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A comparison of shoe insole materials in plantar pressure relief

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Abstract

A clinical study was performed to evaluate the effectiveness of seven shoe insole materials and their ability to relieve areas of high plantar pressure. The following materials were tested: Latex foam, Plastazote^R, Dynafoam^R, Ortho felt, PPT^R, Spenco^R, and Molo^R. Twenty-six patients with areas of high plantar pressure were tested using each of these materials. The Harris and Beath footprinting technique was used to measure plantar pressure. It was found that the average pressure of a clinically painful plantar area was 398.15kN/m^2. All insole materials tested decreased this pressure, with averages ranging from 186.33kN/m^2 to 286.35kN/m^2. PPT, Plastazote and Spenco were the most effective products tested.

Introduction

Areas of increased plantar pressure have been clearly linked to foot pain and discomfort (Godfrey et al, 1967; Silvino et al, 1980). Increased pressure is also responsible for skin breakdown in the denervated foot such as in Hansen's disease and diabetic neuropathy (Bauman et al, 1963; McDowell and Enna, 1974). Attempts to reduce this high plantar pressure have produced a wide variety of shoe insoles which can be inserted into footwear between the shoe sole and the plantar surface of the foot.

Because of the great number of products clinically available, there is a need for experimental data to determine which products are most effective. This study was undertaken to compare seven materials commonly used to reduce plantar pressure. The study measures maximum plantar pressures using the Harris and Beath (1947) footprint technique which enabled both quantitative and qualitative results to be compiled.

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Materials and methods

Description of materials tested

Seven products were evaluated and are briefly described below.

Plastazote^R is a foamed polyethylene of closed cell construction. It is mouldable, bouyant and non-toxic. Plastazote is widely used in orthopaedics as a foot orthosis for protection against pressure points. It can be laminated to other materials for increased reinforcement. Three densities are available. The medium density was tested.

Latex foam is a cellular rubber of open cell construction (absorbs water). It is washable, odourless and can be cemented to other materials. Latex foam has a long history of use in orthopaedics as a footwear insole and cast padding.

Dynafoam^R is a polyvinyl chloride foam compound. It is odourless and water resistant, and quickly forms an impression of the foot.

Ortho felt is a resilient fabric composed of a blend of cotton and wool, with a relatively low tensile strength. Felt is widely used for cast padding and pressure relief pads in shoes.

Spenco^R is a neoprene sponge product with nitrogen-induced closed cells which is covered with a multistretch nylon fabric on one side. It is resistant to decay and odour. Spenco is said to absorb vertical forces, torque, and fore, aft, and lateral shear. It is designed to prevent neuropathic and rheumatoid ulcerations and is marketed for athletes to prevent blisters and callosities (Spence and Shields, 1968).

Molo^R is a combination of latex, jels, leather, cork and other products which are incorporated into a rubbery sheet. Under continued pressure Molo forms an impression of the foot. It is resistant to moisture and can be joined to another substance.

PPT^R is an open cell, porous, firm foam material which relieves local pressure. It is marketed as a "high-energy absorbing substance" that will not "bottom out" under the forces of pressure, shock and shear.

All materials tested were one-eighth inch thick and can usually be added to a shoe without making it too tight to wear comfortably.*

Measurement of plantar pressures

Plantar pressures were recorded using the version of the Harris and Beath footprinting mat manufactured by Berkemann Laboratories and available through Apex Foot Products Corporation, Englewood, N. J. For details of its use and quantification of the recorded pressure, see Harris and Beath (1947) and Silvino et al (1980).

Twenty-six patients were studied, 16 male and 10 female, ranging in age from 25 to 71 years. All patients complained of forefoot pain on weight-bearing and all showed areas of increased pressure under one or more metatarsal heads when tested with the Harris and Beath technique.

Footprints of the 26 patients were initially recorded without orthotic material. Subsequent footprints were recorded for each patient testing each of the materials described above.

The material to be tested was placed underneath the recording paper which was under the Harris mat. When a subject stepped on the mat the pressure recorded represented the interface between the foot and the insole material which is where plantar pressure redistribution occurs.

Footprints using each insole material were compared to the patient's control footprint, and a general category of effectiveness was assigned to each product by the overall improvement observed. The following three categories were used: most reduction in plantar pressure, some reduction, least reduction.

* All products, except PPT, were purchased from the Eneslow-Apex Shoe Corporation, 200 Forest Avenue, Englewood, N.J. 07630. PPT was obtained from Professional Protective Technology, Inc., 21 East Industry Court, Deer Park, N.Y. 11729.

Fig. 1. Footprints recorded using the Harris and Beath footprinting mat and various orthotic materials demonstrate an area of increased pressure under the first metatarsal head; left, with least effective material, centre, with more effective material, and right, with most effective material.

Table I. Comparison of insole products and their effectiveness in reducing plantar pressure. P=26.

Product	Mean pressure under painful matatarsal head (kN/m^2)	Percent decrease in pressure (%)	Category of effectiveness
PPT	186.33	53	most
Plastazote	188.29	53	most
Spenco	193.19	51	most
Dynafoam	230.46	42	some
Molo	232.42	42	some
Ortho felt	266.74	33	least
Latex foam	286.35	28	least
Control	398.15	—	—

Estimation of pressure was made for each footprint using a calibration curve (Silvino et al, 1980). Mean pressure values were then calculated for each product and for the control. Numerical data was evaluated for significance by a two-way analysis of variance.

Results

The seven materials were divided into general categories of effectiveness by the overall appearance of the footprints. Those that showed the most reduction in plantar pressure were Plastazote, Spenco, and PPT. Those that showed some reduction were Dynafoam and Molo. Those that showed the least reduction were Ortho felt and Latex foam.

Figure 1 demonstrates an example of the three categories of effectiveness. The estimated foot pressures appear in Table I. The mean value of pressure under the clinically painful metatarsal head was $398.15 kN/m^2$ without any insole material. When the various products were used the mean pressure at the painful site ranged from $286.35 kN/m^2$ with Latex foam to $186.33 kN/m^2$ with PPT. This represented a decrease in pressure of 28 percent and 53 percent respectively.

Two-way analysis of variance disclosed that all seven products were significantly different from control at the $p<0.01$ confidence level. PPT, Plastazote and Spenco, while not significantly different among themselves, were significantly different from the other products ($p<0.01$). Ortho felt was significantly different from all other products as was Latex foam ($p<0.01$).

Discussion

This clinical study compared the effectiveness of seven shoe insole materials using the Harris and Beath footprinting technique. By observing the general appearance of the footprints, it was found that PPT, Spenco, and Plastazote relieved plantar pressure most effectively. Quantitative data obtained from the footprints agreed with the general categories of effectiveness. Statistical analysis confirmed that PPT, Plastazote and Spenco were significantly more effective in reducing plantar pressure than the other products tested. This conclusion is in agreement with laboratory compression testing of orthotic materials performed by Campbell et al (1982) which included Plastazote and Spenco in the optimal category based on load-deformation curve characteristics.

Utilizing the most effective orthotic material for relief of pressure is important in the prevention of trophic ulceration in the anaesthetic foot as well as in providing relief of pain in such common conditions as metatarsalgia. Past research has shown that clinically painful plantar areas tend to occur at pressures exceeding $254.97 kN/m^2$ (Bauman and Br and, 1963; Bauman et al, 1963; Silvino et al, 1980). All 26 patients studied complained of forefoot pain on weight-bearing and all showed plantar pressures above $254.97 kN/m^2$ at the site of pain (mean $398.15 kN/m^2$, range $260.86 kN/m^2$ to $474.64 kN/m^2$). When insole materials were introduced, the pressure at the painful area was reduced to below $254.97 kN/m^2$ for all the products except Latex foam and Ortho felt.

The study did not consider long-term use of different products by symptomatic patients since that would be difficult to do accurately with so many products. However, this would be an interesting area for a follow-up study now that the materials are categorized as to general effectiveness.

The products that are less effective in relieving high plantar pressure still may have important uses in orthopaedics. For example, Dynafoam, because of its creep properties, forms an impression of the foot or other high pressure area and is useful in covering braces and orthoses. Many of the products tested can be bonded to other compounds for increased

strength or special uses. The relief of pressure by these compound materials has not been studied and is an area where more research is needed.

It has been demonstrated that differences exist between commercially available products in their ability to relieve high plantar pressure and this information can be of great value in prescribing footwear insoles for the many patients suffering from pain or pressure-induced lesions of the feet.

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