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Long term comparison of some shock attentuating insoles

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Abstract

The effect of one years general use on the performance of four shock attentuating insoles is reported. Testing was carried out using the JP Biomechanics Shock Meter on twelve volunteers on a timed oval course at eight intervals during the year. The results show that two of the insoles perform well (Viscolas and PPT) although deterioration does occur after 6–9 months use; the other two insoles (Plastazote and Gait Aid) perform poorly. It is suggested that manufacturers provide some information to the user or supplier regarding the effective life of their products.

Introduction

The orthotics profession in the UK has had a somewhat mixed reaction to the introduction of shock attentuating insole materials, an interest which was initiated in many by the development of Sorbothane. The materials now purported to be of value in shock attentuation are many and yet the generalised use of them has been slow to develop. The author has carried out a number of assessments of many of the materials in a variety of ways to try to establish some guidelines for their use (Pratt et al., 1986; Pratt and Sanghera, 1987; Oakley and Pratt, 1988). Many other reports exist but all of the papers failed to appreciate the long term effects of use on the properties of the insoles (Voloshin and Wosk, 1982; Lees and McCullagh, 1984; Light et al., 1980; McLellan, 1984) despite the fact that evidence exists, both experimental and practical (Campbell et al., 1984), that some of these materials do suffer after use. The author thus decided to measure the shock attentuating effectiveness of some insoles over a protracted period using a new technique (Johnson, 1986) based upon lower limb accelerometry, the Shock Meter. This is a popular technique and one which offers much information but often involving expensive equipment for signal processing and limiting the subject to short walks or treadmill activities. The introduction of the JP Biomechanics Shock Meter offers a substantial benefit for this type of work. The meter analyses the frequency content of the signal using Fast Fourier Transform (FFT) techniques to produce a single number between 1 and 10 to indicate the proportion of the accelerometer signal due to impact; the higher the number the greater the shock. The author thus used this meter to assess four insoles over a period on one month (Pratt, 1988) and this study was extended to cover one years use and it is this study that is reported below.

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Materials and Methods

Four insoles were tested (Viscolas, PPT, Plastazote (45kg/m^3), Gait Aid) selected for the following reasons. Viscolas has been shown to have particularly good shock attentuating properties (Pratt and Sanghera, 1987) but is comparatively heavy when compared with foam materials, the best of which seems to be PPT. Both of these insoles are effective at shock attentuation, although very different in appearance they are both based upon polyurethane chemistry. Plastazote was included in the study because, although experience shows that it suffers considerable compression set with a corresponding reduction in its "cushioning" ability, it is still used by some people to act as a shock attentuating insole. Gait Aid was included because it claims to provide "maximum support" and "shock absorption" by "placing the foot in its correct mechanical position". The insole itself is firm and contoured in such a way as to try to effect the function of the first metatarsal shaft although this was found to be uncomfortable for all of those who used it.

Viscolas and Gait Aid were used in the form of proprietary insoles whereas PPT and Plastazote were cut from sheets, 3.5mm for PPT and 3mm for Plastazote.

Twelve volunteers were recruited for this study, 8 male and 4 female; their ages ranged from 19 to

36 (average 27.8 years) and were selected because they were pain free during gait and had not suffered any recent injury. Each insole was worn by three volunteers and measurements were carried out after 2 days, 7 days, 1, 2, 6, 9 and 12 months in the following manner.

An oval circuit 9.5m × 3.5m on a concrete floor was used and each volunteer, before recruitment, had walked around the track at a comfortable pace and their average circuit time recorded. On subsequent occasions, each volunteer had to walk around the circuit at within ± 10% of their average time whilst wearing the shock meter. Five recordings were made at each visit with the subject wearing socks and then five more wearing socks and insole. The shock meter, consisting of a belt worn pack with readout, an ankle worn accelerometer and an inter-connecting cable, was easy to use, each volunteer calling out the displayed shock factor every two minutes.

The shock meter calculates the shock factor by carrying out an FFT of the accelerometer signal in the frequency range 10–150Hz. This range was found to provide a reliable output, getting over the usual problems associated with the attachment of the accelerometer. By expressing the area under the FFT between 10 and 50Hz as a fraction of the whole area between 10 and 150Hz a number between 0 and 1 is obtained which is subsequently scaled to between 0 and 10 for ease of handling.

The data for each insole were expressed as a percentage of the sock-footed reading and compared with the others.

Results

It is clear from Figure 1 that, for all practical purposes, the shock attentuating properties of Plastazote and Gait Aid are constant (except for less than 2 days use of Plastazote) and poor; ranging from 98.0% to 98.5% for Gait Aid during the year and 97.2% to 99.0% for Plastazote over the same period (the differences between the start and end values are not statistically significant).

The picture is different with Viscolas and PPT, both of which show deterioration during the twelve months. Viscolas changed from 82.2 ± 2.2% to 89.4 ± 3.1% whilst PPT changed from 83.5 ± 1.0% to 93.5 ± 3.2% during the same period. The results show, however, that even after

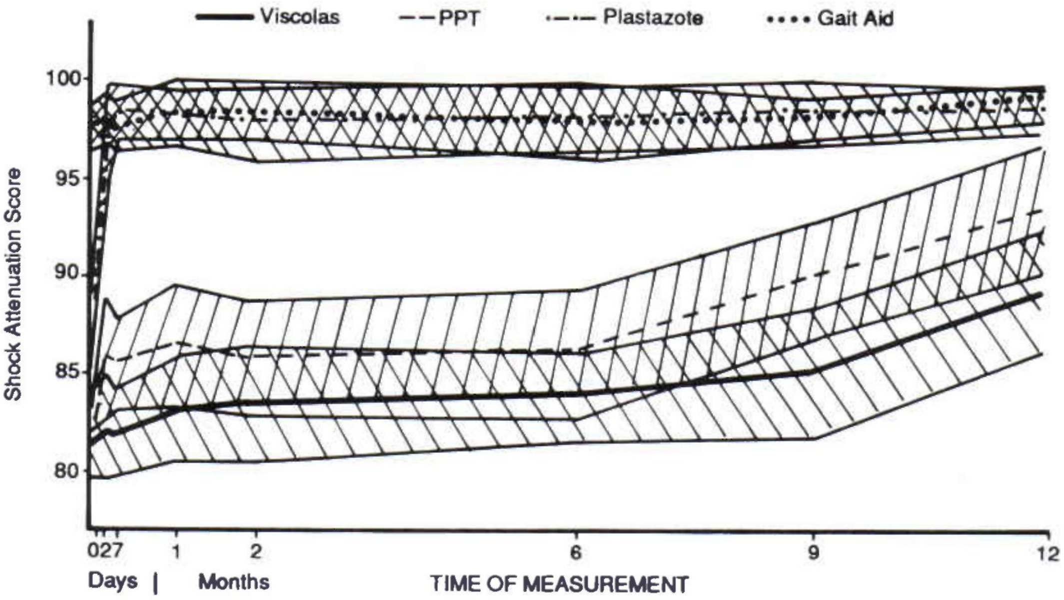

Fig. 1. Shock Meter results for the four insoles tested. the shaded areas either side of each line represent the limits of ± one standard deviation. The numbers on the ordinate indicate the time of the measurement and the numbers on the abscissa are calculated from

$$\frac{\text{(shock factor with insole)}}{\text{(shock factor without insole)}} \times 100$$

Smaller values thus indicate a superior shock attentuating performance.

12 months these two materials perform better than the other two after just two days use.

The reasons for the deterioration were different in the two cases. PPT seemed to pass through a stage of no apparent damage or significant change in properties (up to about 6 months). There was marking of the surface and scuffing in the forefoot region developing after this but this appeared to be a surface effect rather than one of the bulk material. After this the main insole material began to break off mainly in fine particles, but occasionally in larger pieces. At this stage the shock attentuating properties began to deteriorate and at the end of the twelve months much of the bulk of the insole had disintegrated. With Viscolas the pattern of mechanical breakdown was quite different. Whilst the top surface layer of Cambrelle on the insole rapidly showed some signs of wear this did not seem to progress to any significant amount. The main changes took place within the insole with the polyurethane developing transverse splits. Although this damage, again, was seen at quite an early stage, as soon as 2 months in some cases, it did not initially seem to affect the shock attentuating properties of the insole. Up to 9 months the insole was still performing well (80.0 ± 2.2% to 85.3 ± 3.3%) but after this, increased splitting and breakdown of the structure of the insole occurred and the shock attentuation began to suffer, rising to 89.4 ± 3.1%.

Discussion

There is a growing body of evidence of a causative relationship between repetitive impulsive loading and the aetiology and development of some pathologies. Foremost among these is joint degeneration (Radin, et al., 1980; Broom, 1986; Radin, 1987) but many other complaints are also included such as headaches, plantar fasciitis, Achilles tendinitis, osteoarthritis, lower back pain and prosthetic joint loosening (Light et al, 1980; McLellan and Vyvyan, 1981; Voloshin and Wosk, 1982). These points are noted and discussed in the paper by Collins and Whittle (1989) where they make the very valid observation that the visco-elastic components (passive) play only a small part in protecting the body from harmful shock loading. They note, as do others (Pratt, 1989) that active mechanisms play a significant part in the moderation of shock loading and this can be clearly demonstrated. Despite this the augmentation of the shock attentuating mechanisms in the body, both passive and active, by the use of insoles can be of value to certain categories of patients who can be considered to be 'at risk'. Eccentric contraction of muscles to act as controllers of motions used to attentuate shock has been a commonly held belief. However, this view is challenged (Simon et al., 1981; Nigg et al., 1984) and is based upon the view that the reaction time of muscles is too long to actively absorb an appreciable amount of energy, this view being supported by McMahon and Green (1984). It is felt that active shock attentuation by reflex control would be too slow particularly for the early stages of the stance phase. Light et al. (1980) hypothesise that perhaps the muscles are controlled by higher centres and when we are fatigued these controls become less efficient. It is at this stage that artificial shock attentuators would be of value.

The results of this study clearly show that the shock attentuating performance of these insoles can be greatly affected by wear and use. The performance of the insole material depends not only upon the chemistry of the material but also upon mechanical factors such as compression set. Tests by Campbell et al (1984) have shown that Poron (PPT) suffers typically less than 5% set compared with about 70% for Plastazote. It is felt that these results cast in doubt the figures quoted by manufacturers for the performance of their insoles as these all relate to the "as new" behaviour. Some idea of life-time for the material should also be quoted, being based upon some standardised laboratory testing procedures which would be used by all the manufacturers. Until then, small tests such as this, can show the long term performance of these materials and aid prescribers in making the most appropriate material selection for their patients.

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Addresses

Viscolas	Chattanooga UK, Goods Road, Belper, Derby DE5 1UU, UK.
PPT	Langer Biomechanics, Brookhouse Way, 1 The Green, Cheadle, Stoke on Trent, Staffs, UK.
Plastazote	BXL Plastics Ltd, ERP Division, Mitcham Road, Croydon, Surrey CR9 3AL, UK.
Gait Aid	Gait Aid Inc., 4195 Dundas Street West, Suite 303, Toronto, Ontario, M8X 1Y4, Canada.

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