

THE INFLUENCE OF SOCK CONSTRUCTION ON FOOT CLIMATE IN RUNNING SHOES

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INTRODUCTION

For highly trained athletes sweat rates can easily be more than 1 liter per hour. As it has been pointed out by Bar-Or (1998) it is not only the density of the sweat glands which has an influence on the sweat evaporation rate. Bar-Or summarizes work from other authors and concludes that the sweat rate in children and elderly is lower than in young adults. High temperatures and the accumulation of sweat leads to foot discomfort during running. Most runners have made the observation that the type of shoe can influence foot climate considerably. Using innovative fiber technologies manufacturers claim that their socks will keep feet cooler and enhance the transportation of sweat away from the skin. The purpose of this study was to investigate whether sock construction features can influence foot climate.

METHODS

5 different sock models were tested with 19 subjects running in their own shoes a distance of 6000 m on a 400 m track. All sock constructions were commercially available products, differing in material composition, weaving technology and weight. Each subject ran in all 5 sock models (randomized order) on 5 different days. While the 5 different socks were worn on the right foot, a reference sock was always used for the left foot. Foot temperature measurements were taken on both feet immediately before the run, at 400 m, 800 m, 1600 m, 4400 m, and at the end of the run (6000 m). Temperature sensors (Hygrotec NTC50) were attached to the skin under the center of the heel and forefoot (3rd metatarsal head). The resistive thermo transducers are normally used in electronic fever thermometers and thus have a good resolution (0.01 degrees C) and accuracy. Using a precision scale (Lutron Inc. GM-300P, resolution 0.01 gram), sweat accumulation in the socks was measured by determining the weight of the socks before and after the 6000 m run. The tests were carried out on hot summer days at a temperature of 26.5 degrees C (SD 5.8) and a relative humidity of 41.5 % (SD 15.3). Subjective perception ratings for temperature and moisture were given by the subjects for all sock conditions on a seven point perception scale after the 6000 m run. Perception ratings were performed in comparison to the left foot with the reference sock.

RESULTS AND DISCUSSION

Across all sock conditions the average increase in foot temperature of all subjects during the 6000 m run was approximately 9 degrees Celsius under both the heel and the forefoot. The foot temperature at the start of the run was approximately 28 degrees. Temperature under the heel remained always lower than under the forefoot. The temperature difference between the two foot locations was approximately 0.6 degrees at the start of the run and increased to 1.5 degrees after 2800 m. Forefoot temperature increased more rapidly as compared to heel temperature in the first half of the run (figure 1). Figure 2 shows the increase in foot temperature in the 5 different sock models. At 4400 m and at the end of the run 2 sock constructions showed significantly ($p < 0.05$) increased foot temperatures against the other three sock models.

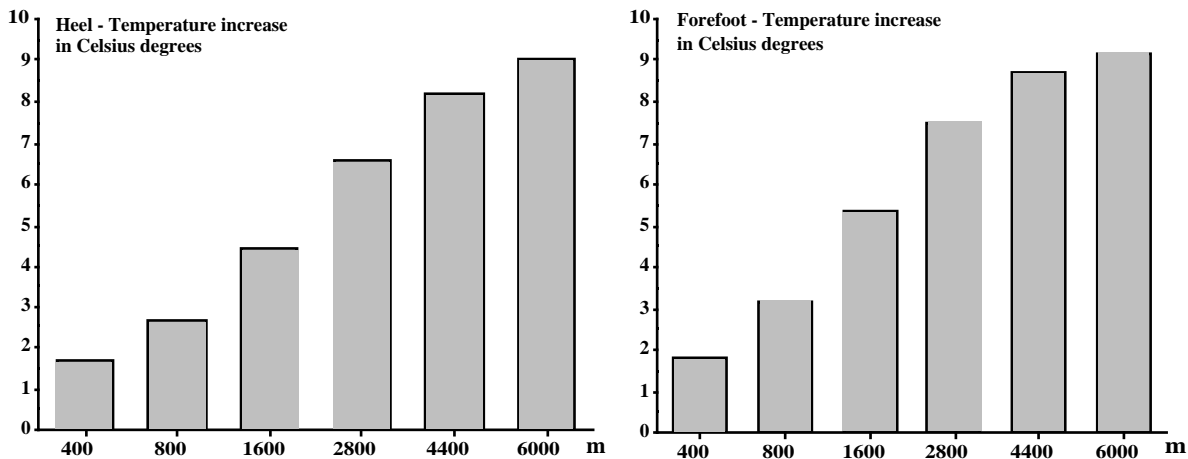


Figure 1: Skin temperature increase under heel and forefoot during a 6000 m run (19 subjects)

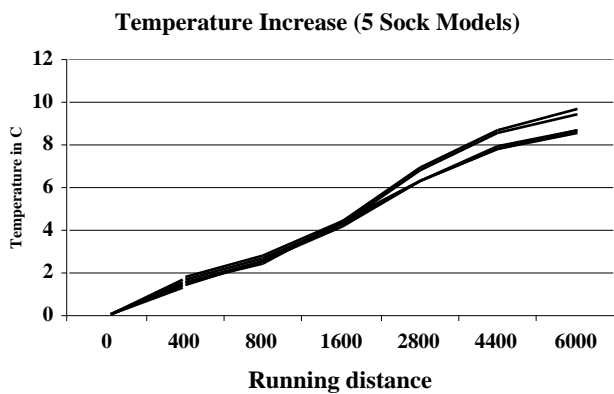


Figure 2: Temperature increase in 5 sock models

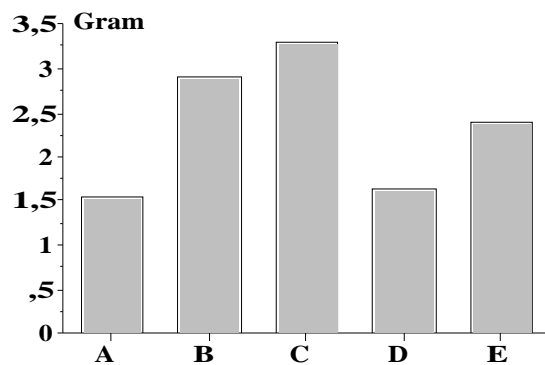


Figure 3: Sweat accumulation in 5 sock models

As shown in figure 3, sweat accumulation in the sock models differed considerably (ANOVA, $p < 0.001$). When comparing model C against models A and D this difference was more than 100 %. No specific material component was identified which could explain the above findings. Often it is suspected that cotton will retain water more than synthetic materials. Sock model C with the highest amount of sweat accumulation had a cotton fiber content of 56 %. However, sock model A with the lowest sweat content had an even higher cotton fiber percentage of 72 %. It appears that a complex interaction between material and weaving modalities determines the water retention properties of socks. Similarly, the reason for the temperature behavior of socks is difficult to analyze from the present sample of diverse sock constructions. Our study demonstrated that sock construction features have a substantial influence on foot temperature development and sweat accumulation in the sock during long distance running.

REFERENCE

Bar-Or, O. (1998). Effects of age and gender on sweating pattern during exercise. *International Journal of Sports Medicine*. 19 Suppl 2:S106-107.

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