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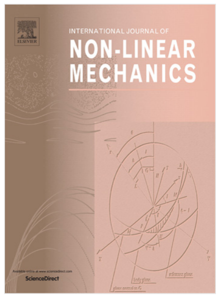

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G. Giantesio, A. Musesti

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Strain-dependent internal parameters in hyperelastic biological materials

G. Giantesio[a], A. Musesti[a]

[a] *Dipartimento di Matematica e Fisica "N. Tartaglia", Università Cattolica del Sacro Cuore, via dei Musei 41, 25121 Brescia, Italy*

Abstract

The behavior of hyperelastic energies depending on an internal parameter, which is a function of the deformation gradient, is discussed. As an example, the analysis of two models where the parameter describes the activation of a tetanized skeletal muscle tissue is presented. In those models, the activation parameter depends on the strain and it is shown the importance of considering the derivative of the parameter with respect to the strain in order to capture the proper stress-strain relations.

Keywords: Hyperelasticity; skeletal muscle tissue; active strain; biomechanics
2010 MSC: 74B20, 74L15

1. Introduction

The theory of hyperelasticity, where the stress derives from a strain energy density, is widely used for modeling the nonlinear mechanical response of many biological materials, see for instance [5]. Denoting with $\mathbf{F}$ the deformation gradient and with $W(\mathbf{F})$ the strain energy density of a homogeneous hyperelastic material, one can express the first Piola-Kirchhoff stress tensor field $\mathbf{P}$ as

$$\mathbf{P} = \frac{\partial W}{\partial \mathbf{F}}(\mathbf{F}).$$

Hence, in the choice of constitutive prescriptions only the scalar quantity W needs to be described, which is much simpler than modeling a tensor such as the stress.

Furthermore, for some complex materials an *internal parameter* γ can be introduced [13, 17], in order to account for microstructural changes, and the energy density becomes a function both of $\mathbf{F}$ and γ. For simplicity, we assume that γ is scalar valued, although similar considerations can be carried on also when the parameter is vector or tensor valued.

Email addresses: `giulia.giantesio@unicatt.it` (G. Giantesio), `alessandro.musesti@unicatt.it` (A. Musesti)