

## Effects of mechanical loading on disc metabolism

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**INTRODUCTION:** Disorders of the intervertebral disc are commonly implicated in low back pain and often associated with mechanical overloading. The purpose of this paper is to review recent studies describing the effects of mechanical loading on intervertebral disc metabolism. This goal is to define hypothetical models that provide a quantitative relationship between mechanical loading and intervertebral disc cell metabolism with the eventual goal of obtaining a predictive model between mechanical loading and disc remodeling.

**METHODS:** The review will cover recent animal modeling and tissue culture studies. In our recent work, quantitative relationships between mechanical loading and disc cell metabolism are obtained using a rat tail model for in vivo studies and bovine caudal discs for whole disc organ culture studies.

Studies on the rat tail model utilized an external fixator that was surgically installed into the tail vertebrae of rats in vivo to allow precise mechanical control over the intervertebral joint loading conditions. These studies addressed the specific influences of loading mode (immobilization, compression & shear), as well as cyclic loading magnitude, frequency, and duration on the short-term intervertebral disc cell anabolic and catabolic gene expression responses.

Studies involving whole discs in organ culture utilized bovine caudal discs that were loaded with static and diurnal compression to evaluate the influence of mechanical loading on cell viability, biosynthetic activity, and disc structure.

**DISCUSSION & CONCLUSIONS:** We hypothesize that disc degeneration results from mechanical damage to the tissue combined with an imbalance between anabolic and catabolic biosynthetic activity. Damage may be quantified mechanically as well as biologically.

Recent results demonstrate a threshold of mechanical loading is required to promote a biosynthetic response. Mechanical loading below that threshold (e.g., immobilization) or

above it (e.g., 1 Hz -- 1 MPa cyclic compression) can stimulate gene expression responses (e.g., Fig. 1).

Anabolic and catabolic responses of disc cells must both be considered. An imbalance between anabolic and catabolic gene expression may lead to protein synthesis or loss (e.g., Fig. 2).

Future studies evaluating the influence of mechanical loading on disc metabolism is necessary to develop a more quantitative and predictive relationship between mechanical loading and disc remodeling.

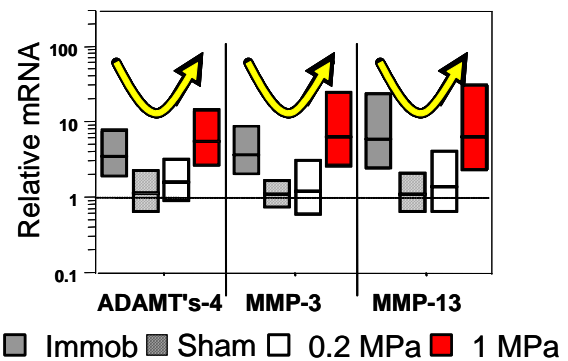


Fig. 1: Relative mRNA expression of annulus cells in response to mechanical loading regimes in vivo using a rat tail model. The amplitudes of 0.2 MPa and 1 MPa correspond to 1 Hz cyclic compression loading, Immob=immobilized motion segments.

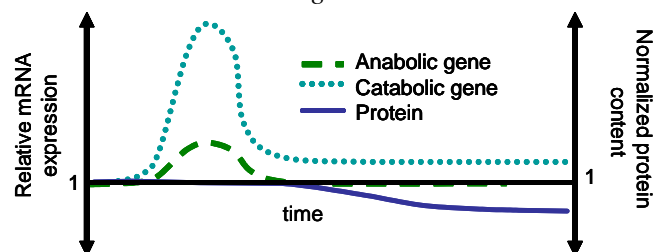


Fig. 2: This schematic of a catabolic remodeling response is one of several patterns describing relationships between changes in gene expression and protein level.

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