EVALUATION OF EFFECTIVENESS OF WATERPROOF/BREATHABLE BOOT-LINERS

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INTRODUCTION

Wet environments require footwear that keeps the feet dry. Walking in waterproof rubber-boots may however make the feet feel uncomfortably clammy. It is claimed that the new generation of waterproof/breathable footwear keeps water out while allowing transport of sweat outwards. The purpose of this labomtory study was to investigate, at different ambient temperatures in a dry environment, whether two different waterproof/breathable boot-liners affect transportation of sweat from the feet and outwards, compared to no such boot-liner. Field experiments were carried out in order to investigate if boot-liners kept the feet dry in a wet environment.

METHODS

When using a boot-liner this was placed between a thin innermost, and a thicker outermost, woollen-sock. The boot used were Norwegian military-leather-boots used by soldiers throughout the year.

Boot-liner **A:** SYMPATEX® (knitted nylon, a polyester film in the middle and polyamide (Cordura) outermost). Water-vapor permeability 22.15 g/m²/h.

Boot-liner B: GORE-TEX® (knitted polyester, 3 mm foam (open cells) in the middle and a teflon film outermost). Water-vapor permeability 28.43 g/m²/h.

The laboratory experiments were conducted at three ambient temperatures, +10°C, -10°C and -25°C, on 6 male subjects. The experiments took place in a climatic chamber and consisted of twice repeated bouts of 40 minutes cycle exercise followed by 20 minutes rest after each working period. The intensity during the working periods was 40% of maximal aerobic work capacity. Weighing of the footwear before and after each experiment was done in order to determine the amount of sweat accumulated in the different layers. Relative humidity and temperature were measured (to be able to calculate water-vapor pressure) between the boot and the outermost sock, close to the ankle, at the middle and end of the resting periods. Measurements of skin temperature at the instep (every minute) and subjective evaluation of thermal foot sensation (every ten minutes) were also made.

In the field experiments, during winter time, boot-liner B (n=3) was compared to no boot-liner. Based upon the laboratory results, boot-liner **A** was not tested in the field experiments.

RESULTS AND DISCUSSION

The accumulation of sweat in the innermost sock, after the two hour experiment in +10°C, did not differ between the boot-liner B and no boot-liner condition. 10% (5 g) of total amount of accumulated sweat in the footwear was located in the innermost sock when using **B** and 7% (4 g) when no boot-liner was used. Use of boot-liner A resulted in a greater accumulation of sweat, 48% (18 g), in the innermost sock. There was less accumulated sweat outside the boot-liner when using **A** compared with the two other concepts. Water-vapor pressure between the boot and the outermost sock also shows less sweat outside boot-liner **A** than **B**. No differences in water-vapor pressure were measured between the two conditions with **B** and without boot-liner (figure 1). At -10°C and -25°C the total amount of sweat in the footwear was low, but also for these temperatures the same tendency appeared.

A waterproof/breathable boot-liner should allow transportation of sweat from the feet to the surroundings, but at the same time prevent water to penetrate from the outside. The laboratory experiments were done in a dry environment in order to investigate if the two boot-liners interfered the sweat transportation outwards in the concept. As showed by both localization of accumulated sweat and water-vapor pressure boot-liner **B** is to be

preferred. Boot-liner A is not to be preferred because it prevents the transportation of sweat from the feet to the surroundings in all the experimental temperatures. Use of boot-liner B did not give any such prevention of sweat transportation.

Subjective evaluation of thermal foot sensation and skin temperature at the instep did not differ according to the concept even though boot-liner A resulted in more sweat close to the feet The laboratory experiment lasted for two hours. We may speculate that a longer use of the boot-liner will result in a larger difference in the transportation of sweat, and a larger sweat accumulation close to the feet may affect the subjective evaluation of thermal foot sensation and skin temperature.

The field experiments established that no boot-liner resulted in wet feet in the environment the experiments were carried out Use of boot-liner B resulted in dry feet and also dry innermost woollen sock.

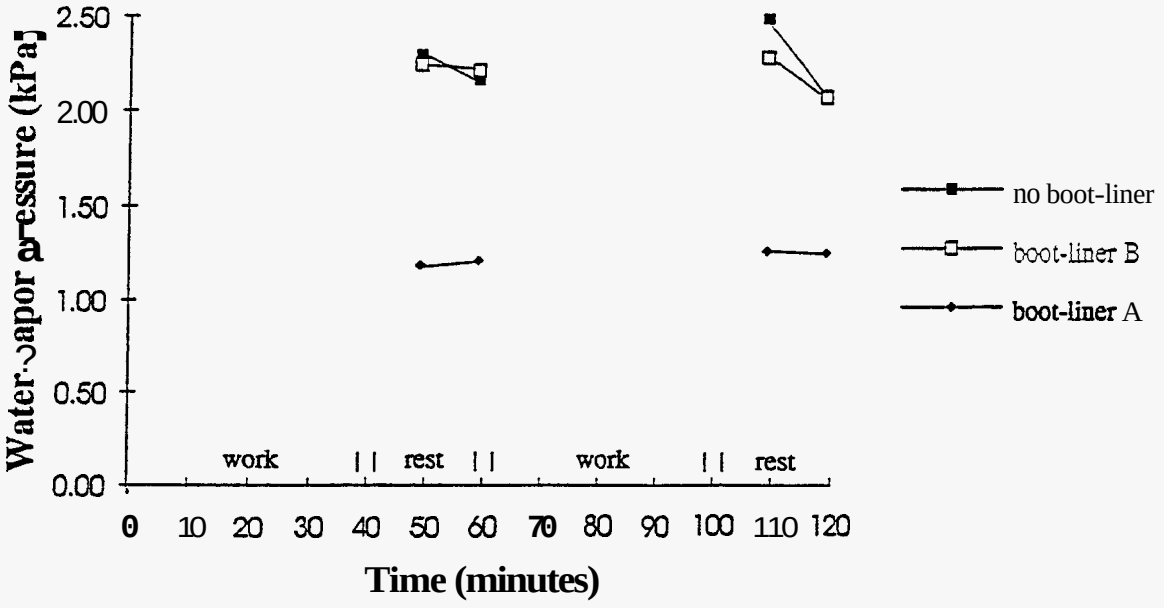

Figure 1 Water-vapor pressure (kPa) inside the boot and outside the waterproof/breathable boot-liner and the thicker woollen sock at +10°C in the laboratory experiments. Water-vapor pressure is calculated for the middle and end of the two resting periods (n=6).

CONCLUSION

In the laboratory experiments the use of boot-liner B did not affect transportation of sweat from the feet and outwards in the concept as boot-liner A did. In the field experiments boot-liner B kept the feet dry.

In order to achieve the best possible transportation of sweat outwards, and at the same time keep the feet dry in a wet environment, it seems that boot-liner B, GORE-TEX® (knitted polyester, 3 mm foam (open cells) in the middle and a teflon film outermost), is to be preferred.

ACKNOWLEDGEMENTS

This study was supported by the Branch Development Program for Textile Industries, represented by Norwegian Clothing and Textile Institute. The authors wish to express their appreciation to the program committee.