

# AN ANATOMICAL, INSTEAD OF TECHNICAL, COORDINATE SYSTEM ATTACHED TO THE TALUS ONLY PARTLY REDUCES ROTATIONS IN FRONTAL AND TRANVERSE PLANE AT THE TALOCRURAL JOINT

<sup>1</sup>Peter Wolf, <sup>1</sup>Gianbattista Pron, <sup>2</sup>Christoph Nester, <sup>2</sup>Richard Jones, <sup>3,4</sup>Anton Arndt, <sup>3</sup>Paul Lundgren, <sup>3</sup>Arne Lundberg

<sup>1</sup>Sensory-Motor Systems Lab, ETH Zurich, Switzerland; email: pwolf@ethz.ch

<sup>2</sup>Centre for Rehabilitation and Human Performance Research, University of Salford, England

<sup>3</sup>Department of Orthopedic Surgery, Karolinska Institute, Sweden

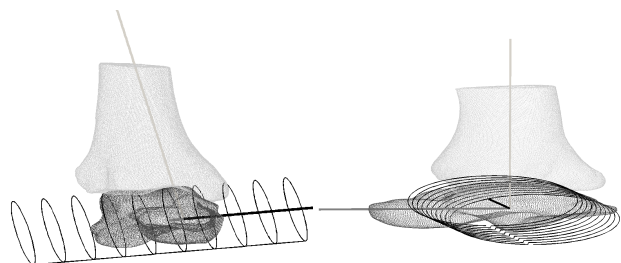
<sup>4</sup>The Swedish School of Sport and Health Sciences

## INTRODUCTION

A general agreement such as that for the definition of the coordinate system at the ankle joint complex [1] does not exist for the talocrural joint. This may be due to the fact that *in vivo* principle rotations during walking and running had rarely been quantified except by our collaboration [2,3]. We reported rotations based on technical frames which were aligned with the global coordinate system during standing reference trials. This methodological limitation might have caused the unexpected great ranges of motion of more than 10 degrees at the talocrural joint which were found in the frontal and transverse plane. Thus, this paper aims to define a functional frame at the talocrural joint to elaborate the crosstalk caused by the use of a technical frame. We hypothesised that a functional frame will reduce the range of motion at the talocrural joint in the frontal and transverse plane.

## METHODS

Before we monitored walking and running of healthy subjects, the foot and marker triads attached to the bones were acquired by computer tomography. As long as marker triads were not rearranged prior to the kinematic investigation, we therefore know the position of the bones, i.e. of the talus and the distal part of the tibia, during the standing reference trials. This allows the definition of a functional frame of the talocrural joint which can be related to the technical frames reported earlier [2,3]. The functional frame is based on a cylinder fitted to the talar dome. The cylindrical axis defines the axis for plantar-/dorsiflexion at the talocrural joint. A line perpendicular to this axis and pointing through the centre of the cross-section at the lower third of tibia defines the add-/abduction axis. The third axis is perpendicular to the other two (see Figure 1).

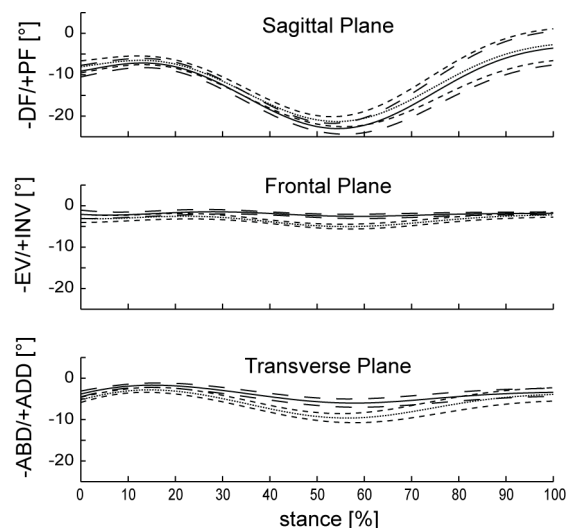


**Figure 1:** Functional frame seen in two global planes.

For all subjects available, ranges of motion were quantified along each axis for all trials (5-10 trials each). Intra-subjectively, ranges of motion based on technical frames were compared to those based on functional frames by a Wilcoxon-test ( $\alpha = 0.05$ ).

## RESULTS AND DISCUSSION

No anatomical frame could be developed for three out of five subjects due either to not acquired markers attached to the tibia during computer tomography or marker triad rearrangement. In the remaining subjects, the range of motion related to in-/eversion and add-/abduction was significantly reduced between  $0.1^\circ$  to  $2.7^\circ$  during running and fast walking (see Figure 2). The fitted cylindrical axis represents the rotation axis during running and fast walking quite well since almost no rotation occurred in the frontal and transverse plane after applying it.



**Figure 2:** Talocrural joint excursions for one subject (mean and 95% confidence interval) during running; functional frame data are shown by the dashed lines.

During walking, in-/eversion was also significantly reduced, but only by a negligible magnitude of about  $0.1^\circ$ . Based on the limited number of available subjects, we suppose that our previously determined talocrural joint rotations are not affected by the use of technical frames. In our subjects, an axis through skin markers at the malleoli, which is often used to describe plantar-/dorsiflexion, deviates in the transverse plane from our technical axis by  $10^\circ$ . Such a deviation results in a crosstalk of  $3^\circ$  in-/eversion if  $20^\circ$  plantar-/dorsiflexion occur. Thus, it is necessary to define a convention related to coordinate systems at the talocrural joint. Additionally, rotation descriptions must be standardized since data is still reported in different ways, e.g. helical axis or Euler sequence, which renders it quite difficult to compare results.

[1] Wu G, et al., J Biomech. **35**: 543-548, 2002

[2] Arndt A, et al., J Biomech. **40**: 2672-2678, 2007

[3] Lundgren P, et al., Gait Posture **28**: 93-100, 2008