EFFECT OF SOFT TISSUE ON DISSIPATING ENERGY & REDUCING FORCES

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During impacts the soft tissues of the body move relative to the underlying skeleton and so the rigid body approximation used in most whole body biomechanical analysis can have limitations. Quantifying both the characteristics of the soft tissue motion and then its effects on joint moments and forces, as well as the forces and energy within the soft tissues themselves can be important for a fuller understanding of impact dynamics. During this part of the applied session examples from both modelling and experimental based research will be presented that demonstrate some of the effects soft tissue motion has on the system dynamics.

KEY WORDS: impact, kinematics, kinetics, wobbling mass.

In impact situations the transient forces involved are normally high and produce mechanical 'shock waves' when compared to muscularly directed human motion (Challis & Pain, 2008). In these situations standard biomechanical methods may not be applicable. In biomechanical calculations of forces for whole body studies the human body is normally considered to be a series of rigid links connected by simple rotational joints. Humans, however, are not made of rigid links and there can be times when this assumption is not valid.

Research has shown that soft tissue motion plays a role in the energy expenditure and force distributions of human motion, especially during impacts (Pain & Challis, 2002, 2004, 2006; Zelick &Kuo, 2010). Measuring and modelling soft tissue and wobbling mass is fundamental to a better understanding of human motion, the forces involved and the passive and active energy dissipation and production. The rigid body assumption leads to limitations in analysis such as: a real set of forces causing intra-segmental motion are ignored, energy is dissipated passively within the deforming soft tissue, changes in inertial parameters of the segment may be significant enough to alter forces and moments calculated at the joints. Often the obvious large errors that would arise during rigid body dynamics calculations are 'mitigated' by putting some form of extra elasticity and damping into one part of the system, such as the foot-ground interface or other contact points. However, this has the result of representing what is a distributed effect at a single point and so does not represent the forces throughout the system accurately, it only does so accurately at a single pre-specified location (Pain & Challis, 2001).

Representing each segment as a rigid body during inverse dynamics analysis, or simulation modelling, is a necessary expedient in most cases to actually being able to solve for the kinematics and kinetics of the system. Even if some form of soft tissue motion or deforming segment is introduced into analysis the dynamic behaviour of that system still needs to be known to a level of accuracy where erroneous values won't result in greater errors than the rigid body assumption.

During this part of the applied session examples from both modelling and experimental based research will be presented that demonstrate some of the effects soft tissue motion has on the system dynamics in light of the statements above. Specific modelling examples will include using a model of the heel and the lower leg to examine the distribution of forces, and a simple whole body model to show how joint forces and moments change when a rigid body model has a first approximation of soft tissue included. Hi-speed video and marker based motion analysis data will be presented to demonstrate characteristics of soft tissue motion. An examination of soft tissue motion of the arm in 2D will be presented along with that of the leg in 3D (Figure 1), and a simple first approximation calculation of the force in soft tissue motion of the shank during a landing will be calculated by the attendees. The effect of inertial changes on inverse dynamics calculations will be demonstrated during a landing with an impact. There will also be brief set of data presented to show how changes in muscle activation, and hence tension, can alter impact forces and energy deposition during an impact.

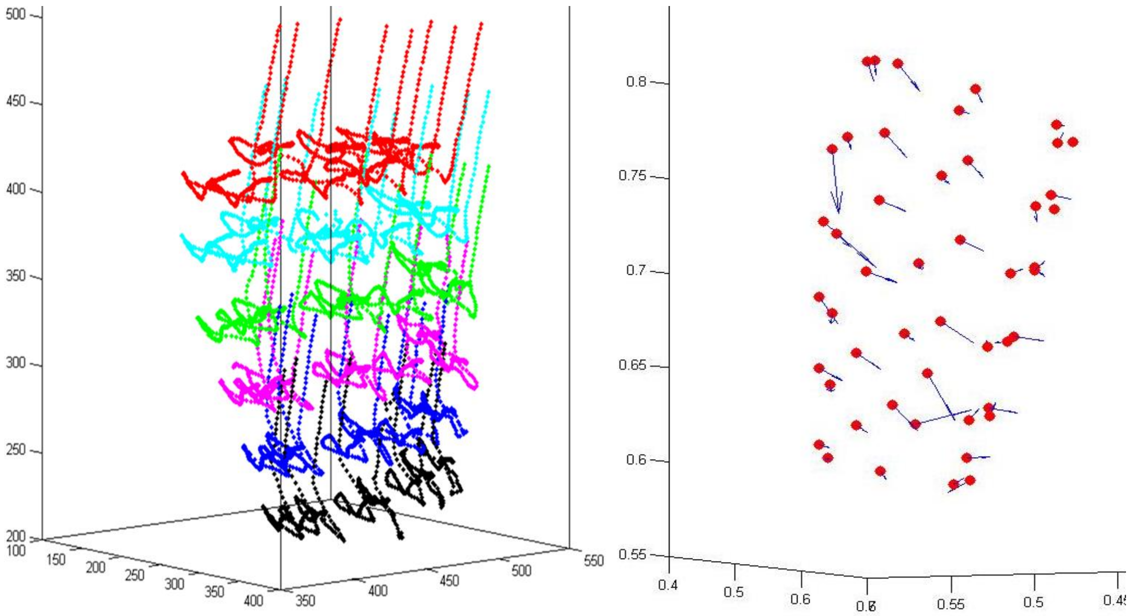

Figure 1. Left: array of 48 markers on the lower leg during fall and landing. Right: for a single frame during an impact marker position in red for a solidified set of markers (a rigid body configuration) with blue arrows showing local deformation, both magnitude and direction, from the rigid body configuration.

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