

REGIONAL AND DIRECTIONAL DIFFERENCES OF THE INTERVERTEBRAL DISC ANNULUS FIBROSUS MECHANICAL PROPERTIES

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ABSTRACT

The loading experienced by military helicopter and fighter aircrew can lead to spinal injury by degrading the soft tissues. Fighter pilots endure low frequency high magnitude loading, while helicopter pilots endure high frequency vibrational loading over longer periods of time. The purpose of this study is to analyze intervertebral disc material properties, including elastic modulus, failure strain, and failure stress. This will provide data to model the annulus fibrosus to predict the risk of injuries. Quantifying the risk to specific spinal locations could provide insight to improve the design of protective clothing and equipment. Single layers of the porcine annulus fibrosus were subjected to tensile failure tests to determine the mechanical properties. Results showed a significantly ($p< 0.05$) higher elastic modulus in the circumferential direction compared to the axial direction. There was also a significantly greater elastic modulus for samples from the lateral region of the disc compared to the posterior region. There was no significant difference for the anterior region or specimen depth with regards to elastic modulus. Failure stress showed significant differences between superficial and deep specimens as circumferential and axial testing directions. Failure strain only had differences between circumferential and axial directions. This data can be used to help predict where in the disc an injury may occur. Because of the decreased posterior elastic modulus, tensile failure is more likely to occur in that region.

Keywords: annulus fibrosus, elastic modulus, failure strain, failure stress, intervertebral disc

INTRODUCTION

Military aircrew endure increased loading during flight. The high frequency vibrational loading of helicopter pilots and low frequency high magnitude loading of fighter pilots can increase the risk of spinal injury [1-2]. Material failure properties of the annulus fibrosus will vary depending on disc region [3-4]. A better understanding of these differences will enable more accurate finite element modelling of the discs to predict injury and incapacitation in military environments. Prior studies used specimens that were
previously frozen or from older human spines [4, 5]. This may affect material properties, so the present study incorporated annulus fibrosus tissue from fresh, young porcine spines, which will be more applicable to a younger military population. Previous research showed varying annulus properties based on disc anatomical region and whether the samples were taken from the deep or superficial layers [3, 6]. The results of the present study will accurately depict the mechanical properties, which is crucial in studying the mechanical response of the spine to long duration vibrational loading, as well as its effect on injury risk.