# IN SITU BIOMECHANICAL RESPONSE OF THE LUMBAR SPINE DUE TO EXTERNAL STIMULI AND MUSCLE ACTIVATION

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## Introduction

With a life-time prevalence of 70% [Waters, 1993] lumbar spine pathologies have grown to epidemiologic proportions. Spine biomechanics are characterized by high complexity due to the occurring interdisciplinary phenomena entailing hundreds of muscle reactions activated during every day activities. FE is valuable for elucidating in situ stress development of the spine, indicating regions susceptible to critical loading. The reflection of active musculature during modelling is vital to the archived bio-realisticity, as peek force values are considerably high. There consists a consensus throughout literature that patient specific models, non-linear properties and solid ligamentous tissue should be considered [El-Rich 2009], to determine etiology of spinal injury.

## Methods

A patient's lumbar spine was reconstructed in its entirety based on high resolution CT. The intervertebral discs (IVD) and connecting ligaments were reverse engineered based on the surface of the interposing vertebral bodies [Tsouknidas, 2012]. The mesh grid was generated in ANSA, in order to consider anatomic characteristics (i.e. integration of annulus collagen fibres), while convergence studies indicated the optimum mesh density. To avoid element shear locking and hourglassing, hexa- and tetra-hedral second order elements with reduced integration were employed for all model entities consisting of at least 4 element layers. AnyBody was used to determine muscle activation on the lumbar spine during running. The Vertical Force Component (VFC) of the ground reaction was registered and the time varying force profile considered along with inertia phenomena due to spine motion. The model was simulated in Abaqus with non-linear, stress strain dependent material properties, thus allowing insight to occurring dynamic response of the spine segment.

The occurring spinal loads are predominantly compressive with a peek value around 0.24s marking heel impact with a descending body motion.

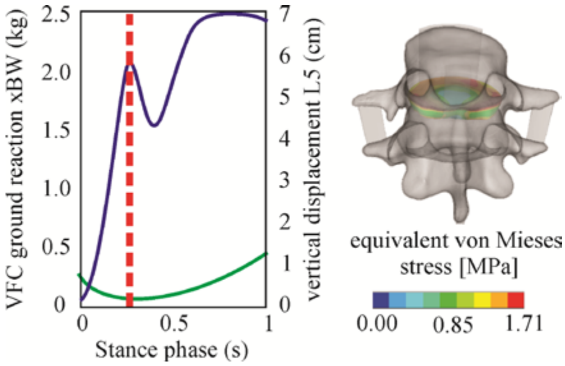


*Figure 1: Stress development within an IVD during running (at 0.24s).*

## Results

The simulation revealed that dynamic loading of a physiological IVD at frequencies associated to running (≈0.2Hz), results in disc pressures that have a beneficial effect on the balance of the IVD's matrix [MacLean, 2004]. Critical regions however, with accumulated stress were observed within IVD (figure 1), indicating that pathological discs or spine patients could be subject to hyper-physiological loading, inducing disc degeneration under prolonged exposure.

## Discussion

The introduced model was validated against literature data [Panjabi, 1994] for flexion, bending and torsion and facilitates the evaluation of activity induced loads on the lumbar spine to predict overloading leading to acute injury or chronic trauma fostered by diurnal cyclic loading [Chan, 2011].

## Acknowledgements

GSRT grant PE8(3227).

## References

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