Evolving Sock Technology: Fit, Fibers, Compression and Moisture Management

Socks can be as important as the shoes we recommend for foot health.

BY BEN PEARL, DPM

Recently, the consumer premium sports sock marketplace has seen innovations in designs for improved moisture management, fit, comfort, and blister prevention. The development in sock technology has provided more options not only for athletes, but for the general public and diabetics as well. These developments include refinement in sock materials and construction. As podiatrists, our sock recommendations can mitigate painful conditions like blisters, calluses, ulcers, plantar fasciitis, arch pain, etc.

Fit Is Foremost

According to Dave Higgins, former President of Thorlo Socks and founder of the OS1st, fit and comfort are the most important considerations when selecting a sock. Simply put, if a sock is not comfortable or easy to put on, the patient will not wear it. Oftentimes, sizes have been lumped together into one size to save costs—a practice that diminishes both fit and compliance. The sock must conform to the anatomic contours of the foot, which can be a challenge if your foot has a high volume instep or a wide ankle or calf. It is also important to recognize that the fit of the sock is integrally related to the fit and construction of the shoe. It follows that if someone is wearing, say, a 'diabetic' or added-depth shoe, it will change the contours between the sock and the shoe, which will affect the fit.

Different brands and styles will fit better for different people. For example, someone with a high-volume instep will often require a whole size up. Different sports require unique characteristics as well. Court sports, for example, involve a lot of side-to-side movement, so a sock that grips the heel and has padding in the forefoot is helpful.

Socks are usually knit in a way to create a pocket effect for the heel so they conform more closely to the anatomic contour of the heel. This is called the gore of the sock. More highly developed and premium versions will have a "Y-Gore" which truly rounds the shape and fit. This feature helps decrease blistering on the back and bottom of the heel. Socks that are geared for better fit will also offer right and left sizing in each pair. Compression socks can help with fit, but calf-high compression socks are difficult to put on and take off. It is also important to note that a shoe that is too tight or too loose will likely affect even a perfectly fitted sock.

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Moisture and Shearing

Moisture (perspiration) management is often the most important component for blister management and hygiene. Moisture increases shear and friction (quarterbacks use this phenomenon to their advantage; they will wet their fingers to increase hand to ball friction, which in turn helps them grip the ball better). This friction on the skin also causes calluses and within the skin causes blisters. Shearing is the primary force that creates blisters; it can occur between the horizontal layers of the skin, and also both at the skin sock interface and the epidermal and subdermal layers. This happens most often when the sock fabric becomes moisture-laden, flattens and sticks to the skin. More premium socks will have resilient fibers, firm terry padding, and the ability to move moisture or at least not absorb and hold it.

Therefore, moisture management within a sock is determined largely by fabric/fiber content and by construction. Generally, the fibers are either hydrophobic and/or hydrophilic. In terms of socks, hydrophobic describes the wicking(movement) of water through the fiber/fabric. Hydrophilic describes drawing water to the fiber and retention.

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These terms can only be used roughly when describing the fluid dynamics in socks, because some fibers have characteristics of both components. Whatever moisture coming off must move away and evaporate from your skin.

What About Fibers?

CoolMax® is a polyester sock fiber. It has roots in the concept writings of Dupont scientists in the 1920's. CoolMax® has a four-layer hydrophilic construction with channels that allow water to move through the fiber. It remains one of the most popular fabrics and is used by big sports apparel companies for their sock lines. Acrylic is another sock material that has good heat retention and hydrophobic properties. Its heat retention and hydrophobic properties are slightly less pronounced than with CoolMax®, but acrylics are usually more resilient. Acrylic is also often a less costly material that is used in some wool blends.

Wool is one of the oldest natural fibers used in socks. Wool can absorb up to a third of its weight in water and is perceived as comfortable in lines such as Smartwool, Balega and Farm to Feet. Like most fibers, wool has its advantages and disadvantages--one of the down sides of wool is it can wear through, creating holes in the heel or toes; on the other hand, wool has air between the fibers which serve as insulation. Wool fabrics are generally preferred to fabrics that are more moisture-absorbing and less protective, like cotton; though sometimes cotton can be added in small increments to add comfort and/or perceived consumer acceptance. Infracare has developed a new pyroelectric fiber, which causes the body's surface temperature to spike where the fabric is in contact with the skin.

When combining hydrophobic qualities and mechanical fiber qualities, the fibers that wick moisture best are (from best to worst): Olefin, CoolMax®, acrylic, polypropylene, wool, cotton. The sock that provides the best wicking solution that utilizes Olefin is Drymax, a two-layer sock material. It contains PTFE, also known as teflon. If you are using high grade materials a hydrophobic/hydrophilic 2-layer system will be more effective than a single layer. The olefin is treated with a chemical process to make it both hydrophilic and hydrophobic.

Drymax had independent lab testing that demonstrated a 17-25-fold wicking ratio over Coolmax. This was a tabletop test and thus did not take into account the heat generated when we sweat. Keep in mind that thicker socks will create more heat and that may increase the perspiration rate. Gus Blythe, the President of Drymax, believes that Coolmax has more of a tendency to carry moisture back to the skin than Drymax. He adds that when we wash socks in detergent, the

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surfactant will make moisture pass through the sock material more easily, which helps its wicking properties.

There have been designs that use double layer socks for anti-blister purposes. Dave Higgins collaborated with Doug Richie, DPM on a double-layer diabetic sock design in the early 1990's. (Dr. Richie and Mr. Higgins are generally recognized as the inventors of the 'Diabetic Sock"). At that time, seamless socks were not readily available and the double-layered design was proven to reduce blistering, even over Acrylic. Prior to the late 1990's and the early 2000's, seamless sock manufacturing processes were limited to very manual "hand looping" and performed almost exclusively in Asian factories with cheap labor. As the demand grew, Italian companies like Lonati and Busi developed seamless sock machines. Now those manufacturing processes are more widely available in Asia.

In a double-layered sock, the second layer may generate excess heat, which translates to sweat. Wrightsock is a brand that has tried to address this by having a very thin inner layer with a variable thickness outer layer depending on the activity. The inner layer of some of the Wrightsock models use Reprieve, a recycled material from plastic bottles that holds up well with wear. There is a limit as to how much you can keep your foot dry inside a shoe that has less venting. Eventually the moisture will not be able to leave the shoe fast enough so vented shoe materials offer a significant advantage for getting the moisture out of the shoe. Leather and synthetic leather shoes are a challenge for even the most wicking sock constructions.

One recent study found little difference between natural and synthetic materials regarding blister frequency in hikers. The study did support the heightened risk of blisters with wet socks. On average, hiking in wet socks was associated with 1.94 times greater risk of experiencing foot blisters.

Antimicrobial Properties

Antimicrobial materials in socks are monitored by the EPA, which limits the claims that companies are allowed to make. Research that is done with antimicrobial products in wounds, for example, does not allow sock manufacturers to make claims on the benefits of the added materials. However, it would follow that you can translate some of the benefits of those added materials. Nano-Silver has been used in socks to provide a bacteriostatic environment, and copper has also been used for its antimicrobial effects. Copper is able to bind with chemicals in sweat like valeric acid and other odor, bacteria and fungus-supporting amides and neutralize them with a chelating process; copper is also considered an essential mineral in the formation and stabilization of skin proteins (sil-

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ver does not have this property). Gus Blythe sees cupron copper as an even more potent copper source.

It should be noted that some socks do not have enough copper to be effective for bacteriostatic benefits. And though The properties of silver and copper in socks both seem to help with bacteriostatic activity, the advantages of copper vs. silver still need further validation with more sock-specific materials research.

Research on Compression and Other Proposed Benefits

Compression socks are being investigated for proposed benefits in injury prevention and exercise recovery. A study two years ago demonstrated decreased calf oscillations by 13% medial to lateral and 20% anterior to posterior in athletes recovering from injuries. The athletes that used the compression socks for secondary recovery of injuries had perceived improvement. Ali et al. showed over-the-calf sport socks with graduated compression would reduce the symptoms of delayed muscle soreness in men after a 10 km road run.

There are some socks that are using tactile sensation to try to improve sensation and circulation. Some evidence seems to point to slightly improved single leg stance postural sway improvement. We use tactile sensation as a cue for the nervous system by tapping into the exteroceptors (the nerve endings responsible for two-point discrimination) on the soles of our feet. Podiatry has largely overlooked tactile sensation in favor of more traditional biomechanics models. This tactile sensation is something they should be paying attention to, however. In particular, textured socks are designed to cue the foot with enhanced information. The textured socks can now not only sense where our posture is standing, but also where our foot is positioned when performing dynamic athletic activities like running and jumping. Emily Splichal, DPM is part of a team that has IRB studies underway. These studies look at balance, MS, and circulation using the textured socks she designed with her company Naboso. Stay tuned for the results of these studies to see how impactful this new concept is.

The incorporation of other functional designs such as padding and splints for conditions like bunions and hallux limitus, turf toe and plantar fasciitis (OS1st) is another way in which we can use socks to benefit our patients. It is important to consider socks as a tool that are in some cases just as important as the shoes we select for foot health and comfortable performance. To remain relevant, podiatry needs to be at the forefront of how fabrics and design innovations offer improved solutions for our patients. **PM**

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References

Richie, Doug Socks and Your Feet: Hosiery is Equipment for the Athlete, AAPSM Website.

A. Ali, M. P. Caine & B. G. Snow (2007) Graduated compression stockings: Physiological and perceptual responses during and after exercise, Journal of Sports Sciences, 25:4, 413-419.

César Augusto da Silva, Lucas Helal, Roberto Pacheco da Silva, Karlyse Claudino Belli, Daniel Umpierre, Ricardo Stein. (2018) Association of Lower Limb Compression Garments During High-Intensity Exercise with Performance and Physiological Responses: A Systematic Review and Meta-analysis. Sports Medicine 48:8, pages 1859-1873.

Freddy Brown, Conor Gissane, Glyn Howatson, Ken van Someren, Charles Pedlar, Jessica Hill. (2017) Compression Garments and Recovery from Exercise: A Meta-Analysis. Sports Medicine 47:11, pages 2245-2267.

Fabrice Vercruyssen, Christopher Easthope, Thierry Bernard, Christophe Hausswirth, Francois Bieuzen, Mathieu Gruet & Jeanick Brisswalter (2014) The influence of wearing compression stockings on performance indicators and physiological responses following a prolonged trail running exercise, European Journal of Sport Science, 14:2, 144-150.

Esther CL, Gabriel GN, Raquel SR, Alfonso MN. The influence of sock composition on the appearance of foot blisters in hikers. J Tissue Viability. 2022:S0965-206X(22)00021-3. Available at https://www.sciencedirect.com/science/article/pii/S0965206X22000213?via%3Dihub.

Weakley, J., Broatch, J., O'Riordan, S. et al. Putting the Squeeze on Compression Garments: Current Evidence and Recommendations for Future Research: A Systematic Scoping Review. Sports Med 52, 1141–1160 (2022). https://doi.org/10.1007/s40279-021-01604-9.

J.I. Priego Quesada, A.G. Lucas-Cuevas, M. Gil-Calvo, J.V. Giménez, I. Aparicio, R.M. Cibrián Ortiz de Anda, R. Salvador Palmer, S. Llana-Belloch, P. Pérez-Soriano. Effects of graduated compression stockings on skin temperature after running. Journal of Thermal Biology, Volume 52, 2015, Pages 130-136.

Additional Sources

Bastien Bontemps, Fabrice Vercruyssen, Mathieu Gruet, Julien Louis. (2020) Downhill Running: What Are The Effects and How Can We Adapt? A Narrative Review. Sports Medicine 50:12, pages 2083-2110.

FJ Oficial-Casado, I Aparicio, I Julian-Rochina, M Blanes, P Perez-Soriano. (2020) Effects of a fatiguing run in popliteal vein flow using sports compression socks. Journal of Industrial Textiles 49:7, pages 967-978.

Kajsa Rennerfelt, Sophia Lindorsson, Helena Brisby, Adad Baranto, Qiuxia Zhang. (2019) Effects of Exercise Compression Stockings on Anterior Muscle Compartment Pressure and Oxygenation During Running: A Randomized Crossover Trial Conducted in Healthy Recreational Runners. Sports Medicine 49:9, pages 1465-1473.

A. Grethe Geldenhuys, Jeroen Swart, Andrew Bosch. (2019) Investigation of the Impact of Below-Knee Compression Garments on Markers of Exercise-Induced Muscle Damage and Performance in Endurance Runners: A Prospective Randomized Controlled Trial. Sports Health: A Multidisciplinary Approach 11:3, pages 254-264.

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