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THE EFFECT OF SOCK FABRIC ON SKIN HYDRATION AND PERCEPTION OF THE FOOT AFTER 1 DAY OF MILITARY USE

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INTRODUCTION

Friction blisters on the feet are among the most commonly-occurring injuries among infantry soldiers (Knapik et al., 1992; Reynolds et al., 1999). Friction blisters are caused by friction between the skin of the foot and the sock. This friction is known to increase with increased moisture content of the sock fabric as well as with an increased skin hydration. The effect of sock fabrics on blister incidence among soldiers has therefore been studied, and reported in different publications (Knapik et al., 1996; Van Tiggelen et al., 2009). These studies concluded that under military conditions the following characteristics are associated with a reduced blister incidence: (i) defined as thicker than typical army socks, and (ii) not having cotton or wool in direct contact with the skin. However, these studies do not allow for differentiating between these factors with regards to blister incidence. Recently, we subjected participants to 30 min of walking on a treadmill in the Empa laboratory. The participants wore on one foot a polypropylene sock (PP) and on the other a wool blend sock (BLEND). This study indicated no difference on skin hydration between the two sock fabrics. This result was not expected since the moisture behavior of these sock fabrics were distinctly different (Rossi et al., submitted).

Therefore, the present study aimed at understanding the effect the sock fabrics on skin hydration at the level of the foot in practical conditions after one day of military use. In addition, the perception of the sock fabrics was assessed. The present study served as a follow-up of a laboratory study reported elsewhere in the proceeding, titled: The effect of sock fabric on skin hydration and skin friction of the foot after 30 min walking on a treadmill (Bogerd et al.).

METHODS

A group of 37 male recruits participated in the present study which lasted four days. The average anthropometrical characteristics of the participants were (mean ± standard deviation): age 20.8 ± 2.0 years, weight 76.3 ± 9.8 kg, height 178 ± 7 cm, and foot length 271 ± 11 mm. The participants wore standard marching clothing for neutral and warm conditions. All participants wore army boots with an integrated GORE TEX membrane (prototype based on KS Leight GTX, AKU, Montebelluna, Italy) in their corresponding size.

The employed sock fabrics were polypropylene (PP: polypropylene/elastane) and a wool blend (BLEND:

wool/polypropylene/polyamide). For each fabric socks were produced (Jacob Rohner AG, Balgach, Switzerland) in five different sizes. The participants wore one of each type on a given foot, either PP left and BLEND right, or vice versa; this order was balanced over the participants. Fresh socks were worn each day, whereas the sock order remained unchanged.

The participants underwent basic military training focusing on securing areas. Daily around 18:00 a 6.5 km march started. The ambient conditions during the march were air temperature 10.6 ± 2.2 ºC, relative humidity 75.6 ± 11.6%, air pressure 964.1 ± 3.7 hPa (SensoTCMod 5507, Sensor Electronic, Gliwice, Poland). Two types of measurements were carried out after the march; (i) a questionnaire including all participants, and (ii) a daily average of 7 participants underwent additional measurements of foot skin hydration and sock gravimetry.

The questionnaire assessed temperature and comfort of the feet among other parameters, using a 10 cm visual analog scale separately for each foot. During the following additional measurements, the socks and boots were removed from the participant by an experimenter, separately stored in plastic bags, and separately on a scale (SB16001, Mettler Toledo, Im Langacher, Switzerland). Skin hydration of the foot was measured using a corneometer (CM 825, Courage & Khazaka, Cologne, Germany). The following sites were evaluated: (i) the plantar surface of the distal phalanx of the first digit (sole of great toe), (ii) the posterior surface of the calcaneus (backside of heel), and (iii) the dorsal surface of the third metatarsal (upper-side of the center of the foot). These sites were measured on the left and right foot, respectively. Before the start of the trial any hairs were shaven from these areas, in order to prevent a measurement error.

All participants were analyzed as one group, using repeated measures analysis of variance (ANOVA) for within-participant effects. A Bonferroni-corrected t-test was used as post-hoc comparison if the level for statistical significance was reached ($p < 0.05$). All tests were carried out using SPSS 18.0. All data processing was carried out using Matlab 7.11 (R2010b).

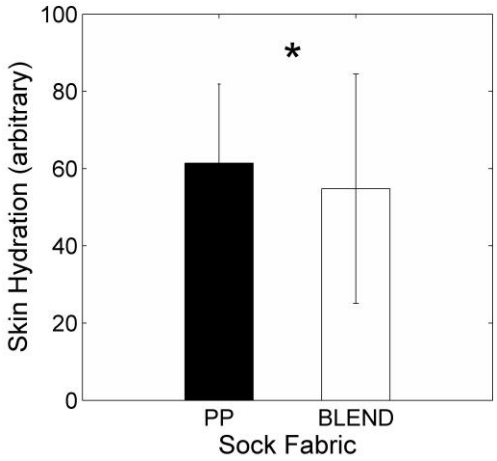

Fig 1. Skin hydration for the posterior surface of the calcaneus (backside of heel). An error-bar indicates a standard deviation; * $p < 0.05$.

RESULTS

BLEND absorbed 2.9 ± 0.3 times more moisture compared to PP after normalizing for the dry-weight of the sock ($p < 0.001$). For instance, the middle size sock BLEND absorbed 6.0 ± 2.6 g, whereas the similar sized PP absorbed 3.3 ± 1.7 g.

The skin hydrations of the posterior surface of the calcaneus and the dorsal surface of the third metatarsal showed differences between PP and BLEND ($p < 0.05$ and $p < 0.01$, respectively). Moreover, BLEND resulted in lower skin hydration compared to PP of 13% and 8%, for the two locations respectively. The day at which the measurement was collected did not affect the measured values. Fig. 1 gives the skin hydration for posterior surface of the calcaneus.

Finally, the intervention effect indicated that compared to PP, BLEND was perceived as cooler, and more comfortable ($p < 0.05$). Fig. 2 gives the average perception responses.

DISCUSSION / CONCLUSION

The present results indicate that a difference in moisture behavior of fabrics is likely to affect skin hydration of the foot. As skin hydration is related to skin friction (Gerhardt et al., 2008), it can be speculated that BLEND would result in a lower foot blister incidence under similar conditions as the present study. However, a targeted study should be carried out evaluating this hypothesis.

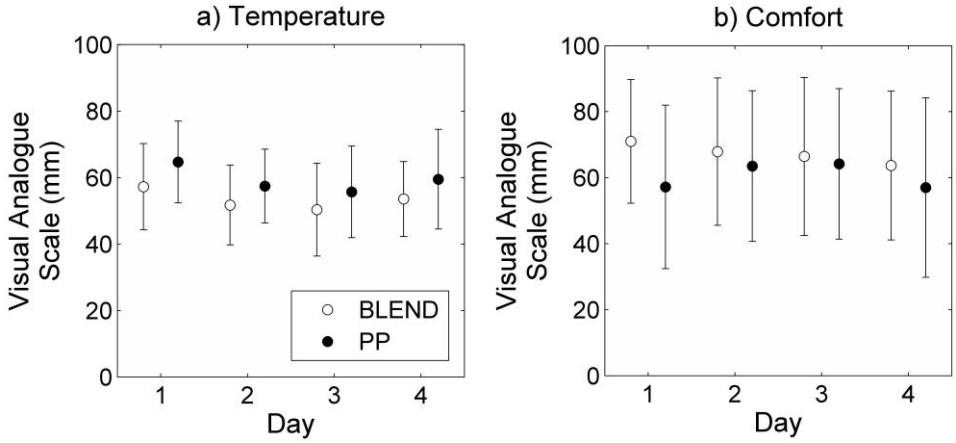

Fig 2. Perception for each day, for PP and BLEND as indicated, given for (a) temperature, and (b) comfort. A dot represents the average, and an error-bar indicates a standard deviation.

In addition, the present study indicates a difference between a laboratory study, optimized for time, and a field study lasting days. The lack of differences on skin hydration in the laboratory study tends to indicate that one should be careful in simulating realistic conditions in a laboratory. For the present studies, it can be learned that 30 min of treadmill walking is insufficient to cause levels of skin hydrations observed after a day of use.

The present results indicate differences between two sock fabrics; a wool blend (BLEND) and polypropylene (PP). Compared to PP, BLEND was rated to be cooler, and more comfortable. BLEND was found to store a factor 2.9 more moisture compared to PP. Two out of three skin sites were found to be different between both fabrics, with dryer skin for BLEND measured on (i) the posterior surface of the calcaneus, (ii) the dorsal surface of the third metatarsal. No difference was found for the plantar surface of the distal phalanx of the first digit, a location probably exposed to higher pressures. Under the present conditions, BLEND should be preferred over polypropylene for the areas of a sock not covering the sole of the feet.

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