**DYNAMIC PATTERNS OF SAGITTAL MOTION IN THE TARSAL JOINTS AND THEIR RELEVANCE TO THE CONSTRUCTION OF THE SHOE MIDSOLES**

[1]Paul Lundgren, [1]Arne Lundberg , [2]Peter Wolf, [3]Christopher Nester, [4]Adrienne Hunt, , [1,5]Anton Arndt

[1] Dept. Orthopedics, Karolinska Institute, Stockholm, Sweden; [2]Sensory-Motor Systems Lab, ETH Zurich, Switzerland; [3] Centre for Rehabilitation and Human Performance Research, University of Salford, England; [4]School of Physiotherapy, The University of Sydney, Australia; [5]The Swedish School of Sport and Health Sciences, Stockholm, Sweden

Email: paul.lundgren@karolinska.se

## INTRODUCTION

Traditionally the foot has been biomechanically divided into the fore- and rearfoot, with the division taking place in the Choparts joint. This joint is however difficult to define with skin-mounted markers. Precise knowledge of the patterns of motion in this area is, therefore, lacking and especially so when it comes to dynamic studies[1,2,3]. The aim of this study was therefore to examine the detailed kinematics of this and other tarsal joints with a quasi-dynamic method as well as a dynamic method. This has implications for the sagittal rigidity of shoe midsoles.

## METHODS

Two methods were used in this study. Radiostereometric analysis (RSA; quasi-dynamic) and motion analysis with skeletally anchored reflective markers (dynamic). A total of seven test subjects were engaged in these studies, however both RSA and motion analysis were available from only two subjects whose data are presented here.

For the RSA-study we used tantalum markers which were inserted under sterile conditions, using standard surgical techniques, in the MT1, navicular, medial cuneiforme, talus and tibia. At least three markers were inserted in each bone. The subjects performed end-of-range weightbearing positions in all three planes of rotation. The uMRSA-software (RSA Biomedical, Sweden) was used for data analysis.

For the dynamic studies intracortical pins were inserted in the same bones as the tantalum markers, again under local anaesthaetic and sterile conditions. Tripods with reflective markers were attached to the pins. Subjects performed repetitive cycles of walking and running recorded by 10 motion capture cameras (Qualysis, Sweden). Ten running and walking cycles were performed, the presented values being an average of these cycles.

## RESULTS AND DISCUSSION

We have used the rotation of metatarsal I in relation to the tibia to represent the range of motion (ROM) of the forefoot in relation to the leg. To this overall rotation, the metatarsal I – medial cuneiform joint contributed only negligibly. The medial cuneiform – navicular joint as well as the navicular – talus joint contribute quite similarly to the overall rotation (Figure 1). In the RSA-study, the same subject showed from lunge-position to maximum voluntary plantarflexion also only negligible ROM between metatarsal I and medial cuneiformi. Further, medial cuneiform – navicular showed almost twice the ROM of navicular-talus.

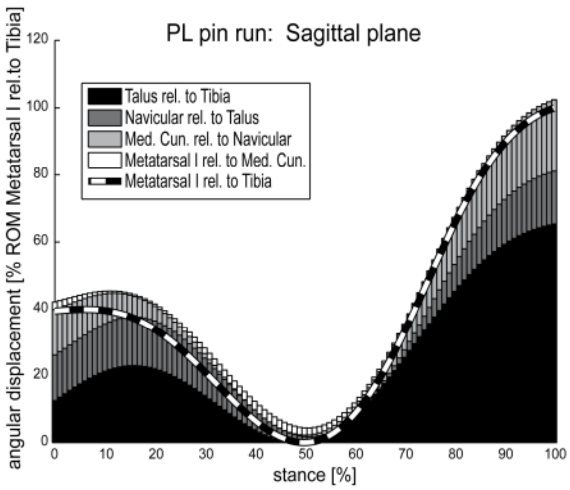


**Figure 1**: One subject in a running trial. Angular displacements are absolute values.

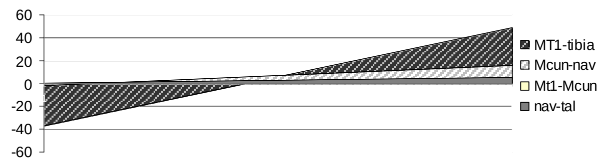


**Figure 2**: The same subject as figure 1. RSA-study. Degrees sagittal rotation from lungeposition to max. plantarflexion.

## CONCLUSIONS

Although ROM in MT1-medial cuneiform was small, that of the medial cuneiform - navicular joint was similar to navicular-talus in the running trials and even higher than nav-tal in the RSA-studies. The reason for the difference was possibly that end of range rotations are not achieved in normal running. Previous data[3] has shown that the MT5-cuboid joint shows a high degree of sagittal rotation during walking. Functionally it is perhaps therefore possible to define an axis between the medial cuneiform-navicular and MT4-5-cuboid joints around which rotation in the sagittal plane takes place. This high degree of sagittal rotation in the area behind the tarsometatarsal joints should be taken into account in the construction of shoe midsoles. The results describe the intrinsic mid-foot motion underlying simplified models dividing the foot into forefoot and rearfoot segments.

## REFERENCES

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