TEMPERATURE INFLUENCE OF VARYING MIDSOLE HARDNESS ON FUNCTIONAL PROPERTIES

F. Kleindienst, B. Krabbe, K. Westphal, M. Grandmontagne, Adidas-Saloman AG – Biomechanical Lab, Scheinfeld, Germany, D 91443

INTRODUCTION
The midsole of a running shoe has to fulfil several functional requirements such as cushioning, stability and a smooth ride. In order to determine mechanical properties of midsoles various methods are used (Misewich et al., 1984). Dynamic material tests are needed for accurate interpretation and explanation of the data from the sensory evaluation by the runners.

REVIEW AND THEORY
The following material study is part of a comprehensive field study is called „Functional Grading of Running Shoes“. The objective of this dynamic material test is to investigate the temperature influence of varying midsole hardness on functional material properties which will also be used during the field study. In addition to the heel cushioning properties the forefoot cushioning characteristics and the forefoot flexibility are examined.

PROCEDURES
To simulate a rearfoot impact a servo-hydraulic device (INSTRON 8502) compressed the rearfoot of each shoe utilizing a missile head with a radius of 25mm, a force magnitude of 2000N within 35ms and decompression within 60ms. Concerning forefoot evaluation a stamp designed like the forefoot section of a last was used. A force magnitude of 2000N within 100ms and decompression within another 100ms was applied. The force-time profiles are similar to the realistic conditions during a running movement. Within the test 20 cycles were performed with a frequency of 1000Hz for each test vehicle. To interpret cushioning characteristics of the rearfoot and forefoot the average dynamic stiffness (Krabbe, 1994) was calculated within the recorded force interval between 1000N and 1500N (Stiffness II). The test procedure for the evaluation of the forefoot flexibility was in accordance with ASTM 790 (3 point bending) using the INSTRON device too. The vertical bending distance was 5mm and the machine was driven with 100ms concerning both bending and relaxation. The bending stiffness was calculated within the recorded distance interval between 2.5mm and 4.5mm.
As a test vehicle a standard running shoe was used with a compressed moulded midsole consisting of pure EVA material. In order to analyse the temperature influence three degrees of hardness (40Asker C, 55Asker C and 70Asker C) were chosen based on the same aforementioned construction characteristics. All three vehicles were investigated at eleven temperature conditions: -20; -15; -10; -5; 0; 5; 10; 15; 21.5; 30; 40°C.

RESULTS
The dynamic material test results clearly demonstrate that the mechanical properties of the varying midsole configurations change as a result of the changes in temperature (Figure 1 and 2). The lower the temperature the harder the Stiffness II of the test vehicles. Lower temperatures result in smaller deformations and greater amounts of energy being absorbed. Varying midsole hardness react in a different way on temperature differences. Figure 3 indi-
cates the differences concerning the deformation of the three different vehicles at one temperature level (15°C).

![Figure 1: Stiffness II – rearfoot cushioning](image1)

![Figure 2: Stiffness II – forefoot cushioning](image2)

![Figure 3: Force and deformation at 15°C (rearfoot)](image3)

![Figure 4: Bending Stiffness – forefoot flexibility](image4)

These findings apply to the rearfoot as well as to the forefoot (observance of “bottoming out effect” on 40Asker C vehicle). With regard to forefoot flexibility varying midsole hardness react in a similar way to temperature differences (Figure 4). There is a similar course of graphs to –10°C but at different levels.

**DISCUSSION**

The findings indicate that runners who use the same shoes during both winter and summer have to absorb greater forces during winter compared to summer if they do not adapt their running style (Kinoshita and Bates, 1996). Lower temperatures also have negative consequences during roll off concerning a smooth heel-toe transition. It is suggested that functional changes due to seasonal temperature differences are considerable and can alter the stress placed on the human body if running kinematics are not changed.

**REFERENCES**