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Technological innovations and biomechanics: Development and optimization in pressure ulcer prevention

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Introduction:

While in interactions with external supports such as shoes, seats or mattresses, human soft tissue can be submitted to large stresses and strains that may affect tissue integrity, especially for people suffering from sensory loss and/or peripheral vascular disease. Basic science has recently made substantial progress as concerns the etiology of deep tissues injuries (DTI). Mechanical compression, ischemia, lymphatic blockage and reperfusion are indeed potential factors triggering DTI (Oomens 2015). Among these factors, the most dangerous one is probably direct mechanical compression that results in high deformations of the subcutaneous tissue layers and that can damage soft tissue in a very short period of time (some minutes).

Methods:

We are today fairly confident in the fact that an efficient pressure ulcer prevention medical device should include, at least, four components:

(1) a compliant support (shoe, seat, mattress) that optimizes the way pressure forces apply onto skin surface and that limits any stress concentration;
(2) an on-line embedded quantitative measurement of the pressure at the support/skin interface;
(3) an on-line estimation of the internal soft tissue deformations;
(4) the estimation of the risk for DTI and if necessary, an alarm sent to the person.

Results:

This invited talk will focus on the solutions and bottlenecks towards an on-line estimation of the risks for DTI. If some new technologies and products can now propose embedded pressure mat to measure the pressure at the support/skin interfaces, a relevant biomarker for estimating tissue internal strain is unfortunately still lacking. The solution is the design of a subject-specific biomechanical model of the *bony prominence / soft tissue / support* interactions computing in real time tissue internal strains. The associated reminding bottlenecks will be discussed: How to generate, in a clinical routine, a subject-specific biomechanical model taking into account the specific anatomy of the subject, in terms of tissue layers (skin, fat, muscles) or shapes of the bony surfaces? How to get such anatomical information without the use of a complex and costly MRI or

CT exam? How to run in real time the non-linear biomechanical Finite Element models required to compute internal strains? How to define a subject-specific threshold in terms of maximal strains values?

Conclusions:

This talk will illustrate the bottleneck questions raised above with some results obtained by our group using biomechanical models of the foot and buttock soft tissues.

References:

Oomens, Bader, Loerakker and Baaijens (2015). *Ann Biomed Eng*. 43(2):297–305.