EFFECTS OF PLANTAR ORTHOSIS ON DYNAMIC PLANTAR PRESSURE MEASUREMENTS IN RUNNERS

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INTRODUCTION

During the past years the use of custom-made plantar orthosis has been sharply increased among athletes. Concurrently, a great effort has been dedicated by orthotic designers and manufactures to improve the quality of their products. Only recently, however, systems that allow dynamic plantar pressure measurements within shoes have became available. Data and information provided by these devices can potentially reveal information about both the structure and the function of the foot and may also be used to evaluate the effectiveness of specifically designed plantar orthosis on plantar foot pressure.

By analyzing the pressure distribution in different plantar areas and the center of force path as well, the aim of this work was to examine the efficacy of specific custom-made orthosis in athletes wearing their own running shoes.

METHODOLOGY

Subjects of the study were 11 male long distance runners (age: 25.3 ± 5.2 yr, body mass: 62.5 ± 4.2 Kg) selected among a population of competitive athletes wearing plantar orthosis. Each subject performed two separate running trials at a 12 km/h on a motorized treadmill: one trial wearing his own custom-orthosis in the shoes, end one trial without. In the two experimental conditions, data for at least six strides for each foot were collected.

The Fscan in-shoe pressure measurement system was used to measure plantar pressure during all trials. The system uses an ultra-thin flexible and trimrnable sensor with 960 sensing locations distributed evenly across the entire plantar surface. These foot sensors can be customized to the individual needs and sizing of each subject.

The FSCAN software was used to evaluate peak average pressure in five areas of interest (Fig. 1): medial heel (MH), lateral heel (LH), medial arch (MA), medial metatarsal region (MM) (first and second metatarsals), lateral metatarsal region (LM) (third, fourth and fifth metatarsals).

The orthosis had been made by different laboratories using the following casting methods:

- Full-weight-bearing polystyrene foam step-in (**M1**);
- Neutral position, full-weight-bearing polystyrene foam step-in (**M2**) (Fig. 2);
- Neutral position, semi-weight-bearing polystyrene foam step-in (**M3**).

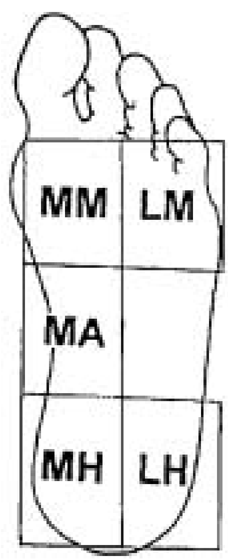

Figure 1. Areas inside of which peak average pressure were measured

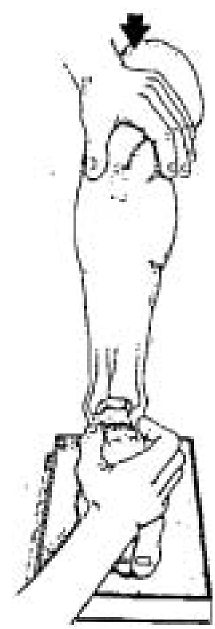

Figure 2. The neutral position semiweight-bearing impression technique

RESULTS AND DISCUSSION

To identify the actual modification of the orthosis on plantar pressure distribution in each subjects, it has been necessary to define the measurement precision of the examined variables. This to avoid that possible systematic test or measuring bias due to the insole sensor measurement and the removal and reinsertion of the insole sensor between measurements could influence the results.

In Table 1 the interclass correlation coefficient (ICC) of two preliminary tests (between the two tests the insole sensor was removed and replaced into the subject shoes) and the coefficient of error (CE) of the plantar pressure in different areas defined in Fig. 1 are presented.

Table I

	MH	LH	MA	MM	LM
ICC	0.86	0.88	0.78	0.61	0.70
CE (%)	7.9	8.5	11	12.5	13.8

Examining individual plantar pressure distribution (Table 2), although in three subjects (S6, S8, S11) the effect of orthosis was not significant in each of the areas considered, significant changes have been found in most of the subjects between the two experimental conditions. However, in three cases (S4, S5, S9), although inserts are thought to redistribute and decrease local plantar pressures

Table 2. Effect of the orthosis on peak plantar pressure in the plantar areas defined in Fig. 1. Only the significant percentage differences are indicated

	MH	LH	MA	MM	LM	Casting Method
S1			11.7			M1
S2	9.8	-10.4		-15.9		M2
S3					-16.8	M3
S4			16.1	18.1	12.5	M1
S5				20.4		M2
S6						M3
S7	12.6	-9.5		-13.1	-14.5	M2
S8						M3
S9				14.8	19.4	M2
S10	-8.1	12.8	17.8			M1
S11						M3

beneath the foot, the orthosis increased significantly pressure in particular areas of the metatarsal region. Furthermore, in three subjects (S1, S4, S10) a dramatic pressure increase has been found in the lateral portion of the midfoot suggesting an overcorrection of the medial arch support. An oversized medial arch might be extremely destructive as it inverts the entire foot and may lead to a variety of injuries. This finding appears to be linked to the casting method (full-weight-bearing cast, M1) used to capture the picture of the foot. Laboratories that insist on this technique typically base their evaluation on static function, with support of the medial arch the primary goal of the treatment. This approach is outdated and inappropriate, as it allows for effective control of the foot only during midstance: the arch support is non-functional during the contact and propulsive periods, as the arch does not firmly contact the foot during these periods.

The pressure maps presented in Fig. 3 describe a case in which the orthosis may be considered effective. The integrate peak pressure 3-D pictures help to illustrate the redistribution of the load into the midfoot area caused by the orthosis which brings the midfoot into contact and leads to a larger support area. This both reduces the average pressure and tends to shift the load off the frequently problematic areas under the metatarsal heads and the heel.

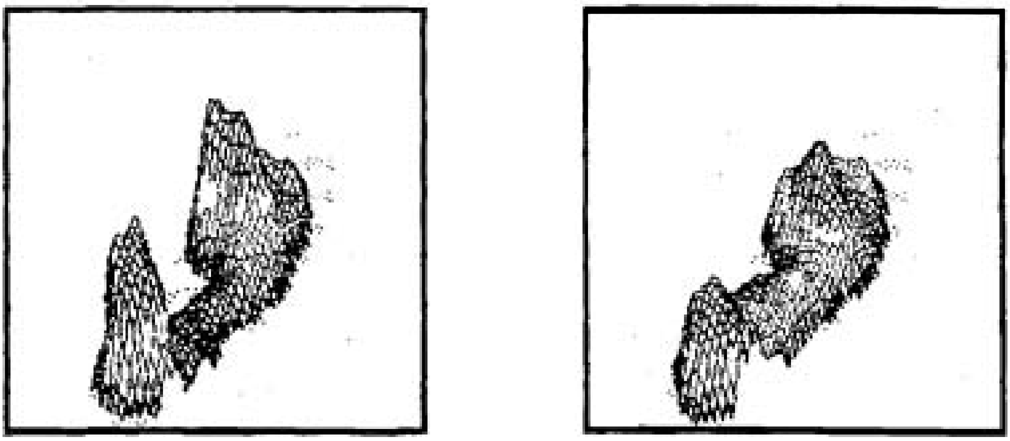

Figure 3. Pressure maps for a subject wearing his running shoes without (left) and. with (right) his custom-made orthosis

CONCLUSIONS

Despite certain limitations of the system, it appears that in a well-controlled experimental setting the FSCAN system is reliable in measuring plantar foot pressures in running and in providing accurate quantitative measurements.

According to previous studies the results of trials with and without orthosis showed a sensitivity to this change in condition. While in some cases the influence of the orthosis on redistributing plantar pressure appeared to be effective, in some subjects the orthosis increased dramatically the pressure in the medial portion of the midfoot and in the metatarsal region. These modifications appear to be somewhat related to the casting methods used to capture the picture of the foot.