

Unroll of the foot during running: the relationship between local plantar pressures, ground reaction forces and foot motion.

1.1 Objective:

In this study the footscan® system was used to quantify local plantar pressures, during unroll of the foot, in barefoot condition. The system combines a very high measuring frequency (>300Hz) with a high spatial resolution (each sensor 0.5 mm x 0.7 mm). It is especially because of these two specifications that the system is suitable for running survey.

How can we interpret the measured local plantar pressures, during unroll of the foot, in a biomechanical way? We stipulated a medial/lateral ratio towards the measured local plantar pressures, and correlated this ratio with the eversion/inversion and pronation/supination movement of the foot in the frontal plane.

1.2 Methods:

On an artificial running track of 20 meters, 8 persons were tested, running approximately 4.5 m/s ($\pm 5\%$). For every person, five valid attempts were processed. For every valid attempt, the ground reaction forces (*Kistler*®, 1200Hz) were measured, the development- during unroll of the foot- from the local plantar pressure were measured (*footscan*®, 300Hz) and the foot/ankle kinematics in the frontal plane were quantified (*NAC high speed camera*, 200 Hz).

For the kinematical analysis, the persons were marked with two points on the dorsal part of the calcaneus and two points on the dorsal part of the lower leg (Edington, 1997). Connecting the points from the calcaneus with a line, and connecting the points on the lower leg with a line gives the angle between the calcaneus and the lower leg towards pronation-supination (beta-angle, β). Comparing the line from the calcaneus with the ground gives the angle of eversion-inversion (gamma-angle, γ).

The following correlations were made towards biomechanical interpretation of the development of the local plantar pressures under the foot:

$$\begin{aligned} [\text{maximal pressure-ratio}] &\sim [\Delta \text{ eversion of the foot after impact}] \\ [\Delta \text{ pressure-ratio}] &\sim [\Delta \text{ eversion of the foot after impact}] \end{aligned}$$

One of the main difficulties was to develop a pressure ratio representing in a proper way the pressure difference between medial/lateral. To do this, we used the pressure pattern under some specific anatomical pressure spots.

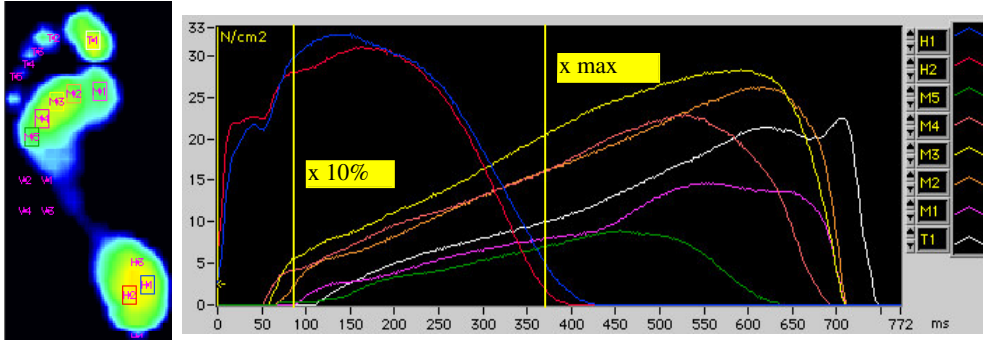


figure 1 : pressure spots used under the foot, two parts under the heel (lateral and medial), five under the five metatarsal heads, one under the big toe.

To calculate the medial/lateral pressure ratio we used these pressure spots:

Medial:

- H1: medial spot under the heel
- M1: spot under metatarsal 1
- M2: spot under metatarsal 2
- T1: spot under the big toe

Lateral:

- H2: lateral spot under the heel
- M4: spot under metatarsal 4
- M5: spot under metatarsal 5

With the ratio $\frac{H1+M1+M2+T1}{H2+M4+M5}$ with $x = \text{ratio} * 1000$

With 'x' =

pressures) $x < 1000 \Rightarrow \sum(\text{lateral local pressures}) > \sum(\text{medial local$

pressures) $x = 1000 \Rightarrow \sum(\text{lateral local pressures}) = \sum(\text{medial local$

pressures) $x > 1000 \Rightarrow \sum(\text{lateral local pressures}) < \sum(\text{medial local$

We calculate this 'x' at 10% of total stance time and we calculate a maximal 'x'. This maximal 'x' is calculated at the point in time where pressure difference between H1 and H2 is maximal.

The idea is to correlate this 'x'-value with the amount of eversion/inversion, pronation/supination from the same attempts.

1.3 Results:

	footscan®		kinematics	correlation	p-value
	Mean ± SD		Mean ± SD		
Med/lat max	2108.58± 964.92	ypro-y0	-9.81±4.30	R = .658	p= .001
Med/lat range	1130± 973.84	ypro-y0	-9.81±4.30	R = .629	p= .000
Med/lat range	1130± 973.84	ypro-y10	-6.09±2.53	R = .528	p= .000
Med/lat max	2108.58± 964.92	bpro-b0	-12.71±4.90	R = .599	p= .000
Med/lat range	1130± 973.84	bpro-b0	-12.71±4.90	R = .513	p= .000

Table 1: correlation between med/lat ratio and kinematics

1.4 Discussion:

It seems possible – after comparing local plantar pressure distribution and kinematics – to predict the footmotion in the frontal plane, during the first part of the stance fase with the ground (table 2). A very important aspect is to stipulate an eversion/inversion axis projected on the transversal plane of the foot. In this investigation this axis was defined having a direction from the medial part of the heel through metatarsal three. If it would be possible to define the bissectrice of the foot in the footscan® software, then better results might be achieved.

The calculation of the bissectrice in the foot is implemented and done automatically in the footscan software now. Results from the new study will be published soon and seem to be very promising.