin surface.7 This is why people are observed to “spit on the hands” before gripping a baseball bat. Increasing levels of moisture on the surface of the feet will increase the likelihood of blistering.

Skin temperature can affect susceptibility to blister formation. Researchers have shown that a temperature increase of 4°C will speed up the rate of blister formation by 50 percent.8 Another study showed that walking on a treadmill for six minutes increased pedal skin temperature by over 6°C.9

This heat buildup may be due to metabolic activity, hyperemic response and frictional force developing against the skin inside of the shoe. Vigorous exercise therefore will increase blister formation by increasing sweat output on the feet and raising skin temperature.

Clearing Up Misconceptions About Friction Blister Prevention

Since we understand the pathomechanics of friction blisters, we should be able to prevent them. Yet currently accepted measures for prevention of friction blisters have little merit and may actually increase the risk of this injury.

Applying antiperspirants to the surface of the foot should conceivably reduce blister rates in athletes. However, studies using antiperspirants have shown mixed results.10 Two well designed randomized controlled trials showed no difference in blister rates when people walking in warm temperatures used a topical antiperspirant on their feet.10,11

Another study of marching soldiers did show a benefit in using an antiperspirant to prevent blister formation.12 However, skin sensitivity reaction to the antiperspirant developed in over 50 percent of the patients. The study authors also noted that adherence with daily use of the antiperspirant was poor.

Applying drying powders to the feet has been a popular remedy for preventing friction blisters yet there is no evidence to support this notion. Three studies have been conducted with the British military testing foot powders to reduce friction blisters.13-15 None of the studies showed a protective benefit of foot powders and one study actually showed that foot powders increased the rate of blister formation.15

Laboratory studies have shown that talcum powder will reduce frictional force on the surface of the foot. However, when moisture combines with this powder, frictional force and abrasiveness actually increase.16 I have observed this commonly in runners when application of a powder eventually leads to a sticky mess on the foot after sweating begins.

Lubricating agents have also been favorite blister prevention measures advocated by doctors, coaches and athletic trainers. However, a landmark study by Nacht and colleagues showed these measures may actually increase blister formation.17 They studied the effects of mineral oil, petroleum jelly and glycerin on the skin of humans and found that all three lubricants would initially reduce the friction force at the skin surface. However, after one hour of rubbing the skin surface, the coefficient of friction returned to baseline and after three hours of rubbing, it actually rose by 30 percent. This may have been due to a hydrating effect on the skin surface as the lubricant was absorbed over time.

Other topical agents that have been advocated for blister prevention include moleskin, tape, tincture of benzoin and viscoelastic dressings. However, there are no published studies to show these measures actually work. Few things applied to the feet will stay intact for more than one hour of vigorous activity. Therefore, measures that focus on footwear may be more efficacious.

Key Insights On Shoe Fit, Insoles And Socks

Most studies on footwear and blister prevention have focused on socks and insoles. The military have conducted several studies on boot systems to reduce blisters but they have primarily focused on fit of the boot rather than specific material characteristics. Surprisingly, studies have failed to link blister protection to the improved fit of military boots.3,13,18

In my clinical experience, most friction blisters suffered by running athletes are not due to improper shoe fit. The majority of blisters I have treated in the medical tents of many marathons are on the plantar surface of the toes and forefoot. Blisters do commonly form on the dorsal surface of the toes and this can be the result of wearing a shoe that is either too loose or too tight. This is similar to the situation with “black toenails” in runners. Changing shoe size does not always solve this problem.

The message here is that excessive friction loads can develop on the surface of the foot even when the shoe is properly fitted. One problem I have observed in running races is the practice of pouring a cup of water over the head when the athlete passes through an aid station. This water runs down the legs, into the shoes and greatly increases frictional forces of the sock against the foot. When it comes to blister prone athletes, some simple advice is to avoid getting their shoes wet during training and racing.

Spence and Shields developed a closed cell neoprene insole (Spenco®), which demonstrated a 25 percent reduction in blister frequency in comparison to standard shoe liners.19 The benefits of neoprene are derived from its low shear modulus. This material can absorb some of the shear stress while reducing this stress on the overlying skin.

Carlson has studied the coefficient of friction (CoF) of three common footwear insole materials and determined that Poron and Plastazote have a lower coefficient of friction than Spenco, particularly when there is exposure to **moisture**.20 See “A Closer Look At CoF Values For Wet Cotton On Insole Materials” at the below right.

Of interest is the recent trend of incorporating silver and copper fibers into the top covers of shoe insoles and into sock yarns. Both silver and copper have excellent insulating properties and may shield the foot from the heat of running and sport surfaces. However, this application has not been tested in any scientific study of friction blister prevention.

Socks have been extensively studied for their potential to reduce friction blisters in active individuals. My colleague Kirk Herring, DPM, and I were among the first to study the effects of sock fiber and sock construction on the frequency of friction blisters in running athletes. Both of our studies were blinded, randomized, prospective trials.21,22

The first study evaluated the difference between cotton fiber and acrylic fiber socks using the proprietary thick-padded Thor-Lo® sock design.21 Acrylic fibers, in comparison to cotton fiber socks, showed fewer and less severe blisters. In another study, we showed that the superiority of acrylic over cotton fibers could not be duplicated if the sock had minimal padding.22

Four different sock studies have been conducted by the U.S. military in an effort to reduce the significant problem of friction blisters affecting marching soldiers.13,23-26 These studies have shown that the combination of a synthetic nylon or polyester liner with an outer padded wool sock significantly reduced blisters in comparison to the standard military sock.

The liner-sock interface typically has a lower CoF than the skin-sock or sock-insole interfaces. Therefore, the notion of setting up a low friction interface on the outside of the liner sock is validated by the end result of reduced peak shear stress on the skin surface.

Socks can reduce friction blisters on the feet by reducing moisture content and friction loads on the surface of the foot. In general, sock fibers that wick moisture from the foot surface are also the fibers that have the lowest CoF. Acrylic fibers and polyester fibers such as Cool Max® are preferred for wicking moisture from the surface of the foot. These and other synthetic fibers will also retain their shape and resist bunching and wrinkling when wet in comparison to cotton socks.

A sock with fibers that have a low CoF can reduce friction loads on the skin surface of the foot. This can be partly dependent on the sock fiber composition as well as the construction of the sock itself. Thicker, padded socks will allow internal movement within the yarn, which will dissipate frictional force on the skin surface. Also bear in mind that “double sock systems” can allow a movement interface between the layers, which can also reduce friction loads on the surface of the foot. This concept of a sock reducing friction on the surface of the foot has been recently validated in a computer model.26

Multiple interfaces are involved with shear force reduction on the surface of the human foot during running activities. The skin-sock, sock-insole, insole-shoe and shoe-ground interfaces are all various levels where friction loads can potentially be dissipated.

Carlson has demonstrated a new, novel approach to reduce shear strain in discrete, targeted areas through the application of a material on the insole or shoe itself.20 A low-friction polytetrafluoroethylene (PTFE) film interface patch can reduce the CoF by 30 to 70 percent and reduce the potential for blisters, callus or skin ulceration. This patented technology is now available in branded products such as ShearBan® and the Richie Ulcer Guard™.

Salient Treatment Tips For Friction Blisters

Levy and colleagues point out that it has been over 30 years since the publication of original research documenting a clinical trial of an effective treatment for friction blisters on the feet.27 Their study represented the most recent attempt with a randomized controlled clinical trial testing the effectiveness of a tissue adhesive, 2-octyl cyanoacrylate (Dermabond, Ethicon, Inc.), in comparison to a standard military blister treatment. This study showed no benefit to this treatment in terms of reduced pain and return to activity.

Today, we are compelled to follow the recommendations proposed 42 years ago by Cortese and co-workers, who studied various methods of blister treatment in 83 patients.28 In this study, preservation of the blister top with drainage performed three times during the first 24 hours resulted in less discomfort and earlier restoration of functional integument. If drainage could be performed immediately, waiting for 24 hours with single aspiration between 24 and 36 hours was optimal.

In my own personal experience, immediate aspiration and drainage of blisters can provide the most effective pain relief. One should puncture the blister in multiple locations at the periphery of the lesion, making sure to keep the roof of the blister intact. However, one must repeat this procedure every six to eight hours during the first 24 hours as the blister roof tends to repair and accumulate fluid rapidly. Removing the roof of the blister can cause more pain and susceptibility to infection.

One should apply a compressive dressing immediately after aspiration to ensure adherence of the blister roof to the underlying layers of the epidermis. This dressing does not have to be specialized. Securing dry gauze with a compressive elastic wrap (i.e. Coban®) seems to work well in most cases.

If the running athlete needs to immediately return to competition, application of a hydrocolloid (2nd Skin® (Spenco), DuoDERM® (ConvaTec)) can be very effective in providing a temporary tissue supplement. These dressings have a limited time of performance during the race and will usually have to be replaced in less than one hour.

Clinicians should exercise caution when using hydrocolloids in friction blister treatment. These dressings will over hydrate the skin and may increase frictional forces over time. Also be aware that maceration of the blister will occur if these dressings are left intact for more than eight hours.

I recommend using hydrocolloids for immediate and short-term treatment of the running athlete with friction blisters. However, I advise removing these dressings at night and replacing them with a standard gauze dressing with elastic compression.

While antibiotic ointments are advocated for the immediate treatment of friction blisters, there is no published evidence that these measures are of any benefit in healing or preventing infection. The initial use of systemic antibiotics is not indicated in the treatment of friction blisters in running athletes.

In Conclusion

Little insight or research into the prevention or treatment of the most common foot injury in sport has been produced in the past 30 years. Physicians, coaches and athletic trainers continue to advocate the use of petrolatum jelly and skin powders to prevent blisters while the scientific literature suggests these measures may actually increase the chance of blistering on the feet.

Podiatric physicians should focus on preventive measures when evaluating running athletes with a history of friction blisters on the feet. Structural abnormalities and biomechanical dysfunction will increase shear stress on discreet areas on the integument of the foot. Proper use of hosiery, shoe insoles and friction reducing modalities can significantly reduce the risk of this potentially disabling injury.

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