

Understanding Blisters and How to Prevent Them

Brian J. Krabak, MD, MBA

Participation in ultramarathon races has grown with an estimated 70,000 runners participating yearly in running races throughout the world.^{5,7,10,13} Ultramarathon races may be characterized as single stage point-to-point continuous races occurring over a specific time period (e.g., 1-2 days) while multi-staged races are point-to-point races that usually occur over 3-7 days. Ultramarathons typically take place in extreme environments with variations in terrain (mountains, snow, sand dunes, river crossings, slot canyons), temperature, and humidity. Such variation can lead to significant injury, including blisters. A foot blister may be considered merely a nuisance, but for some, it may lead to dropping out of an event, or even progress to cellulitis or sepsis; highlighting the importance of a thorough evaluation and optimal treatment.

1. How common are blisters in long distance running events?

Blister rates vary depending upon the distance of the race. Reported rates range from 0.2% to 39% for marathon,¹⁶ 32% to 45% for multi-stage adventure events^{17,19} and represent up to 70% of all medical visits in multiday ultramarathons.¹²

2. Why do blisters occur?

A friction blister injury is due to the repeated action of the skin rubbing against another surface (e.g., sock or footwear). As the external surface moves across the skin, a frictional force opposes the movement. When the external force exceeds the frictional force, movement occurs at the interface of the two surfaces causing sliding. However, these repetitive forces along the surface of the skin cause shear forces within the skin. Excessive shear stress results in exfoliation of the stratum corneum and erythema in and around the zone of injury.^{2,14} Continued shear causes epidermal cells in the stratum spinosum to delaminate, split and die. Cellular necrosis is followed by an accumulation of serum-like fluid (low-protein, electrolyte rich) filling the intra-epidermal split secondary to hydrostatic pressure and formation of a blister. The intact superficial cells of the stratum corneum and stratum granulosum form the blister's "roof." Blister formation is impacted by a variety of factors including the magnitude of the skin shear and number of shear cycles.^{6,14}

3. What other factors influence the formation of blisters?

Skin Characteristics: Maintaining proper skin health is important in preventing blisters. Callous formation can result in greater shear force below the callous, and therefore increase the risk for blister formation. Use of tobacco has been associated with compromised blood flow which could lead to increased shear forces. Friction is lowest when skin is very dry or very wet compared to moist skin, so maintaining dry skin is generally the optimal approach to decrease the risk of blister formation.⁹

Skin – Sock Interface: Moisture wicking socks will keep to foot dry while double layer socks will decrease the compressive forces on the skin.¹ Finding an optimal balance between frictional and compressive forces should be the goal. Abrasive particulate matter (e.g., sand or dust) will also increase friction at the skin-sock interface leading to the formation of blisters. Frequent changing of socks or utilization of gaiters can minimize the accumulation of particulate.

Lubricants and Antiperspirants: Lubricants can decrease friction when first applied, but studies have shown that this only lasts about around one hour. After an hour, the lubricant can increase skin moisture, which is a risk factor for blister formation.¹⁸ Antiperspirants may decrease friction by impacting skin moisture, but frequently cause skin irritation.

Pads and Powders: In theory, pads should disperse the friction forces across the foot (reducing localized shear), but it is not clear if this is true. Powders may impact skin hydration which might reduce the risk of blister formation.⁴

Taping: The simple application of paper tape has been shown to reduce blister formation by 40% in multi-stage ultramarathon runners.¹⁵

Gait Biomechanics and Shoes: The majority of ultramarathon runners utilize a heel-strike pattern, though the pattern may change over the course of the race.⁸ Though studies have shown that altering foot-strike pattern or step cadence can impact the forces to the lower extremity, it is unclear how this impacts the formation of blisters.³ In addition, there are no data to suggest a specific shoe or use of a shoe insert will decrease the risk of blister formation.

4. How do I treat a blister?

Prevention is optimal, but if you experience a blister, it is good to know how to address the problem. When a blister occurs, instituting treatment as soon as possible improves outcome, reduces pain, and minimizes complications from either subsequent tissue damage or infection. In the early stages of blister formation, evaluating for the presence of a sensation of warmth from the hot spot is a warning sign. Prompt attention and rapid treatment can stop the abrasive process to prevent progressive blister formation. Here are some steps for treating a blister:

- **Preparation**: If you attempt to drain a blister (1) prepare the blister area by making sure the skin is clean of dirt and grit and as dry as possible, and (2) clean the needle or safety pin with an alcohol pad.
- **Drainage**: The best protection for a blister is its own “roof,” so efforts should be taken to maintain this natural skin protection. Small friction blisters that are not causing significant discomfort should be left intact. If the skin is not intact, it should be removed prior to dressing. When draining a blister, puncture the blister with the prepared needle or pin at a distal point allowing natural foot pressure to continually squeeze out fluid. If

more drainage is required, use several small holes rather than one large hole, limiting risk of de-roofing the blister. Gently blot out the expressed fluid, cover the now-flattened blister with paper tape that is cut to overlap the edge of the blister.

- **Taping:** A thin paper tape or adhesive tape (e.g., Elastikon) may be utilized to decrease shear to the area of the blister. One should consider using an adhesive substance, such as benzoin (liquid, squares, or spray), to ensure security of the applied dressing.
 - **Intact Skin:** Any tape used for blister treatment should be applied as smoothly as possible. Any folds or wrinkles in the tape should be avoided because they may lead to high pressure and friction areas. Cutting the tape corners to round them and avoiding “dog-ears” will help in avoiding further blisters. All tape should be cut long enough to extend well beyond the border of the blister and any blister pads underneath the tape. Constriction through overlapping of tape and circumferential wrapping of the feet should be avoided as it may lead to venous congestion and subsequent swelling.
 - **Non-intact Skin:** If the blister’s roof is ripped open, trim off the devitalized skin, apply a hydrocolloid layer of a Spenco® 2nd skin pad over the exposed base. As a final layer, apply a shaped adhesive tape (e.g., Elastikon) for extra protection as noted above.

5. How can I prevent blisters?

We can’t prevent every blister, but we can attempt to minimize the risk of sustaining a blister.^{6,11} Below are some steps you can take:

- **Take Care of Your Feet**
 - Keep your feet dry / avoid particulate (sand, rocks)
 - Remove callouses / trim your toenails
 - Use proper fitting (tested) shoes
 - Use proper fitting insoles / orthotics
 - Consider lubricating frequently vs powders vs taping (paper)
 - Utilize moisture wicking socks and change them often
 - Consider using a low friction vs double layer sock
- **Take Care of Your Body**
 - Maintain good nutrition, hydration and sleep
 - Train to allow adaptations to the stress of running and minimize fatigue
 - Optimize your strength, flexibility and running form
 - Avoid tobacco

References

1. Bogerd CP, Niedermann R, Brühwiler PA, Rossi RM. The effect of two sock fabrics on perception and physiological parameters associated with blister incidence: a field study. *Ann Occup Hyg* 2012;56(4):481-8
2. Cornach JS. Epidermal fatigue as a cause of friction blisters. *Lancet* 1973;1:81-3
3. Davis IS. The re-emergence of the minimal running shoe. *J Orthop Sports Phys Ther* 2014;44:775-84

4. Hashmi F, Kirkham S, Nester C, Lam S. The effect of topical anti blister products on the risk of friction blister formation on the foot. *J Tissue Viability* 2016;25(3):167-74
5. Hoffman MD, Pasternak A, Rogers IR, Khodae M, Hill JC, Townes DA, Scheer BV, Krabak BJ, Basset P, Lipman GS. Medical services at ultra-endurance foot races in remote environments: medical issues and consensus guidelines. *Sports Med.* 2014;44(8):1055-69
6. Hoffman MD. Etiological foundation for practical strategies to prevent exercise-related foot blisters. *Curr Sports Med Rep* 2016;15(5):330-5
7. Khodae M, Ansari M. Common ultramarathon injuries and illnesses: race day management. *Curr Sports Med Rep.* 2012;11(6):290-7
8. Kasmer ME, Wren JJ, Hoffman MD. Foot strike pattern and gait changes during a 161-km ultramarathon. *J Strength Cond Res* 2014;28(5):1343-50
9. Kirkham S, Lam S, Nester C, Hashmi F. The effect of hydration on the risk of friction blister formation on the heel of the foot. *Skin Res Technol* 2014;20(2):246-53
10. Krabak BJ, Waite BW, Lipman G: Injury and illnesses prevention for ultra-marathoners *Curr Sports Med Rep* 2013;12(3):183-9
11. Krabak BJ, Waite B, Lipman G. Evaluation and treatment of injury and illness in the ultramarathon athlete. *Phys Med Rehabil Clin N Am.* 2014;25(4):845-63
12. Krabak BJ, Waite BW, Schiff MA: Injury and illness rates in multiday ultramarathon runners. *Med Sci Sports Exerc* 2011;43(12):2314-2
13. Lipman GS, Scheer BV. Blisters: the enemy of the feet *Wilderness Environ Med* 2015;26(2):275-6
14. Lipman G, Krabak BJ: Foot Problems and Care. In *Wilderness Medicine*, 7th edition. Auerbach PS (Ed) Philadelphia, PA: Elsevier, pp 580-593, 2016
15. Lipman GS, Sharp LJ, Christensen M, Phillips C, DiTullio A, Dalton A, Ng P, Shangkuan J, Shea K, Krabak BJ. Paper tape prevents foot blisters: a randomized prevention trial assessing paper tape in endurance distances II (Pre-TAPED II). *Clin J Sport Med* 2016;26(5):362-8
16. Mailler EA, Adams BB. The wear and tear of 26.2: dermatological injuries reported on marathon day. *Br J Sports Med* 2004;38:498-501
17. McLaughlin KA, Townes DA, Wedmore IS, Billingsley RT, Listrom CD, Iverson LD. Pattern of injury and illness during expedition-length adventure races. *Wilderness Environ Med* 2006;17:158-61
18. Sivamani RK, Goodman J, Gitis NV, Maibach HI. Coefficient of friction: tribological studies in man - an overview. *Skin Res Technol* 2003;9(3):227-34
19. Townes DA, Talbot TS, Wedmore IS, Billingsly R. Event medicine: injury and illness during an expedition-length adventure race. *J Emerg Med* 2004;27:161-5