

# DETERMINATION OF PRONATION PARAMETERS BY MIDSOLE DEFORMATION IS INDEPENDENT OF RUNNING VELOCITY

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## INTRODUCTION

Since rearfoot motion is discussed to be related to overuse injuries in running its analysis has become mandatory in running studies. Various direct (motion analysis systems) and indirect (electrogoniometers) measurement devices have been used to determine rearfoot motion parameters. Recently, two innovative indirect systems have been developed based on the findings of Hennig & Milani (2000). They found a load shift in the rearfoot area from lateral to medial during early ground contact. This load shift can be identified by usage of discrete pressure sensors under the heel (Brauner et al., 2008) or by measuring local midsole deformations by use of Hall sensors (Milani et al., 2008). Both strategies require the calculation of an algorithm to determine maximum pronation and pronation velocity. However, rearfoot motion (Nigg, 1987), impact forces, and pressure distribution (Hennig & Milani, 2000) depend on running velocity. Usage of pressure distribution to determine rearfoot motion has been shown to be reasonable independent of running velocity (Brauner et al., 2008). The goal of this study is to analyze the effect of different running velocities on rearfoot motion calculation from local midsole deformations.

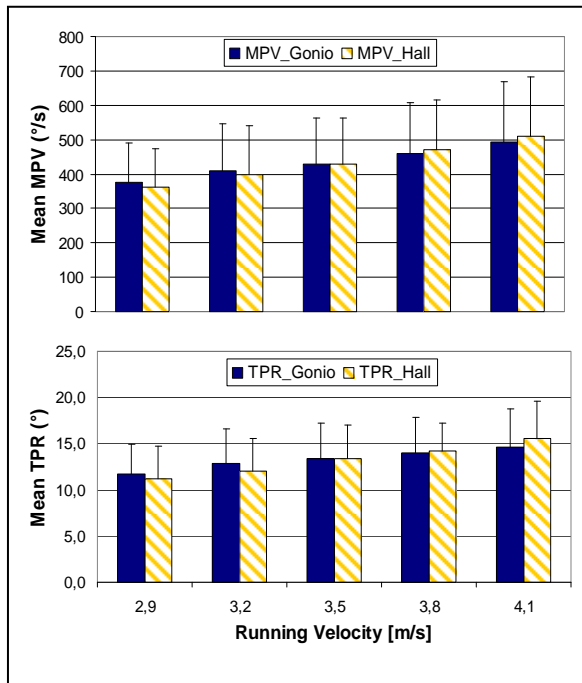
## METHODS AND PROCEDURES

13 male (25.0yrs  $\pm$ 2.8, 71.5kg  $\pm$ 7.8) runners took part in the testing. All subjects were familiar with the laboratory testing conditions and categorized as heel-toe

runners. Running velocity conditions were 2.9, 3.2, 3.5, 3.8, and 4.1m/s ( $\pm$ 0.1). Speeds were controlled by three photoelectric barriers and executed in randomized order. Subjects performed five repetitive trials for each velocity condition on a runway across an integrated KISTLER force plate (9287BA). All subjects used an EVA test shoe with 10 Hall sensors placed within the EVA midsole around the heel cup (Milani et al., 2008). Deformation data were collected and post processed according to Milani et al. (2008). As additional reference an electrogoniometer was used to measure pronation ( $TPR_{Gonio}$ ) and maximum pronation velocity ( $MPV_{Gonio}$ ) (Milani & Hennig, 1995). To calculate pronation ( $TPR_{Hall}$ ) and maximum pronation velocity ( $MPV_{Hall}$ ) the necessary algorithms were determined for the running velocity of 3.5m/s and then applied to the deformation data of the other velocity conditions. For statistical validation of the algorithms, Pearson's correlation coefficients were calculated by correlating goniometer pronation values with the pronation values determined by the Hall sensors.

## RESULTS

In accordance to the literature,  $TPR_{Gonio}$ ,  $MPV_{Gonio}$ , impact force, and tibial acceleration increased highly significantly with increased running velocity ( $p < 0.001$ ).  $TPR_{Hall}$  and  $MPV_{Hall}$  data showed similar patterns (Figure 1).



**Figure 1: Velocity dependency of TPR and MPV determined by goniometer and Hall sensors (n=13)**

Correlation coefficients calculated by comparing goniometer and Hall sensor data at different running velocities confirm this observation (Table 1).

Parameter	Velocity Ranges (m/s)			
	2.9 ( $\pm 0.1$ )	3.2 ( $\pm 0.1$ )	3.8 ( $\pm 0.1$ )	4.1 ( $\pm 0.1$ )
MPV	0.857	0.861	0.825	0.794
TPR	0.820	0.846	0.793	0.666

**Table 1: Coefficient of correlation of rearfoot motion determined by goniometer and Hall sensors (n=13)**

## DISCUSSION

The algorithms to calculate TPR and MPV using local midsole deformations developed by Milani et al. (2008) proved to be also valid at changing shock parameters due to different running velocities. Hennig &

Milani (2000) observed that higher running velocities lead to higher local loading peaks. However, they also showed that these peaks occur earlier in time. This reciprocal behaviour facilitates the determination of pronation parameters by deformation values at different running velocities, since maximum deformation peaks and the corresponding times to maximum deformation are used in the algorithm to calculate rearfoot motion.

## SUMMARY

Considering the velocity range of recreational heel-toe running (2.7 - 4.2m/s), midsole deformation can be used to calculate rearfoot motion parameters such as pronation and maximum pronation velocity in a modified EVA shoe. Additional data of midsole deformations of the forefoot might improve the algorithm at higher running speeds.

## REFERENCES

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