Intervertebral Disc Biomechanics

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2015

document version
Publisher's PDF, also known as Version of record

citation for published version (APA)
Vergroesen, P. P. A. (2015). *Intervertebral Disc Biomechanics: Long-term Axial Loading Studies*.

The main function of the intervertebral disc is to transfer the mechanical loads of the spine. However, few studies have investigated the —predominant— long-term axial biomechanical behaviour of the intervertebral disc. The recent development of axially loaded bioreactors for the intervertebral disc allows the study of this behaviour, in particular diurnal loading. In this thesis, we firstly aimed to assess normal long-term axial biomechanical behaviour of the intervertebral disc in dynamic equilibrium, and the determinants thereof. Secondly, the effects of degeneration and subsequent water loss on long-term axial intervertebral disc biomechanics were investigated.

We have found that intradiscal pressure is essential for normal axial biomechanics, and to provide anabolic mechanobiological cues to the nuclear chondrocytes. This intradiscal pressure is generated by the proteoglycans' pre-eminent ability to attract and bind water. This attraction of water or swelling pressure generates fluid flow into the disc upon unloading, and is essential for the maintenance of disc height and daily creep. With degeneration, the proteoglycans in the nucleus pulposus are lost, swelling pressure is reduced, and intradiscal pressure dwindles. The effects of degeneration on intervertebral disc biomechanics are thus: a loss of disc height, and a loss of daily fluid flow or creep. Hence, monitoring of disc health from a biomechanical perspective should include monitoring of changes in disc height, and in speed and volume of daily creep. Stiffness in axial compression proved to be a less valid parameter for the determination of degeneration. Similarly, MRI grading techniques, although they are often used, are only moderately related to the biomechanical function of the intervertebral disc. Finally, evaluation of regenerative strategies can be adequately assessed in a bioreactor prior to in vivo experiments in order to reduce laboratory animal use, costs, and increase the speed of innovation.