Temperature development & comfort grading measured with four different insoles

A.J.M. van der Velde

February 2007

Temperature development & comfort grading measured with four different insoles

A.J.M. van der Velde

Abstract

The goal of this research was to compare four different insoles with different top materials and a different middle layer which results in a recommendation on the best material use for the top. Compared are the subjective comfort and the objective temperature development in the shoe with different insoles.

Introduction

One of the important comfort factors is temperature. The temperature development in the shoe during the day is also related to shear-forces between the top of the insole and the foot. Shear-forces have a significant influence on occlusion of the blood flow within the tissue (Goossens, Zegers et al. 1994). The temperature increase will make the feet to sweat which is a common problem.

During this research four different insoles and their temperature development in the shoe for thirty minutes and comfort are compared. Liquicell is a material that should reduce shear-forces under the foot and therefore the temperature development should be smaller.

Materials & Methods

During thirty minutes the temperature was measured with thermoelectric couples T placed between the top of the insole and the area of the ball of the foot at 0.72*L. The thermoelectric wire T that is used has a range of - 200°C to 400°C with a significance of 0.5°C. A squirrel data logger of Grant 2020 series is used to convert the electrical signal into a temperature sampling at a rate of 1Hz.

Four different insoles were used during this research, leather and brushed nylon top with a PU middle layer (shore C 30°), nylon-mesh top with an EVA middle layer, and a leather top with liquidcell plied underneath with a PU middle layer. The liquidcell pads are plied at 0.18*L and 0.72*L at the pressure points of the foot according to Snijders (1995). Assumed is that the temperature development in the left shoe is the same as in the right shoe. The research is conducted over two days but on the same part of the day.

In order to exclude the influences of different socks and shoes, all the test-persons wore the same socks and shoes. The shoes were provided by Bata Industrials, Safety shoes, BS2000 Tacoma 4.

Five male test persons were asked to participate in this research (mass 77 kg (s.d.12), length 183 cm (s.d.7)). These test persons are healthy, no diabetics or other foot relating problems. The test persons have a European shoe size 42 ± 1. Only male test persons were asked to participate due to the differences in body temperature of men and women (Kim, 1998).

The volunteers walked on a treadmill for thirty minutes. Thirty minutes is chosen because this is the Dutch norm for health and exercise (NNGB, 1998). The volunteers were asked to adapt the treadmill to the most comfortable walking speed.

Different insoles are placed into the right and the left shoe and asked is what insole is most comfortable in the beginning and at the end of the thirty minutes. Due to the different insoles in the left and right foot it is easier for the volunteer to compare both sides.

Figure 1. Walking on the treadmill

Results

The first day the EVA-nylon mesh and PU-brushed nylon where put into the shoes. The EVA-nylon mesh was placed in the right shoe and the PU-brushed nylon in the left shoe. The average walking speed was 2.55 ± 0.3 km/hour. In the beginning the volunteers were asked what shoe was the most comfortable and give it a grade from 1 to 10. There are no real differences between the two shoes. Only one participant mentioned that the right insole was more comfortable at the area of the heel. After thirty minutes of walking the questions about comfort are asked again. The person who mentioned, during the first comfort rating that the right was more comfortable than the left, felt no difference at the end. One person mentioned that the left PU-brushed nylon was more comfortable because of the temperature, the right shoe felt a lot warmer that the left shoe.

The second day the left shoe the PU-leather insole was placed and into the right shoe the PU-leather-liquicell insole was placed. The participants walked for thirty minutes on the treadmill, average speed of 2.6 ± 0.28 km/hour. The same questions relating comfort were asked. There was no real difference felt in the beginning, only one person referred to the left insole being the most comfortable one. The most participants, four out of five referred to the right shoe to be the most comfortable one after the walk of thirty minutes.

	Grade begin	**Grade end**	**Difference**
EVA-nylon mesh	7.50	7.25	- 0.25
PU-brushed nylon	7.38	7.38	-
PU-leather	7.30	6.94	- 0.36
PU-leather-liquicell	7.10	7.40	**+ 0.30**

Table 1. Comfort grading

To make a comparison the temperature increase is determined and is presented in figure 2. Figure 3 presents the temperature development of the different insoles. In figure 2 and 3 it can be noticed that when wearing the EVA insole the temperature rises more than when wearing one of the other insoles. The PU-leather insole with liquid-cell plied underneath the leather top is responsible for a reduced amount of temperature development.

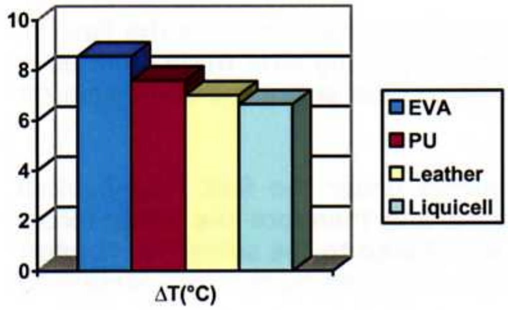

Figure 2. Temperature increase

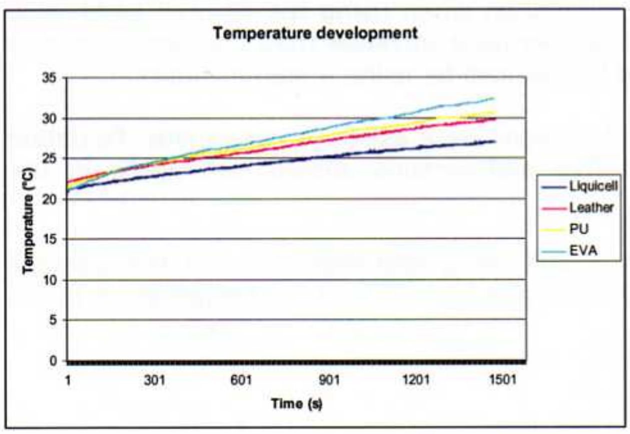

Figure 3. Temperature development

Discussion

In table 1, the comfort grades in the beginning and end are presented along with the difference between the beginning and the end. The comfort grading of the PU-brushed nylon insole is not presenting any difference between the beginning and the end. The EVA-nylon mesh and the PU-leather are showing a decrease in comfort during the walking period of thirty minutes. The PU-leather-liquicell is showing an increase in comfort grading after thirty minutes of walking on a treadmill. PU-leather-liquidcell is the most promising insole to introduce as a comfort insole. The PU-brushed nylon insole could also be fabricated with the liquidcell pads and is very promising.

In figure 2, the temperature development from the different insoles is shown. There is a tendency that the PU-leather-liquicell insole has a reduced temperature development and therefore the shear-forces are reduced by the use of the liquicell pads at the area of the heel and the ball of the foot. The EVA insole with a brushed nylon top has the most temperature increase and therefore assumed is that the shear-forces under the foot are larger when wearing an EVA insole than when wearing a PU-liquicell insole. Also the leather insole is showing a less temperature increase than the insoles with a textile top (nylon mesh and brushed nylon).

Conclusions & Recommendations

The most promising insole to use for an insole that increases comfort is the liquicell insole. It was the only insole that got a higher comfort grading after thirty minutes of wearing them. The other insoles got a lower comfort grade or got the same comfort grade.

The temperature increase is related to shear-forces under the foot. The liquicell insole is showing the lowest temperature increase and therefore the shear-forces under the foot are decreased. The shear-forces are related to the subjective comfort grading which correlates to the highest comfort grades given by the test-persons to the liquicell insole after thirty minutes.

If the shear-forces under the foot are decreased the blood circulation will not be decreased resulting in a better blood circulation when using the liquicell pads. Also the leather insole is showing a lower temperature increase than the textile insoles and shear-forces under the foot should be reduced by using a leather upper.

During this research only five male test-persons were asked to participate. To obtain a better scientific result more than five test-persons should participate in the research.

After thirty minutes the temperature is still rising and therefore the test-persons should walk for a longer period. Also a time of acclimation of the temperature in the shoe should be introduced.

References

Goossens, R, Shear stress measured on three different cushioning materials, March 2001

NNGB, 1998 http://www.sportzorg.nl/voeding-en-bewegen/de-nederlandse-norm-gezond-bewegen-nngb.html

Snijders C.J., Biomechanica van het spierskeletstelsel, G. James Sammarco, H10 Biomechanica van de voet, (1995) 223-251, (in Dutch)