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Comments on the “Influence of the load modelling during gait on the stress distribution in a femoral implant” by Gervais et al.

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Gervais et al. [1] have recently published in the *Multibody System Dynamics* journal a study entitled “Influence of the load modelling during gait on the stress distribution in a femoral implant” where they put forward an interesting inverse dynamics method with flexible bony segments in order to estimate the loads applied to a femoral implant. They have compared different static and dynamic methods to estimate the joint loads required as boundary conditions for a finite element analysis of the implant. These joint loads are obtained either by considering the body weight in a static condition or by computing the inter-segmental forces and moments using inverse dynamics.

It seems that the authors did not really distinguish the inter-segmental forces and moments from the loads transmitted to the joints or to the bony segments. However, in biomechanics, the inter-segmental forces and the forces transmitted to the joints (generally designated as joint reaction forces, joint or articular contact forces) are two different things.

Inter-segmental forces and moments

From an external point of view, the inter-segmental forces and moments represent the resultant of the contact actions of the body with the environment (typically at the foot-ground contact), as well as the gravitational, centrifugal and Coriolis actions arising from motion of the segments. These are the forces and moments computed by inverse dynamics, and in the paper of Gervais et al. [1], efficiently computed with flexible multibody dynamics.

Though, from an internal point of view, these inter-segmental forces and moments represent the resultant of the mechanical actions of all the anatomical structures crossing the joint: skin, fat, fascias,

bi- and mono-articular muscles, ligaments and articular surfaces. The loads transmitted to the joints correspond to the articular contact forces. That is, the loads transmitted to the joints represent a component of the inter-segmental forces and moments, a component which cannot be obtained without taking into account the actions of the muscles (and of the ligaments and other passive structures, but which are neglected most of the time).

Forces transmitted to the joints and bony segments

Not only 1 body weight (BW) but 2.5 BW have been considered an “improved static” loading conditions of the implant, as explained by the authors [1], based on *in vivo* instrumented prosthesis measurements [2]. The same rationale could have been followed for the dynamic loading conditions. For gait, *in vivo* measurements from instrumented implants [3,4] as well as simulation results from musculoskeletal models [5,6] have reported 2 to 4 BW of compression of the femur. Similar measurements and results have reported hip and knee contact forces in the same range, *e.g.* [7,8]. Furthermore, modelling studies have demonstrated that the forces transmitted to the joints and bony segments are mainly due to the contributions of the muscle actions (*e.g.* rectus femoris and hamstrings) [9,10] as opposed to gravitational, centrifugal and Coriolis actions. That is why musculo-tendon forces have to be taken into account, like in previous musculoskeletal models with flexible bony segments, *e.g.* [11]. In other words, the muscle actions should not be omitted when estimating the stress or strain in the bone or the implant.

It is only in the case of lower limb amputees, *e.g.* transfemoral amputees with osteo-integrated implants measured *in vivo* using embedded sensors [12], that the forces transmitted to the bony segments remain of 1 BW during gait. In this case, the flexible inverse dynamics proposed by Gervais et al. [1] would perfectly apply, typically because the prosthetic component include deformable parts and because the classical inverse dynamics methods has been found inaccurate in this case [13,14].

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