by Patrick Carley, MS, PT

Postal workers respond positively to shoe inserts

Increasing complaints of pain at the feet, knees, and back reflect a desperate need to reduce ground reaction forces while standing and walking. Cushion pads at stationary work stations are an attempt at a solution but do not address a mobile work setting. Employees' complaints of pain and discomfort could be related to the onset or progression of such common pathologies related to the feet, knees, and back as articular cartilage degeneration and osteoarthritis.[1]

As our workforce begins to advance in age, we can presume that they will be more likely to experience these maladies. As a result, the general workforce would certainly benefit from an effective cushion interface to prevent or delay exacerbation of these symptoms.[2]

Choices have been limited to either consumer-variety orthotic devices available at the local drugstore or custom-made orthoses. It was apparent to us that a large gap existed between these choices, one that we hoped to address with alternative orthotic insert possibilities that offered durability and functional support at a reasonable price. Based on this criteria, a search of manufacturers and retail sources revealed that there were no viable choices presently on the market. Past studies have investigated viscoelastic materials with little success in preventing or reducing injuries.[3] The current medical regime presents a complicated view of the natural topology of the foot that leaves one with the sense that only rigid support is appropriate.[4]

Limited mobility or static standing work represent a crucial and timely need for viable shoe inserts that enhance the natural structure of the foot while reducing the ground reaction forces imposed at the workplace. Many employees spend up to eight hours a day on thinly covered or plain concrete work surfaces, with many of those workers having 10 to 30 years of exposure in manufacturing and service industries. Shoe inserts that enhance the natural topology of the foot, with the proper composite of flexible materials, could potentially result in a significant prospective reduction of healthcare costs.

Rearfoot motion control can reduce back and knee pain in workers standing on concrete surfaces.

Method

We conducted a two-part study at a regional bulk mail center (BMC) of the U.S. Post Office. The initial phase was to evaluate a variety of materials, or combination of materials, that currently compose various shoe insert designs. Each was assessed for its appropriate applications and merits in the workplace, based on the responses of workers compared with known principles of kinesiology. The literature offered direction and suggestions for certain properties to consider, but our effort was limited to materials that were pliable and could easily be molded for modifications.[5,6] The initial phase was used to confirm material and design suitability in this setting.

Polyethylene, elastomers, and polyurethane represented the materials tested that generally make up the inserts now on the market. Each of these has a narrow range of characteristics that can be modified for desired results.

Polyethylene compresses easily under body

pain on a body diagram and assign it a Borg Pain Scale rating. The scale rating ranged from zero to 10, with zero meaning no pain and 10 indicating severe pain. A total of 42 participants were issued the study inserts with instructions to wear them at work for a three-month period that extended from the middle of November 1997 to the middle of February 1998. This period included the Thanksgiving and Christmas bulk mailing season, which involves increased volume (catalogs, large packets, boxes, etc.), in addition to increased hours, and the opportunity for overtime work. All of the participants worked in the BMC-East, standing throughout an eight-hour day, and were expected to wear the inserts throughout the three months.

Results

The results of the second phase of the study showed that a total of 30 participants fulfilled the study requirements and wore the inserts for three months. Of the 12 participants dropped from the study, four had been transferred, five no longer worked at the BMC, two forgot to wear them the entire period, and one loaned his pair of inserts to a friend who refused to give them back. Of the 30 remaining participants, 57% (17) wore the 3/4-length design and 43% (13) wore the full-length design, which were randomly assigned at the outset of the study. The group profile revealed an average age of 46.3 years old, with 23% being female and 77% being male. The pain-location profile reflected that 60% had back pain, 9% had knee pain, and 31% had foot pain. It was common for participants to complain of pain in the back or the knees in combination with foot pain, but foot and back pain were undeniably the predominate concerns.

Subjects who wore 3/4-length inserts all reported a positive response with regard to pain reduction.

All participants had experienced pain in the feet, knees, back, or a combination of these locations, as required by the selection criteria, before wearing the inserts. The average participant's complaint of pain was 5.5 as measured by the Borg Scale

After wearing the inserts for a period of three months, however, the average participant reported that pain was significantly reduced to an average Borg Scale rating level of only 1.8, a reduction of 67% in perceived pain at the feet, knees, and/or back. Only 10% of the entire group reported no perceived change in or relief from discomfort during or after work hours over the three month period. Those three participants wore full-length inserts. Subjects who wore the 3/4-length version all reported a positive response with regard to pain reduction, as evidenced by the change in post-study pain scale ratings and additional comments. None of the 3/4-length participants stated that there were any complications of toe cramping or additional heat in the shoes.

Statistical analysis of the pre- and post-study Borg Scale pain reporting data comparisons found them to be statistically different at the 0.01 level using a paired-T statistical testing method. A total of 90% of participants submitted positive comments supporting continued use of the inserts at the work site and into the future. There were no incidents of injuries caused by the study inserts. No participants complained of ankle instability from wearing the inserts. One participant experienced material failure caused by difficulty in properly fitting a full-length insert into a work boot. All other test inserts in the study maintained their material integrity and did not cause any additional injuries or difficulties. The end-of-study follow-up observation of the inserts showed that the topcover and supporting polyurethane material were similar to the first day of issuance with no breakdown in the composite material.

Discussion

The biomechanics of the kinetic chain can be recognized during static standing postures. As the workday proceeds, there is an eventual fatigue of the supporting foot musculature, which encourages a lowering of the medial longitudinal arches of the feet. A valgus position, and resulting eversion of the subtalar joints, is observed in the calcaneus. The valgus bias of the calcaneus precipitates a lateral distortion of the heel's fat pad. The talus and tibia rotate internally as the subtalar joint assumes its new alignment. The medial condyle of the femur, which rests at the posterior aspect of the medial meniscus and medial condyle of the tibia, becomes more internally rotated while maintaining knee extension. The normal resting position of the femur is now more internally oriented, due to internal tibial torsion, and promotes forward trunk flexion.[9-11]

The rearfoot segments of the talocrural and subtalar joints are the main interface between the leg and mobility of the forefoot.[9,10,12] Orthotic insert design must allow for a balanced transition of forces as the orthosis interacts with the opposing ground. Orthoses have been shown to mediate the influences of tibial torsion on foot structure.[13,14] Unchallenged valgus bias at the knee caused by internal tibial torsion tends to result in further internal rotation of the femur. The magnitude of the internal rotation increases for a lateral vector at the knees and a bias for bilateral hip flexion.[6,9,10,15] An additional consequence of internally rotated femurs not only affects the low back pain but also the increased lateral force vectors at the patella. This is observed as increased Q angles and femur orientation. The greater the lateral force vectors acting on the patella, the greater the potential for various patellofemoral pain symptoms.[13,16-17] The ensuing overall postural change can be observed as a lowering of the foot arches; further internal rotation of the tibia; increased Q angles; further internal rotation of the hips, causing slight flexion of the trunk; and an anterior bias of the body's center of mass. This describes the sequence of the body's kinetic chain in relation to ground reaction forces typically noted during extended standing static postures.[1]

Workplace static postures can have a profound influence on symptomatic pain that may potentially manifest as the onset or exac-

weight over a relatively short amount of time (two to three weeks). As the material collapsed, it provided little sustained motion control to the structures of the foot. The gel-like material of elastomers were good at mitigating shear forces. The extent of the ground-reaction force equals the change in momentum at heel strike.

Elastomers absorb the mass and velocity forces of the heel strike by their ability to deform the material interface. As the heel and midfoot leave the ground, the elastomers dissipate energy as heat and regain their original shape. However, this gel-like material had difficulty controlling the motion of the foot effectively and tended to be too heavy in the shoe, given the thicknesses (2 to 3 mm) needed for this particular design.

We found polyurethane defined with less than a 2% compression set to be the best choice for durability, wear needs, and cushioning characteristics for this insert design. It represented a resilient, nondeformable material that would augment the support and motion control desired, while not being restrictive or corrective. The flexibility of the polyurethane materials worked equally well with shoes, sneakers, and work boots. The thickness and location of the polyurethane material achieved the motion control and cushioning needed to be effective for long periods of standing.

Another consideration was to safely address the general population by matching each participant with his or her correct size. Most inserts available require some cutting or trimming of the material before placing the insert into the shoe. This represents a potential for poor fittings and material folds that cause pressure-related problems for the feet. Our approach required the design of the inserts to be size-specific and approximate the ranges in available shoe sizes.

The basic paradigm of the insert was predicated on a reciprocal profile of the topology of the foot, given the size varieties of the general population. The design called for an extensive modeling process so that the support proportions of the heel and arch could be maintained within half a shoe size. In that way, the inserts could be safely and easily dispensed by medical personnel or safety departments without the need for time-consuming adjustments.

The design demonstrated the ability to enhance the normal shock absorbing characteristics of the foot while reinforcing the natural structure of the foot as it interacts with the ground below and the torsion forces of the tibia and femur above. The shoe inserts were made in two basic formats, a full-length and a 3/4-length version. They were individually sized with heel and arch dimensions appropriate to each specific size.

TABLE 1. BREAKDOWN OF PAIN DATA BY PATIENT

AGE	C/O PAIN	PRESTUDY PAIN*	POSTSTUDY PAIN*	CHANGE	INSERT
51	Knee	7	0	-7	3/4
34	Back	8	2	-6	3/4
41	B/K	8	4	-4	3/4
37	Back	8	2	-6	3/4
48	B/k	7	2	-5	Full
37	Back	5	2	-3	Full
48	Back	6	3	-3	Full
39	B/k	2	2	0	Full
47	Feet	4	1	-3	3/4
49	B/f	5	1	-4	3/4
55	K/f	8	2	-6	3/4
53	B/k/f	7	1	-6	3/4
63	Feet	5	1	-4	Full
50	B/k	8	2	-6	3/4
57	B/K	6	5	-1	Full
39	Back	5	4	-1	Full
51	Back	4	4	0	Full
35	Feet	3	2	-1	3/4
40	Back	6	1	-5	3/4
41	Feet	6	0	-6	3/4
46	Feet	6	0	-6	3/4
46	Feet	3	1	-2	3/4
50	B/k/f	7	3	-4	Full
52	Feet	4	1	-3	3/4
35	Feet	6	1	-5	Full
55	Back	6	1	-5	Full
54	B/k/f	5	1	-4	Full
35	Back	4	1	-3	3/4
52	Feet	3	3	0	Full
50	Knee	4	1	-3	3/4
46.3	Mean	5.5	1.8**	-3.7**	
7.7	Std. Dev.	1.7	1.3	2.0	

*rated using the Borg Pain Scale
**Statistically significant at the 0.01 level

Second phase

The second phase investigated the mitigating effects of the newly designed inserts throughout the kinetic chain by monitoring changes in the symptomatic responses of the postal workers.

This phase involved subject selection from the pool of postal workers at the BMC. The criteria required that workers spend more than 50% of their workday standing on thinly covered or plain concrete surfaces. The selected subjects must have chronic complaints of pain at the feet, knees, or back not currently being treated by a physician. Participants were asked to fill out a pain questionnaire to assess the peaks of pain; time of day; incidents per week; seasonal variations; and location of pain. They had to draw the location of their

erbation of pathology. Sustained forward trunk bending requires back muscles to counterbalance the shift in the body's center of mass. The effective force of those muscle contractions will increase disk pressures, especially in the lumbar disks. The inadvertent loss of normal lumbar lordosis will orient those increased forces toward the posterior aspect of the disk structures. A common complaint of those postal workers with back pain was a constant discomfort localized equally on both sides of the low back area. They also described their pain as a discomfort that progressively worsened toward the end of the workday. Some of the postal workers were diagnosed with degenerative disk disease. There were no participants at the time of the study with a recent diagnosis of disk herniations.

The common complaint noted in the feet was described as pain toward the medial aspect of the calcaneus that would extend periodically to the midfoot area. This became progressively worse through the workday. Workers perceived the unyielding hardness of the concrete work surface as the main origin of their foot discomfort. Cushioning or rubberized floor mats were a high priority in some areas but limitations on their use existed in others.

Knee pain was typically described as anteromedial knee pain associated with patella mobility. One participant did have existing pain at the medial joint line just prior to the study that was later diagnosed as a torn medial meniscus. This individual noticed that the inserts helped alleviate a significant amount of discomfort for the first six to eight weeks of the study.

The combination of materials and design characteristics permitted this insert to perform as both an effective shock attenuator and a cushioning device. The inserts fulfilled their more important purpose of providing motion control and support to the structures of the foot. In addition, the inserts demonstrated a positive influence on lower extremity biomechanics.

This implication of overall improvement throughout the kinetic chain was observed in a common response of the postal workers: They felt as though they were standing up straighter throughout the workday. The application of this motion-control insert as an interface between the ground and the worker was noted early in the study and continued throughout the three-month study period.

The literature describes the beneficial use of shoe inserts in reducing terminal shock.[5-8] The shock-attenuating characteristics of inserts have also been shown to functionally improve back pain. However, there are many designs and products on the market that claim to have the same results but lack the biomechanical components needed to effectively support the foot structure and influence the kinetic chain. The positive response of the workers in this study necessitates a discussion to consider properly designed shoe inserts as personal protection equipment. The data from this study suggest that inserts could be in the same classification with such injury-preventive devices as gloves or back belts.

The 3/4-length inserts tested in the study appear to have a broader application while providing the greatest reduction in pain symptoms. The participants who wore this type did not complain of toe cramping, additional heat within the shoe, or any fitting problems.

The ease of wearing and the absence of any associated fitting difficulties would certainly support the general application of the 3/4-length insert for consideration as a personal protective device for the workplace. Additionally, the manufacturer stated that the cost associated with the 3/4 length would be less than that for the full-length version due to reduced material expenses.

Conclusion

Shoe inserts can be a cost-effective injury-preventive strategy for employers and can have a meaningful impact on employees by reducing pain symptoms of the feet, knees, and back. This study demonstrated that properly designed inserts can reduce the degree of perceived pain in those areas mentioned. An extension of that approach could help prevent or delay exacerbation of those conditions associated with the areas of discomfort noted in the study. Although prevention receives less attention than it deserves, the inevitable aging of the workforce will command more attention in the future because of higher worker compensation, lost workdays, and elevated healthcare costs. Realistic and cost-effective measures will offer management purposeful solutions for employees in meeting their short- and long-term needs. The use of properly designed 3/4-length shoe inserts should be one of the first considerations for employees required to stand for extended periods in the workplace.

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Atlantic Footcare (a division of ATP Manufacturing, LLC, North Smithfield, RI) assisted in this project by supplying materials, modified shoe inserts, and engineering support in the final adjustments necessary for the new insert designs.

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