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Subject-specific modeling for real-time pressure ulcer prevention in sitting posture

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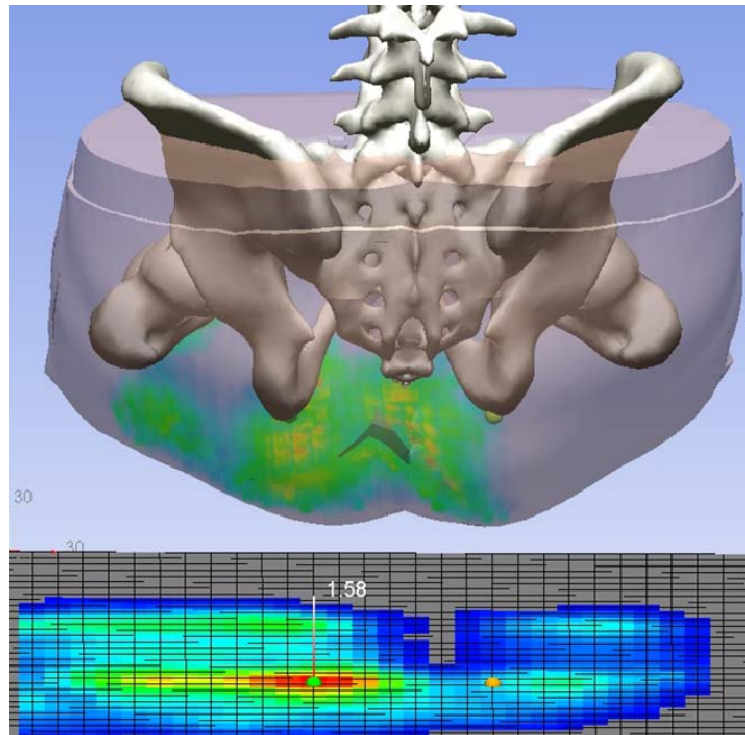
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Introduction: Ischial pressure ulcer is an important risk for every paraplegic person and a major public health issue. Pressure ulcers appear following excessive compression of buttock's soft tissues by bony structures, and particularly in ischial and sacral bones. Current prevention techniques are mainly based on daily skin inspection to spot red patches or injuries. Nevertheless, most pressure ulcers occur internally and are difficult to detect early.

Methods: Estimating internal strains within soft tissues could help to evaluate the risk of pressure ulcer. A subject-specific biomechanical model could be used to assess internal strains from measured skin surface pressures. However, a realistic 3D non-linear Finite Element buttock model, with different layers of tissue materials for skin, fat and muscles, requires somewhere between minutes and hours to compute, therefore forbidding its use in a real-time daily prevention context. In this work, we propose to optimize these computations by using a reduced order modeling technique (ROM) based on proper orthogonal decompositions of the pressure and strain fields coupled with a machine learning method.

Results: ROM allows strains to be evaluated inside the model interactively (i.e. in less than a second) for any pressure field measured below the buttocks. In our case, with only 19 modes of variation of pressure patterns, an error divergence of one percent is observed compared to the full scale simulation for evaluating the strain field.



Discussions: This reduced model could be the first step towards interactive pressure ulcer prevention. The all on-line computations could be ported to a micro-controller embedded within a pressure mat placed on a wheelchair, thus providing a daily pressure ulcer prevention set-up.

Clinical relevance: Coupled with the TexiMat textile pressure sensor (www.texisense.com) that continuously measures pressure frames under the sitting subject, the real-time ROM strain estimation inside the gluteal soft tissues should help to provide an interactive pressure ulcer risk assessment.

References:

Luboz V., Baillet M., Boichon Grivot C., Rochette M., Diot B., Bucki M. & Payan Y. (to appear). Personalized modeling for real-time pressure ulcer prevention in sitting posture. *Journal of Tissue Viability*.