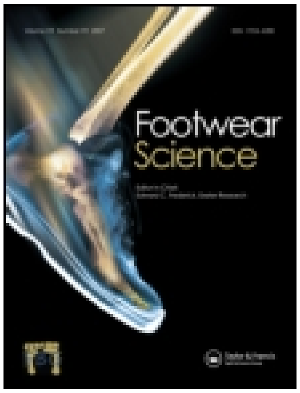

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The effect of temperature on the rebound characteristics of material combinations commonly used in diabetic insoles

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The effect of temperature on the rebound characteristics of material combinations commonly used in diabetic insoles

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Introduction

It has been shown that mechanical properties of the insole materials affect plantar pressures during walking (Healy *et al.* 2010). The mechanical properties of foam materials used as insoles are dependent on the temperature and this temperature influence alters the energy return efficiency. Furthermore, the cushioning characteristics of the material also differ under varying temperature conditions. Despite a number of studies investigating the effect of temperature on the midsole (Mansour *et al.* 2001), there is a paucity of information on the effect of temperature on the insole material commonly used in diabetic footwear.

According to the standard testing procedures (ASTM, DIN, EN, ISO, BS) the material data are determined at pre-determined temperatures refer to 'room temperature' (20°C or 23 ± 2°C). For insole materials the real material temperature can be considered close to the temperature of the human body (Maluf *et al*. 2001). The increase in the insole temperature occurs due to contact with body, and may be affected by the ambient environment and by repetitive loading due to activity level. These variations in temperatures can cause the insole materials to behave differently as compared to the data given by the suppliers.

The insoles for patients with diabetic foot syndrome consist of a combination of several layers of different materials. This usually consists of a base material (PU or EVA) covered by a top layer of a more compliant material (Poron® Rogers Corporation or x2® schein orthopädie service KG) together which contribute to cushioning and plantar pressure distribution.

Purpose of the study

The purpose of this investigation was to elucidate the rebound characteristics of a combination of different materials commonly used within diabetic shoes as insoles or footbeds at room temperature and to compare the results at three different elevated temperatures.

Methods

A Zwick 3107 rebound tester was employed to determine the rebound resilience of foams to DIN EN ISO 8307. Five different materials including: low, medium and high density EVA and low and medium density PU were used as an insole base. Four different top cover choices including Poron® 94, Poron® 4000, ×2 soft, ×2 medium were glued over the top of the base. The specimen size was 10 cm × 10 cm with thickness of 3 mm.

The rebound ratio was calculated as the ratio of rebound height to the drop height. The samples were heated up in an oven for an hour to simulate the elevated temperature.

Results

Differences in the rebound behaviour of the material combination was observed at room temperature (Table 1 and Figure 1)

There was a general trend towards an increase in the rebound as a result of the increase in temperature when Poron® 94 and Poron® 4000 were used as a top cover.

When ×2 material was used a top cover the rebound characteristics as a result of increase in temperature were less affected.

Discussion and conclusion

The rebound characteristics of Poron® material combinations were highly affected by the temperature increases, while the ×2® combinations were less affected, making ×2® more consistent in terms of rebound characteristics across temperatures.

In some cases, changes in the temperature from 20°c to 55°c increased the rebound up by twofold for the Poron® as the top cover.

The results of this study contribute to further understanding of the changes in material characteristics with changes in temperature and can have major implications in the selection of the most appropriate material for use

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Table 1. Rebound ratio for the different material combinations tested at different temperatures.

The effect of temperature on rebound characteristics	Temperatures			
Material Settings	20c	37c	45c	55c
3mm LD EVA + 3mm Poron 94	12.1%	15.8%	21.0%	24.1%
3mm MD EVA + 3mm Poron 94	7.3%	10.6%	14.8%	17.5%
3mm HD EVA + 3mm Poron 94	6.8%	10.1%	13.0%	14.8%
3mm LD PU + 3mm poron 94	8.4%	11.9%	14.0%	16.1%
3mm MD PU + 3mm poron 94	8.0%	10.0%	11.7%	14.5%
3mm LD EVA + 3mm Poron 4000	19.3%	26.0%	31.8%	36.2%
3mm MD EVA + 3mm Poron 4000	14.8%	20.9%	24.7%	28.6%
3mm HD EVA + 3mm Poron 4000	14.4%	19.8%	23.9%	27.0%
3mm LD PU + 3mm poron 4000	16.6%	21.7%	25.4%	26.2%
3mm MD PU + 3mm poron 4000	14.0%	19.2%	22.5%	22.0%
3mm LD EVA + 3mm ×2 maroon	19.2%	20.9%	21.2%	22.8%
3mm MD EVA + 3mm ×2 maroon	14.2%	13.7%	13.7%	13.9%
3mm HD EVA + 3mm ×2 maroon	10.3%	10.1%	10.1%	10.8%
3mm LD PU + 3mm ×2 maroon	14.3%	15.0%	14.0%	13.7%
3mm MD PU + 3mm ×2 maroon	12.6%	12.9%	12.4%	12.7%
3mm LD EVA + 3mm ×2 petrol	17.9%	17.9%	18.3%	19.6%
3mm MD EVA + 3mm ×2 petrol	12.5%	11.3%	11.2%	11.7%
3mm HD EVA + 3mm ×2 petrol	9.1%	8.2%	8.4%	8.8%
3mm LD PU + 3mm ×2 petrol	12.5%	12.5%	11.9%	11.8%
3mm MD PU + 3mm ×2 petrol	12.4%	11.0%	10.9%	11.1%

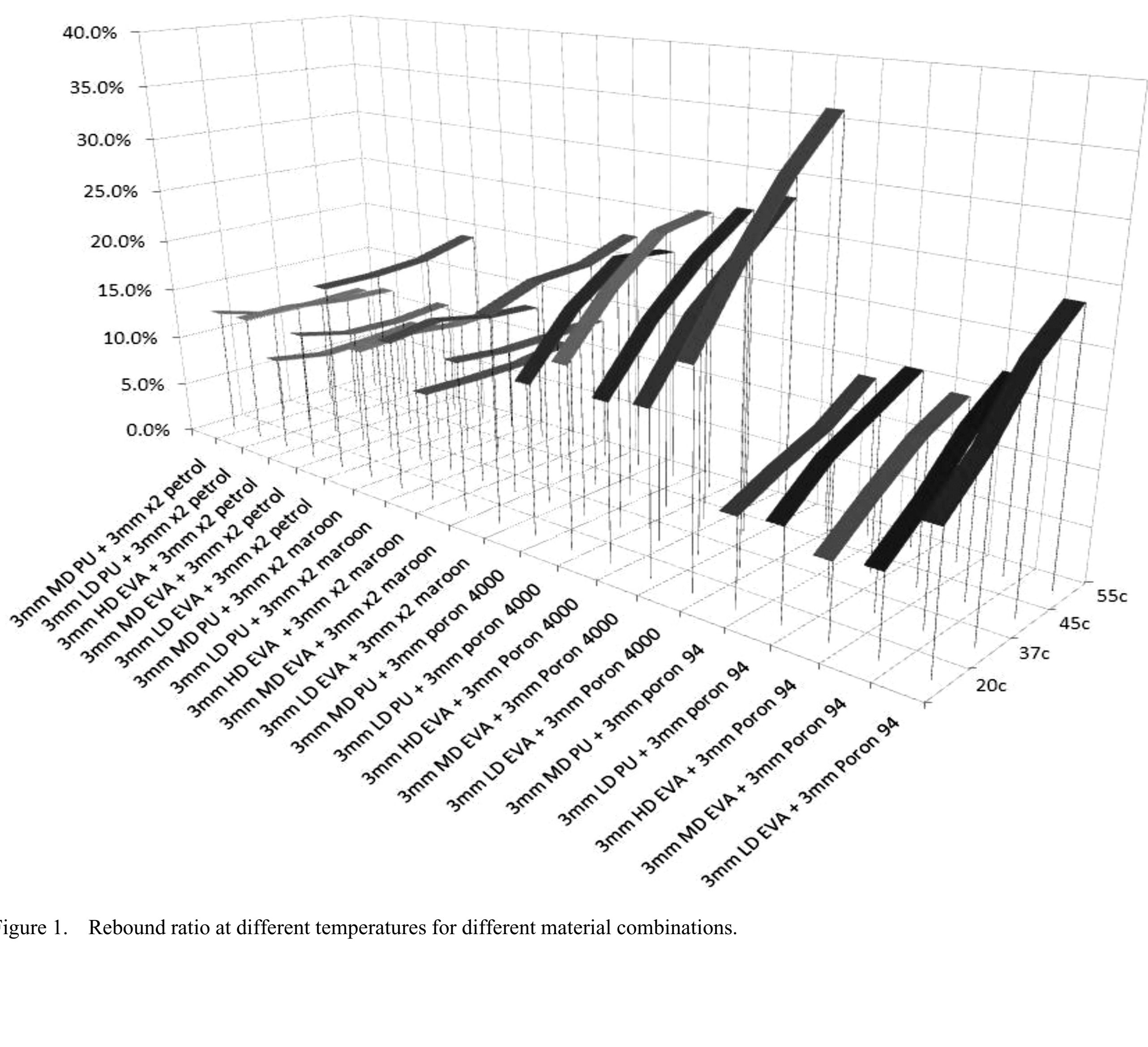

Figure 1. Rebound ratio at different temperatures for different material combinations.

within footwear in relation to the ambient temperature or activity level.

Acknowledgement

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Development of well-fitting shoes for children and adolescents

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Introduction

Best guidelines for shoes are feet without shoes (Staheli 1991). Therefore, children's shoes should not restrict the physiological maturation process of feet. A first attempt to cover natural variability in children's feet (to achieve better fit) was a clustering approach by Mauch (Mauch *et al.* 2008), that was based on static 3D foot scans. However, dynamic information about foot deformation is important for the fit of shoes. One major aspect of well-fitting children shoes, with respect to the maturation processes, is a physiological allowance. In the past, interpretations of imprints and plantar pressure analysis or comparisons of loaded and unloaded foot morphology were consulted to reply to the question of dynamic changes (Cheng *et al.* 1997, Maier 2003). Nevertheless, children's dynamic 3D foot deformation has not been evaluated before, as the 3D scanner technology in the past was not sufficient to allow the capturing of dynamic deformations of the foot during walking.

Purpose of the study

The purpose of the present study was the capturing and evaluation of 1) dynamic foot deformations of children's feet during walking as well as 2) specific children's lasts to work out recommendations for the construction of well-fitting footwear for the feet of children and adolescents.

Methods

DynaScan4D, a five-scanner system based on active triangulation, was used to capture static and dynamic 3D foot and last morphology (Schmeltzpfenning *et al.* 2009).

A total of 2554 healthy children and adolescents (aged 6 to16 years) participated in the study. Static measures of the feet at full and half weight bearing, as well as three dynamic trials during walking (walking speed was adjusted to body height) were captured. Furthermore, typical children's lasts were measured. Additionally, body weight, height, gender, age, and ethnicity were recorded. Typical and important foot measures (length, width, girth, and angles measures) in the construction process of shoes were evaluated.

Comparisons between static and dynamic foot measures were based on matched pair t-tests, differences between children's feet and lasts on analysis of variance (ANOVA). Influences of anthropometrics were calculated by multiple linear regression analysis. Additionally, repeatability of foot measures (intraclass correlation coefficient, root mean square error) was analysed to allow the interpretation of the static and dynamic results. All levels of significance were set at $p < 0.05$.

Results

(1) Dynamic foot measures differ with statistical significance from static loaded foot measures. Maximum dynamic foot length, forefoot and rearfoot width, and forefoot angles exceed static values. Girth measures in the midfoot are smaller in dynamic situation.
(2) Differences between typical lasts and children's feet were found for the location of first and fifth metatarsal heads, and for the magnitude of midfoot girth, forefoot angles, and ball and heel width.

The calculated allowance (extension, advance, and semiannual growth) was smaller than previously assumed.

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