# ELECTROGONIOMETRIC EVALUATION OF FOOT KINEMATICS DURING WALKING AT DIFFERENT VELOCITIES

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## INTRODUCTION

Exaggerated pronation of the foot (hyperpronation) is a factor that induces painful conditions in the foot and eventually musculo-skeletal problems in the more proximal parts of the lower extremities e.g. shin pain, medial knee pain. However, evaluation of the relationship between the degree of foot pronation and musculo-skeletal disorders in the lower extremities is difficult because the quantification of foot pronation is either based on simple static measurements with a rather low repeatability (Weiner-Ogilvie and Rome, 1998, Vinicombe *et al.*, 2001) or rather complicated 3-dimensional movement analysis of the structure and foot kinematics which are costly and time consuming in daily clinical practice. Consequently, the purpose of this study was to develop and test a clinical applicable method which with good accuracy quantifies the degree of foot pronation both the statically and dynamically (Leardini *et al.*, 1999).

## METHODS

Fifteen persons participated in the study (8 females and 7 males), age 40 yrs (S.D., 8 yrs), height 1.76 m (S.D., 0.10 m), and body weight 72 kg (S.D., 16 kg) and shoe size 41 European sizes, (S.D., 3 European sizes).

The quantification of foot pronation was based on a combination of static photographs of the foot and electrogoniometric measurements of the calcaneal angle and the height of the medial arch of the foot respectively: 1) Calibrated digital photographs were taken of the loaded foot during upright standing in the frontal plane from the dorsal side and in the sagittal plane from the medial side. 2) Two flexible wire goniometers (Biometrics®) were skin mounted one measuring the angle of calcaneus in relation to the shank in the frontal plane and one measuring the angle between the calcaneus and the first metatarsal bone in the sagittal plane. Additionally, two foot switches were placed under the heel and the forefoot respectively to measure temporal gait parameters.

The participants were asked to walk barefooted on a treadmill at three different velocities: 2.0, 4.5 and 5.5 km/hr while data were collected. All signals were sampled at 1000 Hz with a PC-based data acquisition system and processed in Matlab®. All procedures were repeated two times to evaluate the re-test reliability of the method. Two static measures were extracted from the digital photographs: the calcaneal angle in the frontal plane and the vertical height of the navicular bone and from the goniometer signals the dynamic changes in same parameters over the full step cycle were obtained.

## RESULTS AND DISCUSSION

The comparison of selected parameters between the two tests did not reveal any statistical test-retest differences related to the test procedures.

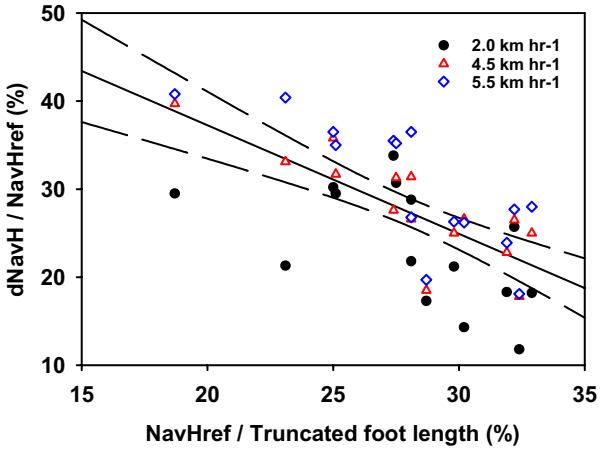


**Figure 1**: The relationship between the normalized static navicular height and the normalized dynamic navicular drop during walking at different velocities.

The static navicular height had a range of 36 – 62 mm between participants in the examined group (group mean 51, S.D., 7 mm), and the amplitude of the navicular movement during a full step cycle during walking at 4.5 km $hr^{-1}$ ranged between 9 – 17 mm (group mean 14, S.D. 2 mm). The static calcaneal angle in the frontal plane ranged between -2 – 10 deg (group mean 6, S.D., 4 deg) and the corresponding amplitude of calcaneal rotation during the step cycle walking at 4.5 km $hr^{-1}$ ranged between 8 and 33 deg (group mean 20, S.D., 5 deg). The magnitude of both calcaneal and navicular movement increased with increasing velocity. An inverse relationship between the normalized static navicular height and the normalized changes in navicular height during walking could be demonstrated (Fig.1).

## CONCLUSIONS

We believe that we have developed a clinically applicable method to evaluate the degree of static and dynamic foot pronation with good accuracy. The method represents a tool for evaluation of the quality/efficiency of a wide variety of operative procedures and/or rehabilitation/training procedures that aim to correct for hyperpronation of the foot.

## REFERENCES

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