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Technical note

Transversely isotropic tensile material properties of skeletal muscle tissue

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ABSTRACT

Of the plethora of work performed analyzing skeletal muscle tissue, relatively little has been done in the examination of its passive material properties. Previous studies of the passive properties of skeletal muscle have been primarily performed along the longitudinal material direction. In order to ensure the accuracy of the predictions of computational models of skeletal muscles, a better understanding of the tensile three-dimensional material properties of muscle tissue is necessary. To that end, the purpose of this study was to collect a comprehensive set of tensile stress–strain data from skeletal muscle tissue. Load-deformation data was collected from eighteen extensor digitorum longus muscles, dissected free of aponeuroses, from nine New Zealand White rabbits tested under longitudinal extension (LE), transverse extension (TE), or longitudinal shear (LS). The linear modulus, ultimate stress, and failure strain were calculated from stress–strain results. Results indicate that the linear modulus under LE is significantly higher than the modulus of either TE or LS. Additionally, the ultimate stress of muscle was seen to be significantly higher under LE than TE. Conversely, the failure strain was significantly higher under TE than under LE.

1. Introduction

Measurement of individual muscle performance could allow for the monitoring of disease progression, evaluation of therapeutic intervention efficacy, and improvement in the understanding of how various conditions affect muscle function. In the absence of direct measurement of individual muscle function, investigators have used computational models to try and fill gaps in knowledge. Models of skeletal muscle have advanced from the unidirectional Hill-type muscle model introduced in 1938 (Hill, 1938) to three-dimensional continuum-based muscle models that have been developed more recently (Blemker and Delp, 2005; Gielen et al., 2000; Jenkyn et al., 2002; Johansson et al., 2000; Martins et al., 1998; Odegard et al., in press; Yucesoy et al., 2002). Regardless of the level of complexity, the inherent validity of a model is tied to the material properties used to determine model parameters. Given this, it is surprising to note the relative lack of studies examining the material properties of skeletal muscle tissue.

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