

# Knee moment profiles during walking: errors due to soft tissue movement of the shank and the influence of the reference coordinate system

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## Abstract

The effect soft tissue movement of the shank had on knee joint moments during natural cadence walking was investigated in this study. This was examined by comparing knee moments determined from bone-anchored and surface mounted tracking targets. Six healthy adult subjects participated in this study. The largest difference (3 N m) occurred about the AP axis, with smaller differences of approximately 2 and 1 N m about the flexion/extension (F/E) and longitudinal (Long) axes, respectively. The magnitude of these differences would not likely affect the clinical interpretation of the data. The effect of reporting knee moments in two different orthogonal reference systems was also examined. The peak extension moment was significantly greater when expressed about an anatomical axis following the line of the malleoli than when the moment was reported about an axis parallel to the frontal plane of the shank. In contrast, the first peak abduction moment was significantly greater when expressed about an axis perpendicular to the frontal plane of the shank. Care should therefore be exercised whenever comparisons between studies are made in which the reference axes are not aligned. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Knee joint moments during walking are common measures of instrumented gait analyses. Joint moments are determined using inverse dynamics and standard motion analysis methods. Segmental kinematics required of inverse dynamics are typically based on the motion of retro-reflective tracking targets attached to the leg. The targets are separated from the underlying bone by muscle, skin and fat, collectively referred to as soft tissue. Soft tissue of the shank moves relative to the tibia during natural cadence walking, and consequently, so do the tracking targets [1–3]. Soft tissue movement

of the shank is therefore a potential source of error when estimating the net magnitude and expression of knee joint kinetics.

Only one study has reported the effect of soft tissue movement on kinetic estimates at the knee [4]. Holden and colleagues compared joint loads for three subjects during natural cadence walking based on kinematic data calculated from bone anchored and surface mounted tracking targets. Relative motion between soft tissue and bone resulted in flexion/extension (F/E) and abduction/adduction (Abd/Add) moment errors as large as 9 N m. The authors stated the magnitude of these differences would not likely affect the clinical interpretation of the data. This finding is significant since joint moments are often used in planning and evaluating patient treatment. For example, Abd/Add loading history of the knee has been used by Noyes and

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