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Technical note

Assessment of some shock absorbing insoles

D. J. PRATT, P. H. REES AND C. RODGERS

Orthotics and Disability Research Centre, Derbyshire Royal Infirmary, Derby

Abstract

Due to the increase in prescription of insoles to relieve symptoms due to skeletal shocks at heel strike a pilot study was initiated to look at some materials used for this purpose. Five materials were examined (Plastazote, Spenco, Sorbothane, Poron (PPT) and Viscolas) by two methods. The first method used an accelerometer mounted between the teeth of one of the authors (PR) to record skeletal shock. The second method used a force plate to record the shock produced by dropping a ball-bearing onto the insoles from a standard height. The results showed that Plastazote is poor at absorbing shock with Spenco and Sorbothane being quite good. The best insole materials tested were Poron (PPT) and Viscolas with the latter being marginally superior. No account was taken of degradation of the materials in use except that Plastazote worn for 72 hours was also used in the study, this producing the worst results.

Introduction

There has been a trend towards the prescription and supply of shock absorbing insoles not only for proven clinical/medical conditions but also, as a result of the increase in popularity of sports and other leisure activities, for the non-specific painful heel or foot. This has resulted in many new products being introduced and many older products being used in this new context.

A recent publication (Campbell et al, 1984) examined the compressive behaviour under simulated use of foamed orthotic shoe insoles. These foams were all considered to be "cushioning" or "pressure-distributing" (Albert, 1981; Wood, 1981) and are generally felt to function as a soft-tissue supplement. The matching of the mechanical characteristics of the soft tissues of the foot to those of a material inserted into footwear has already been reported to be of value (Beach and Thompson, 1979).

The small study reported here does not try to examine the effects upon the insole material due to heat, perspiration and any mechanical degradation due to continuous stress reversals but looks simply at two methods of assessing the shock absorbing value of five materials, four newer products (Spenco, Sorbothane, Poron (PPT) and Viscolas) and medium density ($45 kgm^{-3}$) Plastazote as a reference. Plastazote was included in this study as locally it is being used as a shock absorbing insole material although it is generally felt that this is a poor choice for this application.

All correspondence to be addressed to Dr. D. J. Pratt, Orthotics and Disability Research Centre, Derbyshire Royal Infirmary, London Road, Derby.

Materials and methods

The five materials tested vary in their form. Plastazote and Poron are available in sheet form and are cut to size. Viscolas is available both as a ready made contoured insole and in sheet form. Spenco and Sorbothane are available as ready made insoles with Spenco being of a uniform thickness and Sorbothane being contoured. Sorbothane has a slight longitudinal wedge and Viscolas has a medial arch support and a thicker perimeter. Plastazote is well known to suffer from rapid compression set (bottoming). The other materials apparently do not suffer this to the same extent. It was thus decided to carry out an extra test on old Plastazote (Plastazote worn by one of the authors (PR) for 72 hours). The ready made insoles were nominally 5-6mm thick in the heel region and so in the cases of Plastazote and Poron the closest match was used, 6mm for both.

Two tests were used to assess the materials for their shock absorbing properties. Firstly an accelerometer (Bell and Howell — 25g) was attached to an orthodontic impression plate (Fig. 1) and held firmly in the teeth of one of the

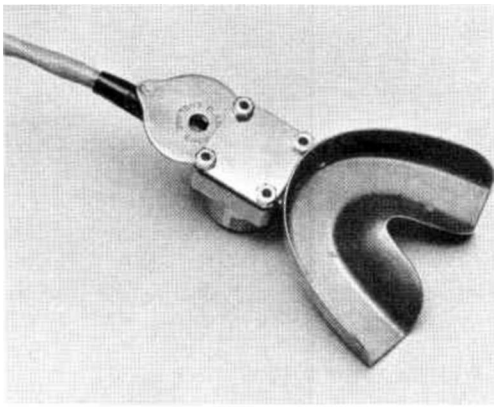

Fig. 1 The accelerometer shown attached to the orthodontic impression plate.

authors (PR). He then walked along the length of a gait laboratory with each insole in turn and then without any insole and on each pass he stepped onto a Kistler force plate. The accelerations and vertical foot/floor reaction forces were recorded on a storage oscilloscope and dumped onto a chart recorder for analysis. At least five sets of data were collected for each insole before proceeding with the next. The use of an accelerometer attached to the teeth in assessing skeletal transients has been well documented (Light et al, 1980). This does give a lower signal than that provided via attachment direct to the tibia but is less invasive and preferred in this context.

The second test method was to drop a 0.056kg ball-bearing from 1.02 metres onto each sole in turn placed on top of the Kistler force plate. The vertical force was recorded on a storage oscilloscope and again dumped onto a chart recorder for analysis. The traces were averaged by the oscilloscope for each insole prior to dumping.

Results

Figure 2 (left) shows the results from the gait assessment method of insole assessment. They are all expressed in multiples of g and are normalized to a standard vertical foot/floor reaction force. The accelerations ranged from about 0.6g to about 1.15g with a fairly even spread. Without an insole the acceleration was 1.08g (±0.06) which was very similar to old Plastazote (1.07g ±0.05). New Plastazote was better at 1.02g (±0.12) with Spenco and Sorbothane both at 0.92g (±0.07 and ±0.08 respectively). Poron had a value of 0.86g (±0.06) and Viscolas had the best value of 0.74g (±0.13). There is considerable overlap between many adjacent groups although the underlying trend is clear.

If these results are compared to those in Figure 2 (right) almost the same order is observed. This figure shows the results expressed in terms of the height of the first peak after contact of the ball-bearing but this is directly related to the absorption of the shock impact. Old Plastazote is still worse than the other insoles at 60mm (±5.5) but new Plastazote, Spenco and Sorbothane have very similar values of 50.0mm (±5.3), 48.25mm (±7.2), and 49.5mm (±6.8) respectively. Poron and Viscolas again perform the best with values of 41mm (±4.0) and 39.9mm (±4.9) respectively.

Discussion

For a shock absorbing insole to be of clinical value it must provide good absorption and its properties should last for a long time. The work of Campbell et al, (1984) has indicated that the probable useful life of materials such as Plastazote and Spenco may not be long when compared to Sorbothane and Poron. They did not test Viscolas but the indications are that it should perform as well as Sorbothane in this respect. So although the tests reported here show the shock absorbing properties of the materials at their best, except for Plastazote, these may not last for long if compression set is marked. In this context the best materials seem to be Sorbothane, Poron and Viscolas with a preference for the last two. In addition, a strongly damped response to impact is to be preferred and this is the sort of behaviour exhibited by all of the materials except Plastazote. These results do not mean that Plastazote should not be used as an insole material but it should not be used as a shock absorbing material.

Plastazote is a closed-cell foam and as such should exhibit shock absorbing properties. This is because each cell forms a small "cushion" against the impact forces. However a slow compression takes place over a few days use because the closed cells are not impermeable, but allow gas to escape. Potential energy stored in the deformed matrix causes air to be drawn back into the cells when unloaded but a permanent set is produced due to damage to

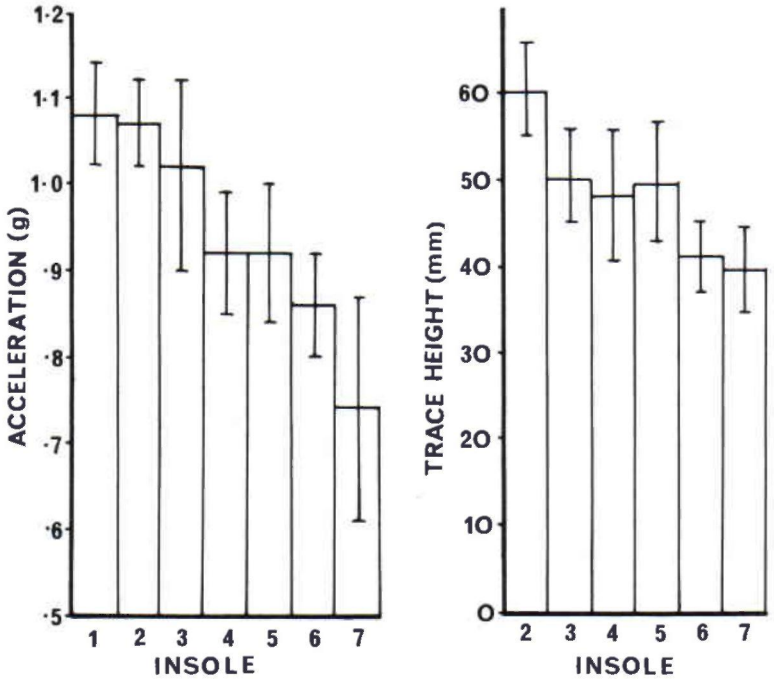

Fig. 2. Left, the results from the gait assessment of the insoles. The accelerations are quoted as multiples of g and the vertical bars represent ± one standard deviation from the data. The numbers along the x-axis indicate the following insoles:- 1—footwear only, 2—"old" Plastazote, 3—"new" Plastazote, 4—Spenco, 5—Sorbothane, 6—Poron (PPT), 7—Viscolas. Right, the results from the impact assessment of the insoles. The impact peak is measured in millimetres and the vertical bars represent ± one standard deviation for the data.

some of the cells. This effectively limits the useful life of the material which, when new, is not a good choice as a shock absorbing material in this application.

This study is a small preliminary one aimed at identifying some aspects of shock absorbing insole characteristics which will be of value in selecting the most appropriate material to use in a given clinical situation. The effects on these insoles by other factors (other than loading, static and repetitive) such as perspiration, scuffing and torsional wear need to be assessed before any definite conclusions can be drawn. However, this contribution illustrates that there are some basic differences between the insoles studied which may make selection of a suitable material a little easier.

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Viscolas is a new shock absorbing insole material and is available from the Chattanooga Corporation, 101 Memorial Drive, P.O. Box 4287, Chattanooga, TN 37405, U.S.A.

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