**Ankle joint moments during walking in normal and symptomatic pes planus males**

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**Introduction**

As causative factors in producing motion, joint moments are valuable in assessment and management of people with marked deformity or neuromuscular disease. Pes planus has been a popular topic of research. It is described as a ‘maladaptive’ disorder, for which the highly specialised human foot has limited tolerance, and which can result in changes in muscle function (Olsen et al., 1983). For people (S) with symptoms attributed to pes planus, there have been numerous investigations of walking and running kinematics and kinetics, particularly for the frontal plane, but not of ankle joint (AJ) moments. In this study, 3D AJ moment profiles were obtained from S subjects and compared to a database of normal (and asymptomatic) (N) subjects for walking at a self-selected natural pace.

**Methods**

Subjects were fifteen males (19-43 years), with musculoskeletal symptoms attributed by clinicians to pes planus. The leg and rearfoot segments were defined by surface markers. Video data were recorded at 60Hz via seven cameras and a motion analysis system (EVa HiRes™). Ground reaction forces were recorded at 960Hz from a force platform (Kistler™). Ten walking trials were recorded at a natural walking pace. The two joints of the AJ complex (talocrural and talocalcaneal), comprising the rearfoot segment, were considered as a single universal joint, with its origin midway between medial and lateral malleolar markers. Sagittal, frontal and transverse moments of the leg on the foot were calculated in the segment coordinate system with inverse dynamics software, based on a standardised reference position. Data were magnitude normalized before averaging across participants, to body weight and height. Mean stance phase profiles were compared to profiles for N males (Hunt et al., 2001). Statistical tests included the repeated measures analysis of variance (ANOVA).

**Results & Discussion**

Symptomatic study participants had a mean height of 1.76m (SD .65; range: 1.65-1.89), mean mass of 77.5kg (SD 13.2; range: 55-101.8) and mean age of 26yrs (SD 7, range: 19-43), and compared well to the N participants, who had a mean height of 1.78m (SD .74; 1.63-1.92), a mean mass of 78.3kg (SD 10.8; 61-100) and a mean age of 25yrs (SD 5;18-38). Mean walking velocity the same as for the N group, at 1.6 m.s⁻¹ (SD 0.2; range: 1.3-1.9). The times that were calculated for the N group for foot flat and for heel rise, were used for the current data to enable comparison. Thus, foot flat was 21% stance and heel rise was 62% stance. From the vertical ground reaction forces, peak weight acceptance occurred at 20% stance, and push-off at 78%.

Moments of the leg on the foot for the two groups are graphed together (mean + 95% confidence intervals) for the three planes in Figures 1-3. Symptomatic pes planus subject data (S) are the solid lines, normal subject data (N) are the hashed lines. Although moment profiles were not markedly different between the two groups, ANOVA tests confirmed several specific differences.
The peak plantarflexor moment (Figure 1) at push-off was greater (p<.05) for the S group (0.087 vs 0.081). The dorsiflexor peak, soon after heel contact was later in the S group (p<.01) (8% vs 6% stance), but this difference was unlikely to be functionally significant for such a small time difference.

In the frontal plane (Figure 2), where for the N group, there was an evertor moment after heel contact, for the S group it was invertor. At 10% stance, this difference was significant (p<.01), although it possibly did not represent a major functional effect, because of the small magnitude involved (0.002 evertor vs 0.0002 invertor). The S group invertor moment was greater at foot flat (p<.05).

In the transverse plane (Figure 3), differences between the S and N groups were not significant because of variability within the groups.
In the sagittal plane, the slightly greater ankle joint plantarflexor moment for the S group in late stance occurred with a decreased amount of rearfoot dorsiflexion. This indicates that greater moments were being generated by the ankle plantarflexors, supplying a greater eccentric contraction against the forward motion of the leg over the foot. In the frontal plane, between heel contact and 10% stance, there was a negligible invertor ankle joint moment in the S group, compared with an evertor moment in the N group. Thus, for these S subjects, there was possibly a minimal eccentric invertor action at the ankle joint, rather than a concentric evertor action. Between 10% stance and foot flat, the ankle joint invertors were acting eccentrically in the S group, as in the normal subjects, although with a greater force as indicated by the tendency to less eversion, in combination with the greater invertor moment.

In the current study, while significant differences occurred between the symptomatic pes planus and normal subjects in the parameters measured, these differences were small. It is therefore difficult and possibly erroneous to ascribe a definitive clinical interpretation to them. However, the possibility that even small differences could have clinical implications, cannot be ruled out. As stated by Harris et al. (1948), while compensatory muscular support in pes planus may be possible, but not problematic in the short term, over long periods, it may be physiologically inefficient and the foot will not necessarily function well. For most of the current subjects, the constrained task of laboratory walking at a natural pace was perhaps not sufficiently provocative to demonstrate large differences. Nor was the testing sufficiently related to the functional aggravating factors, as the reported symptoms were not usually experienced during normal walking. The stance phase profiles obtained might therefore only have been expected to distinguish small differences. The possibility also exists that the symptoms experienced by the subjects were not really due to pes planus.

References