ROTATIONS IN REARFOOT JOINTS AT END OF RANGE WEIGHT BEARING

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INTRODUCTION

Physiological end of range in the rearfoot joints while under body weight represents a normal functional scenario, as for example in squatting. However, the relative contributions of the relevant joints are unknown. From in-vivo, quasi-dynamic experiments using radiostereometric analysis (RSA) [1], we know: that between 10% and 41% of total foot plantarflexion during ankle joint plantarflexion is due to motion in the joints of the medial longitudinal arch, in particular the talonavicular joint; that during inversion-eversion motion of the foot, frontal plane motion occurs primarily at the talonavicular joint, rather than at the subtalar joint, as is commonly believed. Indeed, from a bone motion study of living subjects, the contribution of talocrural joint to inversion-eversion during the weight bearing phase of walking, has been calculated as 30% [2,3].

Undoubtedly, individual joints will have differing amounts of congruity in different loading circumstances and contribute differently to specific weight bearing functions. In the current study we sought to determine:

- Total rotations required for normal function.
- Joint kinematics during two different approaches to achieving maximal voluntary dorsiflexion.

METHODS

In this descriptive study of joint kinematics of the foot, radiostereometric analysis (RSA) was employed to identify 3D rotation and translation of the joints of the rearfoot (talotibial, talocalcaneal, calcanealcuboid and talonavicular joints) in three normal subjects. Each of the relevant bones had been previously implanted with between 3 and 4 (radio opaque) tantalum markers under local anaesthetic utilising standard surgical procedures. Ethical approval for the study was obtained from the Karolinska University Hospital local ethics committee. Synchronised double X-ray exposures were taken to calculate the relative positions of the segments relative to a calibration coordinate system defined by a cage with tantalum markers.

The subject stood with the examined foot within the calibration cube. X-ray exposures were taken in the following positions: (i) neutral: a neutral (reference) position with the subject standing straight and relaxed with their weight even between both feet, (ii) inversion (foot turned in), (iii) eversion (foot rolled out), (iv) plantarflexion (demi-pointe position), (v) active full dorsiflexion, (vi) lunge (passive dorsiflexion). Individual joint rotations relative to the reference position were calculated using RSA. Rotations about the X-axis (mediolateral axis) were calculated for the two dorsiflexion and the plantarflexion positions, while Y and Z rotations were calculated for the inversion and eversion positions.

RESULTS AND DISCUSSION

The total range of motion at the talus-tib joint between a foot position of maximum plantarflexion and one of maximum dorsiflexion (lunge) was 60º. Whilst plantarflexion was greatest at the talus:tib joint (30º), there were 10º at the nav:talus joint. Not unexpectedly, the lunge position induced more talus-tib dorsiflexion than did active dorsiflexion (30º versus 18º), and therefore more useful in the clinical setting.

Between the positions of maximum eversion and inversion, there were the following total amounts of inversion-eversion: 42º at the nav:talus, and 17º at each of the calc:talus and cub:calc. These figures confirm the nav:talus as the joint that is most important to these end of range foot movements, as indicated previously [1-3]. Interestingly, whilst rotations for both the calc:talus and cub:calc were even between inversion and eversion rotations, eversion motion was only 7º for the nav:talus (Figure 1), compared to 35º for the inversion motion. Associated with this end of range foot inversion, was a notable amount of vertical axis rotation (adduction), especially at the nav:talus joint (28º).
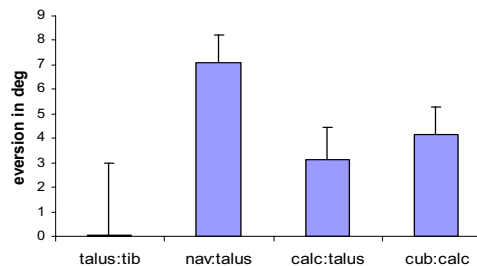

Figure 1. Eversion joint motion (Y axis rotation) for maximum foot eversion.

There was little variability across the 3 current subjects, perhaps indicating that individual joints contribute similarly.

REFERENCES

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