Orthopaedic Shoes for Bilateral Partial Foot Amputations[1]

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MOST physicians and competent orthotists recommend the use of orthopaedic shoes in cases requiring shoe modifications or braces. However, in practice, the term "orthopaedic" is loosely applied to a variety of shoes of widely different cost, construction, function, durability, and appearance. Orthopaedic shoes are distinguished from stock or nonorthopaedic shoes by a steel shank, a long, high, reinforced counter and internal corrections; prescribed modifications are incorporated as elements of the shoe construction rather than added externally. These are clear differences, and the superiority of orthopaedic shoes is generally recognized.

Although related, there are two vastly different types of shoes labeled "orthopaedic." One is the kind of shoe described above, which is usually referred to as the *custom* orthopaedic shoe; the other is the *stock* orthopaedic shoe. The latter usually contains a steel shank, and in certain instances it also includes a long medial counter and Thomas heel. At this point, however, the similarity to custom orthopaedic shoes ends. Additional corrections which are prescribed must be added externally. They do not include the reinforcement required to prevent "breaking" of the sole at undesirable points and to prevent lateral bulging of the uppers.

Despite these disadvantages, stock orthopaedic shoes are frequently prescribed or selected by patients. Cost is probably a significant if not decisive factor since typical costs for stock orthopaedic shoes average half or less than half the cost of custom orthopaedic shoes. On analysis, however, cost differences tend to narrow, as the useful life of custom orthopaedic shoes is longer. In our opinion, the functional and cosmetic advantages of custom orthopaedic shoes far outweigh the cost differential.

Apart from considerations of cost, stock orthopaedic shoes may be selected because the appearance to the untutored eye of a new pair seems adequate, and because the patient may seem initially to walk in much the same manner when wearing equally new custom orthopaedic and stock orthopaedic shoes. Not immediately apparent are the quick deterioration and shorter life of the stock orthopaedic shoe and the functional value of the custom orthopaedic shoe. Because of adaptive measures employed by the patient to overcome deficiencies in the stock shoe and to present a normal appearing gait, the external appearance of the gait pattern with the custom shoe may not always be superior. Adjustments made by the patient to adapt himself to the shoes are revealed in the interaction of forces between the foot and the ground during the stance phase of walking. It is primarily to these forces that the wearer of custom shoes reacts when expressing a preference for the function of one shoe over another, even though improvements by a reduction in gait deviations may go undetected during visual observation.

A recent experience illustrates these points. A young man with congenital deformities of the feet, for whom orthopaedic shoes had been prescribed, was tested in our laboratory. (He also had congenital deformities of the hands.)

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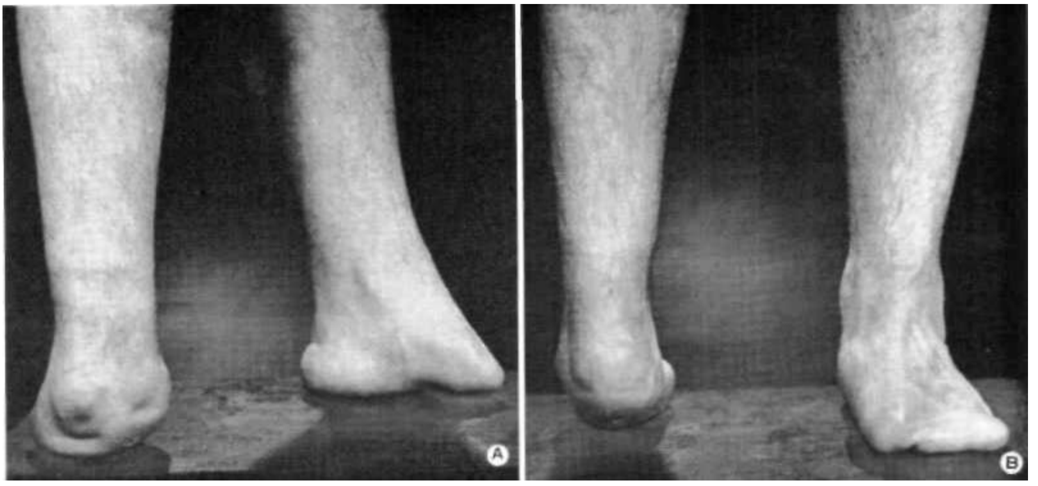


Fig. 1. Congenital bilateral amputations with absence of tarsals in the right foot and presence of tarsals in the left. *A,* Lateral view; *B,* frontal view.

Fig. 2. Stock shoes showing deformation after 12 months' wear. *A, B,* Externally added heel and sole extensions can be seen.

He was considered an excellent subject for this type of analysis because of the remarkable adaptations he had made to his deformities. Despite their severity, he was an extremely adept walker with a nearly normal gait whether he wore shoes or not. We believed that his high adaptability would tend to mask, to an unusual extent, any gross differences in his gait and that, therefore, detectable differences could be attributed to the function offered by the shoe.

THE SUBJECT

The subject for this study was a 19-year-old congenital amputee with partial hands and feet (Fig. 1). At the initial examination he was wearing previously prescribed stock orthopaedic shoes with steel shanks as the only special feature. Added externally were sole and heel extensions (Fig. 2). After approximately 12 months of wear a severe break in the tarsal region of the right shoe and another, though

Fig. 3. Stock shoes showing: *A*, break in tarsal region; *B*, uncosmetic external corrections; C, protruding short steel shank and a wear pattern indicative of lack of support in the metatarsal and toe areas.

less severe, of the left shoe were exhibited. The lateral walls of both shoes bulged excessively, resulting in permanent deformation and reduction of support. The short steel shank protruded through the sole at a point corresponding to the break, and the wear of the soles revealed a pattern of little or no support anterior to the shank which terminated at a point corresponding to the tarsometatarsal joint line (Fig. 3).

He was fitted at a commercial establishment with a prescription for custom orthopaedic shoes recommended by the Veterans Administration Prosthetics Center (Fig. 4). These shoes were specially reinforced with long, flat steel springs and steel shanks installed between inner and outer soles to increase the resistance to dorsiflexion after mid-stance and to shift the "toe break" further forward. They also featured stiff, high, long counters and a wider heel base with a reversed Thomas heel on the right shoe to increase lateral support. An inside cork extension was prescribed to accommodate leg shortening. After four months of use the wear pattern of the soles indicated that the patient was receiving support; that is, resistance to dorsiflexion or "shoe break" extended all the way out to the toe (Fig. *4B).*

PROCEDURES

To record the gait performance of the patient as completely as possible, several methods were employed. Thirty-five mm. motion pictures were taken in both the anteroposterior and the mediolateral planes as the patient walked with his old shoes and with his new shoes. Similarly, cyclographic recordings were made of angular and linear displacements at the hip, knee, and ankle. Force plates were used to record the ground reaction forces during stance phase. Finally the patient's opinions were recorded.

RESULTS

A motion-picture analysis showed that the subject walked very well with both stock and custom orthopaedic shoes. He was able to make small but significant compensations in his body alignment and in the timing of his movements with the result that the total body

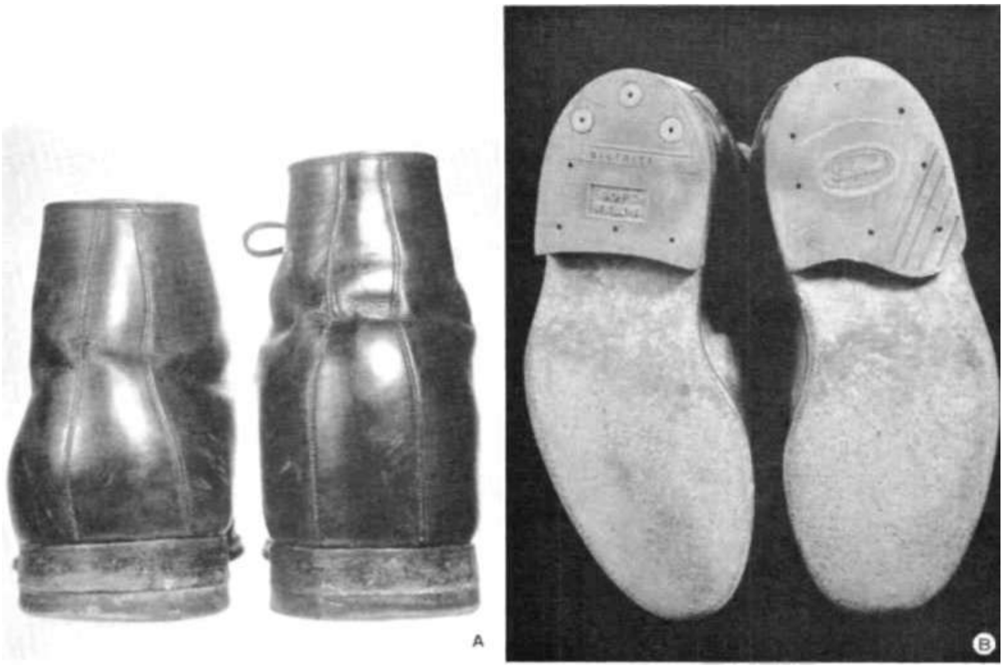


Fig. 4. Custom shoes after four months' wear showing: *A,* cosmetic advantage; *B,* **reversed Thomas** heel and an even wear pattern indicative of support provided over entire surface.

center of gravity maintained a smooth translatory path.

In general, the more detailed cyclographic recordings clearly demonstrated a remarkable ability on the part of the patient to maintain a reasonably normal gait pattern despite differences in functional losses between right and left leg and substantial differences in the height and functional character of the shoes.

As shown in Figures 5 and 6, displacement patterns—that is, the motions of the hip, knee, and ankle in space—were essentially similar with both stock and custom shoes. The consistently higher elevation of each of the major joints with the custom shoe was due simply to differences in the elevation of the shoes.

Although knee-flexion patterns with custom and stock orthopaedic shoes were generally similar, flexion of the left knee during the early stance phase was reduced substantially with the custom shoes (Fig. 7). This was attributed to the increased support provided by the custom shoes in the tarsometatarsal region with a consequent reduction of the "drop off" on the right leg during late stance. As a result of the excessive "drop off" due to the "break" of the stock orthopaedic shoes, the hip remained at a lower elevation than it would otherwise have attained. The lower hip elevation necessitated additional compensatory flexion of the left knee by the patient in order to walk in a reasonably symmetrical manner. Reducing the "drop off" maintained the hip at a higher elevation and made this additional knee flexion unnecessary.

A computation of the actual forces applied to the ground was made by resolving both vertical and horizontal force components. Indicated in the following tabulation are the peak forces applied to the ground during the period of heel contact to foot flat and between the instant of heel off and push off in two trial runs with the stock shoes and in two trial runs with the custom shoes.

Axial load (lb.) in two typical trials

		Heel Contact to Foot Flat		Heel Off to Push Off		Differences	
	Trial	Right	Left	Right	Left	Right	Left
Stock shoes	1	225	263	185	192	40	71
	2	219	252	184	192	35	60
Custom	1	211	258	195	192	16	66
shoes	2	212	251	188	193	24	58

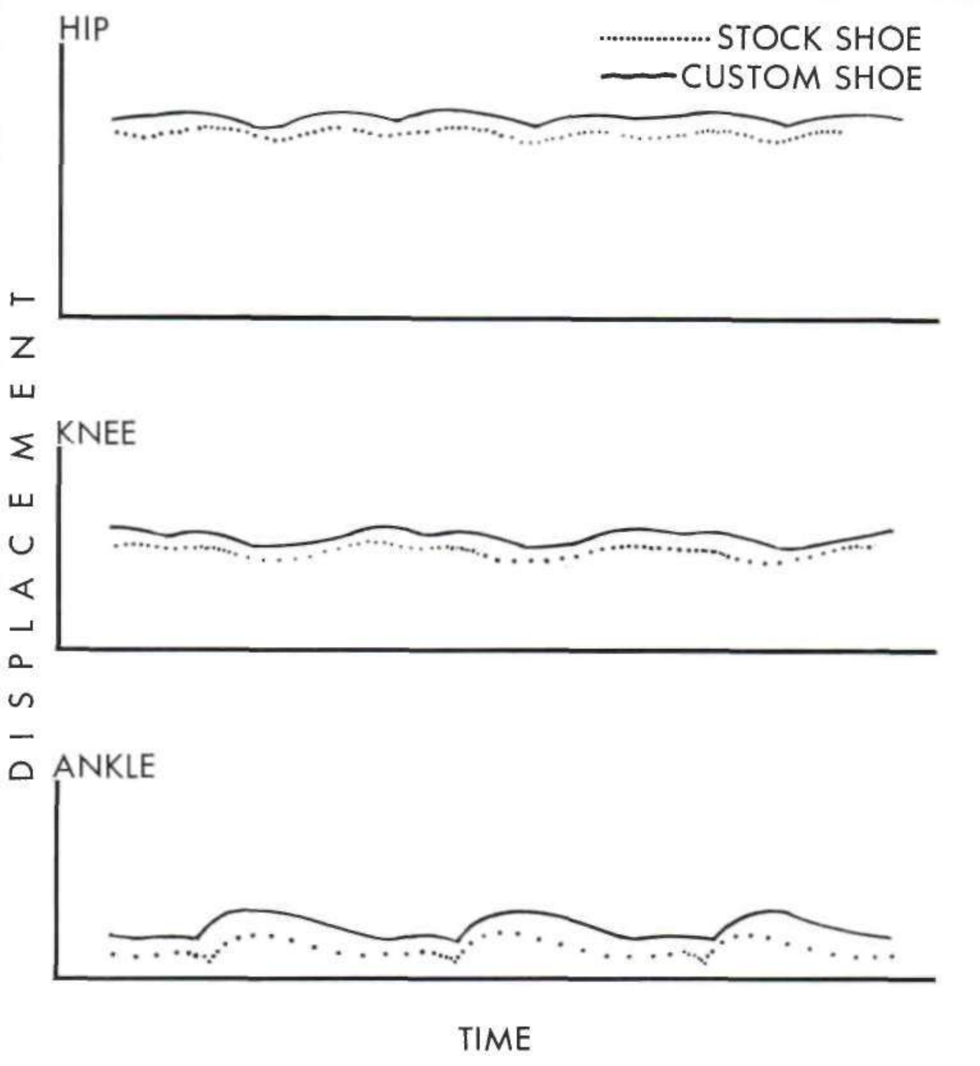


Fig. 5. Horizontal displacement of targeted points on the subject's right lower extremity during ambulation,

As the patient weighed 196 lb., it may be seen that the differences between the first and second peaks were substantially lowered on the right foot and somewhat less diminished on the left foot when the custom shoes were worn, demonstrating a more nearly equal application of forces to the ground. These differences were due primarily to his ability to maintain higher fractions of his body weight on the supporting foot after heel off.

Figure 8 graphically illustrates, for comparative purposes, the average peak magnitudes of the axial load during heel contact to foot flat, and during heel off to push off. The most significant effect on gait of the custom shoes was to diminish the magnitude of the force with which the heel was initially applied to the ground and to increase the force applied to the ground during the portion of stance corresponding to the period between heel off and push off. Although the absolute values of these changes are small, they had highly significant

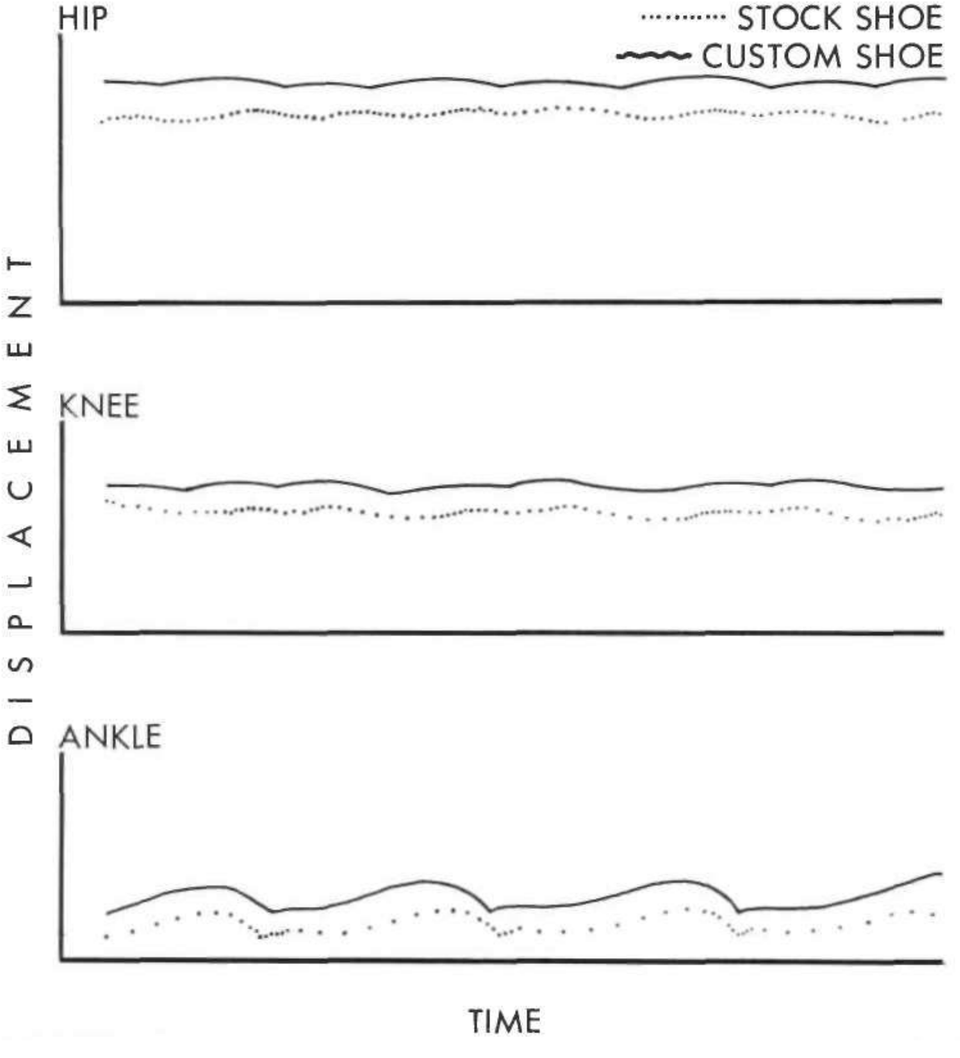


Fig. 6. Horizontal displacement of targeted points on the subject's left lower extremity during ambulation.

effects in reducing the patient's adaptive efforts and in reducing shoe wear. As might be expected in the complete absence of plantarflexion in the right foot, the effects were greater on the right side.

SUBJECT'S OPINION

The subject stated unequivocally that the custom orthopaedic shoes were far superior to the stock shoes that he had previously worn. They were more comfortable, they provided better support, and the inside buildup was more cosmetically desirable. The subject wore the custom shoes home and refused to take the stock shoes with him, discarding them on the spot.

SUMMARY

There is very little question in our minds of the superiority of custom orthopaedic shoes over stock orthopaedic shoes. Even in the case

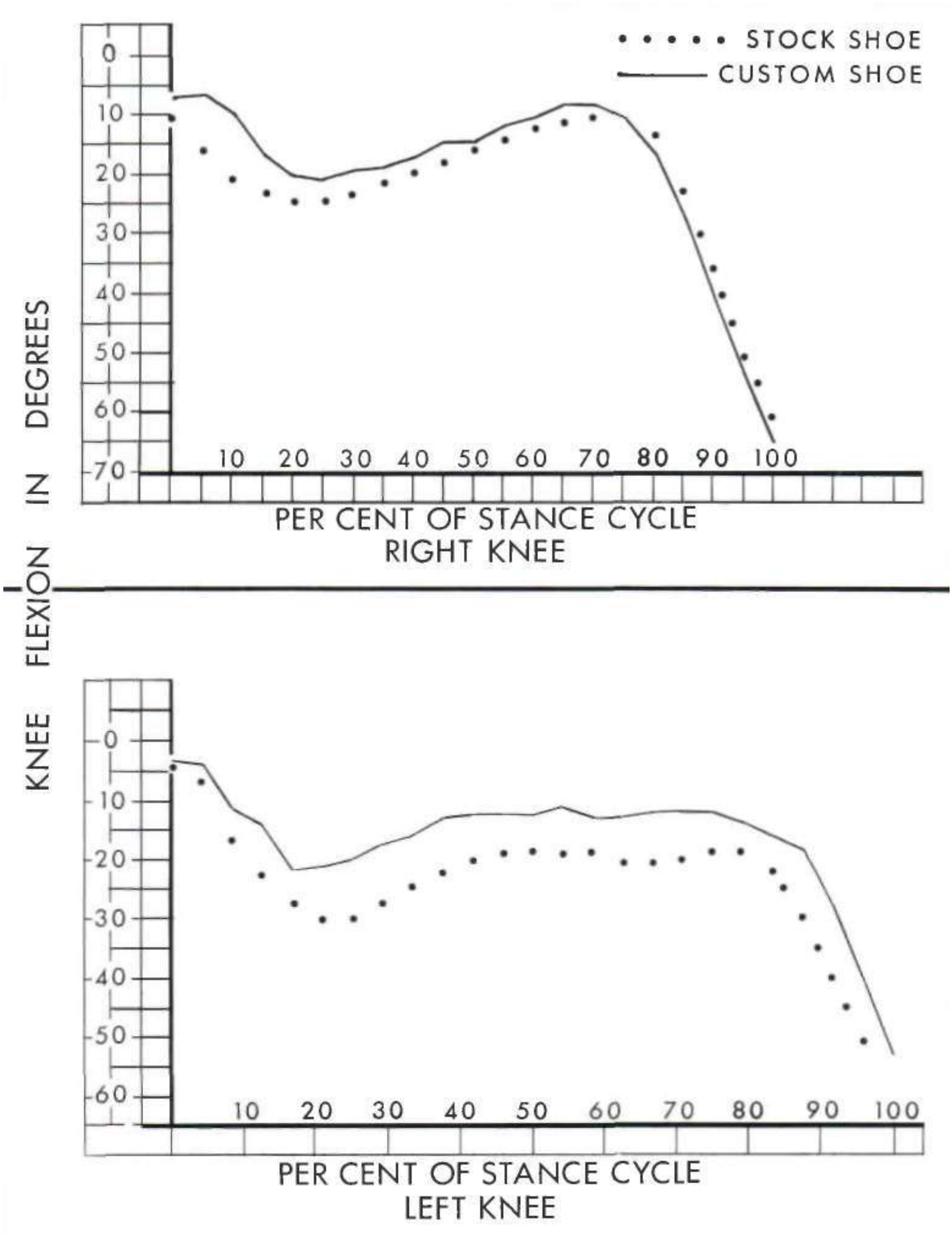
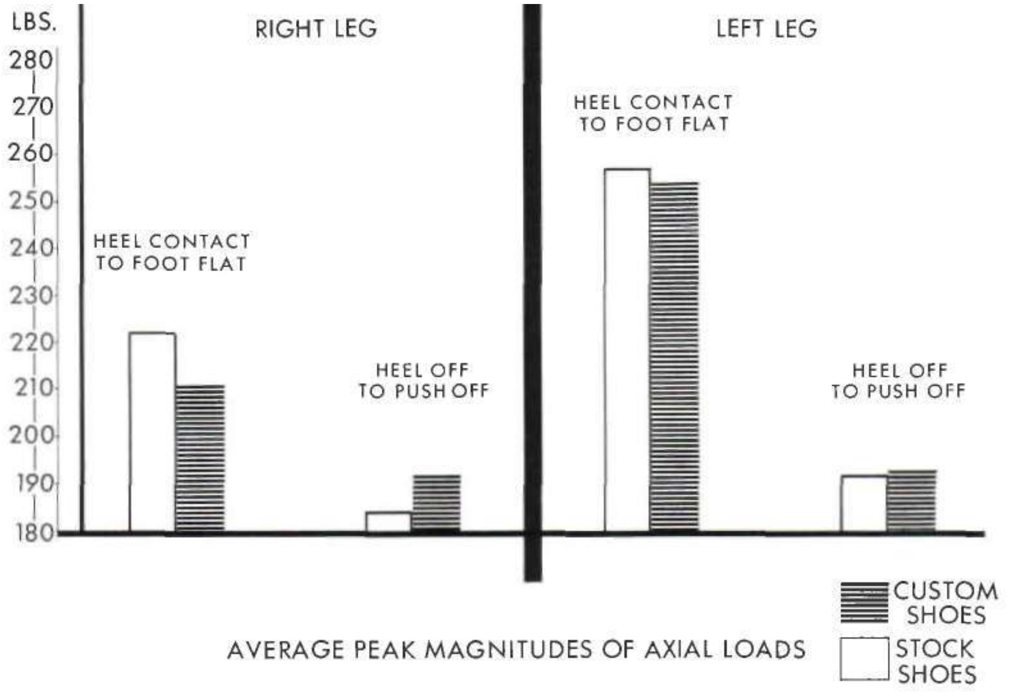


Fig. 7.

described in this article when, at first glance, the need might be considered minimal, clear advantages were provided. On this functional basis alone preference should go to custom orthopaedic shoes. Further study of the life expectancy of custom and stock orthopaedic shoes should serve to clarify objectively where real economy in this matter lies.


LBS.
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270
260
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RIGHT LEG
LEFT LEG
HEEL CONTACT TO FOOT FLAT
HEEL OFF TO PUSH OFF
HEEL CONTACT TO FOOT FLAT
HEEL OFF TO PUSH OFF
AVERAGE PEAK MAGNITUDES OF AXIAL LOADS
CUSTOM SHOES
STOCK SHOES

Fig. 8.