Inverse finite element characterization of soft tissues using genetic algorithm

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Human body finite element (FE) models for use in impact simulations require soft tissue characterization at high strain rates. The objective of the current work is to extract viscoelastic properties of passive muscle tissues at high strain rates and study their rate dependency. A procedure to identify the dynamic properties of passive muscle tissue under impact has been proposed using isolated-tissue experiments, FE simulations and Genetic Algorithm (GA) based optimization. Data from nineteen impact tests on unconfined isolated human muscles for strain rate ranging from 132/s to 262/s were used [1]. Tissues were compressed up to approximately 50 % strain and the force-time response was recorded. FE simulations of these impact tests have been performed in the present study by modeling the muscle as linear viscoelastic. RMS of the deviation between the experimental and FE force data, sampled at 10 kHz, was then minimized to predict the material parameters, bulk modulus, short-term shear modulus and long-term shear modulus. This parameter identification process was automated using PAM-CRASH^{TM}, open source GA code [2] and C++ programming. In the present study a predefined generation size is used for optimization. Optimal bulk modulus, short term shear modulus and long term shear modulus for three average strain rates were found to be 73200, 13100, 347 Pa for 136/s; 278000, 26200, 1510 Pa for 183/s; 317000, 34900, 5210 Pa for 262/s respectively. The variation obtained in these properties with strain rates suggests that the linear viscoelastic model being used for muscle tissues is not a perfect choice for characterizing the dynamic compressive behaviour of these tissues. The proposed methodology offers a method for determining soft tissue properties at different strain rates. The usage of GA based optimization eliminates the determination of derivatives as used in conventional optimization techniques [3]. With minimal effort, this method can also be extended to other material models considered for muscle characterization.

REFERENCES

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