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THE EFFECT OF SOCK FABRIC ON SKIN HYDRATION AND SKIN FRICTION AFTER 30 MIN WALKING ON A TREADMILL

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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). Blister incidences ranging between 40% and 80% were counted for 15 soldiers after a 20 km march (Knapik et al., 1997). In fact, blisters can result in off-duty time of an average length of two days for 2% to 10% of soldiers (Knapik et al., 1996; Knapik et al., 1992). In addition, Van Tiggelen et al. (2009) have suggested that blister induced discomfort causes changes in gait patterns, in an attempt of reducing blister-induced discomfort, which can lead to overuse injuries, e.g., at the knee and ankle.

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). The conclusions of these studies were 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.

The present study aimed at understanding the effect the sock fabrics on skin hydration and skin friction at the level of the foot after 30 min of walking under on a treadmill. The moisture transport behavior of the two sock fabrics used were previously characterized and found to represent two extremes among a larger sample of fabrics (Rossi et al., submitted). The present study preceded a field study reported elsewhere in the proceeding, titled: The effect of sock fabric on skin hydration and perception of the foot after 1 day of military use (Bogerd et al.).

METHODS

Twelve healthy male recruits participated in the study. The average anthropometrical characteristics of the participants were (mean ± standard deviation): age 19.9 ± 0.7 years, weight 72.5 ± 8.7 kg, height 176 ± 8 cm, and European boot size 43 ± 1. The participants wore standard marching clothing for neutral and warm conditions. All participants wore army boots with an integrated GORE TEX membrane (KS Leight GTX, AKU, Montebelluna, Italy) in their corresponding size. The study was approved by the Ethics Committee of St. Gallen, Switzerland.

The employed sock fabrics were polypropylene (PP: polypropylene/elastane) and a wool blend (BLEND: wool/polypropylene/polyamide). For each fabric, socks were produced in three different sizes (Jacob Rohner AG, Balgach, Switzerland). 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.

The participants walked for 30 min with a speed of 5 $km \cdot h^{-1}$ on a treadmill (PPS 70 L, Woodway, Weil am Rhein, Germany), without inclination. All walking phases took place in a climate chamber with an ambient temperature (T_a) of 17.1 ± 1.3 ºC and relative humidity (RH) of 53 ± 5%. The walking phase was preceded and followed by measuring phases. These measuring phases took place in a second climate chamber stabilized at T_a = 25.5 ± 0.2 ºC and RH = 52 ± 1%.

After the socks and boots were removed from the participant by an experimenter, they were separately stored in plastic bags, and weighed 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 on the left and right foot: (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), (iii) the dorsal surface of the third metatarsal (upper-side of the center of the foot). Before the start of the trial any hairs were shaven from these areas, in order to prevent a measurement error.

Fig 1. An experimenter during a skin friction assessment.

Skin friction was measured by moving the heel over a glass plate attached to force transducers (Fig. 1). The experimenter moved the (nude) posterior surface of the calcaneus over the glass plate from left to right and back; seven to eight such cycles were made consecutively during 60 s, first for the left foot, then for the right foot. A glass plate was chosen as friction partner since, in contrast to fabrics, its properties change little between measurements, and it is easy to clean using ethanol. The glass plate used (Matt 14, Fällander Glas, Zürich, Switzerland) was slightly rough, for which it is known that skin friction increases with increasing wetness (Derler et al., 2009); fabrics typically show a qualitatively similar behavior.

The following forces were measured in the direction along three axes: (i) the normal force (F_n), perpendicular to the force plate, (ii) F_x, along the longitudinal axis of the body of the participant, and (iii) F_y, in the direction of movement of the foot. The coefficient of friction (COF) was calculated as $COF = (F_x^2 + F_y^2)^{1/2} / F_n$.

Repeated measures analysis of variance (ANOVA) for within-participant effects were used for the statistical analysis of most datasets. 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 14.0.

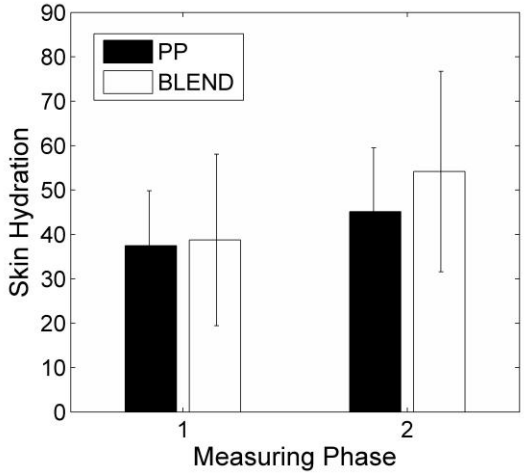

Fig 3. Skin hydration for the the posterior surface of the calcaneus (backside of heel); for measuring preceeding (phase 1) and succeding (phase 2) the walking exercise.

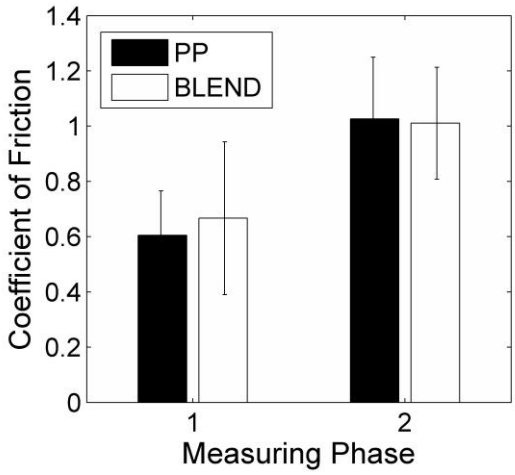

Fig 4. Coefficient of friction for measuring preceeding (phase 1) and succeding (phase 2) the walking exercise.

RESULTS

The weight differences before and after walking for the socks was significantly different between the sock fabrics ($p < 0.001$), with 2.0 ± 1.2 g and 4.7 ± 1.8 g, for PP and BLEND, respectively. Results for skin hydration indicated no intervention effect (Fig. 3). However, a time effect was present, indicating lower values (drier skin) for measuring phase 1 compared to measuring phase 2 ($p < 0.001$). COF from eight participants could be analyzed. Fig. 4 gives all analyzed COF. Similar to skin hydration, no intervention effect was found for this parameter. However, a time effect indicated a difference for the COF between the first and the second measuring phase ($p < 0.05$).

DISCUSSION / CONCLUSIONS

Differences between the sock fabrics were found for weight gain, confirming at least partly the difference in moisture behavior between the two sock fabrics. The differences in moisture behavior of the two sock fabrics did not result in measurable differences in parameters measured on the skin of the foot. It is suggested that a surge in these parameters lasts minutes; the development thereafter is undetectable, within the conditions of 30 min of walking as for the present study.

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