Abstract ID-215

A FINITE ELEMENT BASED METHOD FOR SUBJECT SPECIFIC SOFT TISSUE ARTEFACT REDUCTION IN MOTION ANALYSIS

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Keywords: gait analysis, finite element, soft tissue artefact, lower limb, subject specific model

Summary: Motion analysis based on skin markers tracking is widely used,particularly in clinical and sports musculoskeletal modelling. A main source of error is the soft tissue artefact, due to deformable connection between skin and bones, yielding non-consistent joint kinematics. Optimization methods are widely used, with described limitations (Cereatti et al. 2017). We propose an alternative finite element based approach which was first implemented for the lower limb.
This first model included pelvis, femur and tibia. Bones were represented by a set of high stiffness beams (E=12GPa) connecting functional parts, for example for pelvis left/right acetabulum and left/right iliac spines, respectively anterior and posterior. Two elements types connected each skin marker Msi to its corresponding bone Bi: combination of springs connected Msi to a subcutaneous point Msci (1 mm distant), and accounted for all the soft tissue deformability, while a stiff beam connected Msci to Bi. Each hip joint was modelled using a stiff bar (HJ) joining centers of acetabulum and femoral head, thus allowing free rotation while controlling translation using the HJ length (0,001 mm in this first model). The same approach was considered for knee joints.
Ms (skin markers) displacements were incrementally introduced (for each time frame of the gait cycle) and the resulting Msc and B nodes displacements were computed using ANSYS software taking into account geometric non linearities. The model was applied on 85 subjects (age 18-59 yrs) that performed both EOS biplanar X-rays and gait analysis using plug-in-gait markers protocol. The whole model comprised 62 nodes and 88 elements. Computation was fast, robust, with consistent joint motion as controlled by the joint bars length.
The main advantages of such approach are simplicity and versatility, allowing further investigations of various parameters, particularly soft tissue deformability (which could vary according to the anatomic region and patient age or status), and joint characteristics (such as knee hyperlaxity). Such approach also allows further refined joint modelling, as well as extension to the whole body. Coding in a dedicated solver is in progress to use the model in routine gait analysis.