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Deep Tissue Biomechanics During Pressure-Induced Pain

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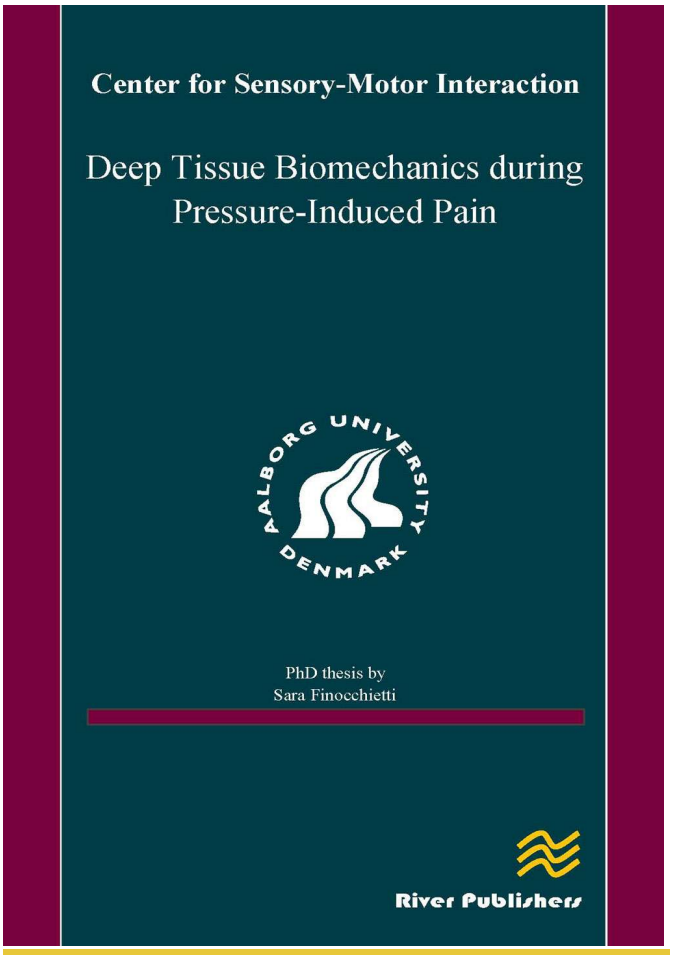
Muscle pain is difficult to localize and is generally referred to deep structures. Pressure algometry has become a widely used technique to quantitatively assess deep tissue pain sensitivity in experimental and clinical studies. The algometer is a simple device, where pressure is applied and transmitted to the deep tissue through the skin and the subcutaneous tissue, eventually exciting deep-tissue nociceptors that initiate the pain sensation. So far there has been limited knowledge on the pressure distribution in the tissue and which tissue actually is mainly affected. This Ph.D. project aimed to describe the relation between structural mechanical properties, i.e. stress and strain, in tissues where the pressure stimulation is applied and relate them to the pressure pain sensitivity. Three dimensional finite-element computer models have been used to describe the mechanical stress/strain distribution in the deep tissues of the lower leg during pressure stimulation. The relation between tissue indentation and pressure stimulation intensity was extracted from the simulation models and were validated with human experimental data. Study I showed that muscle mechano-nociceptors stimulated by pressure indentation do not experience the externally applied load by itself, but encode compressive strain rather than displacement or stress. Moreover, extrinsic and intrinsic factors seem to play an important role in pressure pain threshold measurements.

The probe shape and diameter are extrinsic factors. The probe has to be chosen in relation to the tissue investigated: Small probe area on bones (III) and large probe area on muscles (I). The simulations showed that a larger area of the periosteal tissue was strained using a small probe (0.03 cm2) compared to a larger one when stimulating on bone, while on the muscle, as the probe diameter increases, a wider portion of the muscle was strained. Moreover, rounded probes prevent shear strains and are more suitable for deep tissue pain assessments (I).

Hardness and subcutaneous adipose thickness are intrinsic factors and influence pressure pain measurements. A harder muscle present lower strain peak and, as a consequence, higher pressure stimulation intensities are required to reach the pain threshold (II). In addition, the magnitude of transcutaneous pressure transmitted to the deep tissue is smaller in the cases with very thick subcutaneous tissue (II). Additionally, the strain distribution is also evaluated in relation to repetitive pressure stimulations at short ISI, the muscle strain increase during repeated stimulations although not sufficient to increase the pain facilitation due to temporal summation (IV).

Those findings are highly clinically relevant and comparison of pressure algometry assessments between groups of subjects has to be cautionary done.



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