

How Do Disc Degeneration, Age, Sex, And Level Affect Lumbar Intradiscal Pressure? Evaluation Of An In Vitro Database Comprising 107 Human Specimens

Christian Liebsch¹, Hans-Joachim Wilke¹
¹Ulm University Medical Center, Ulm, Germany
christian.liebsch@uni-ulm.de

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INTRODUCTION: Hydrostatic pressure inside the nucleus pulposus, better known as intradiscal pressure, represents a fundamental parameter for the estimation of loads and muscle forces acting on the spine. Moreover, intradiscal pressure is a major biomechanical indicator for various spinal pathologies, such as deformities and degenerative diseases. However, potential factors influencing the intradiscal pressure are indeterminate. The aim of this study therefore was to evaluate primary effects of intervertebral disc degeneration, age, sex, and segmental level on the intradiscal pressure of the lumbar spine using a large in vitro data collective.

METHODS: 107 human functional spinal units (32x L2-L3, 16x L3-L4, 59x L4-L5) from 68 donors (50±12 years, 19-74 years, 42% female) were evaluated from an in-house database. All specimens were loaded displacement-controlled (1°/s) with pure moments of 7.5 Nm in flexion/extension, lateral bending, and axial rotation using a well-established spine tester [1]. Intradiscal pressure was measured by means of flexible pressure sensors (FMSPEZ50, MIPM GmbH). Disc degeneration was assessed from radiographs using a validated classification system for the lumbar spine [2]. Statistical differences between intradiscal pressure values were evaluated using the Kruskal-Wallis test with Dunn-Bonferroni post-hoc correction for degeneration grade, age, and level, as well as the two-sided Mann-Whitney-U test for sex in SPSS 27. The significance level was set to 0.05.

RESULTS SECTION: The intradiscal pressure was significantly reduced for degeneration grades 1 (mild degeneration) and 2 (moderate degeneration) compared to grade 0 (no degeneration) in all motion directions and for the intrinsic pressure at 0 Nm ($p < 0.05$). The intradiscal pressure significantly correlated with age ($p < 0.05$), especially in extension (Pearson's $r = -0.687$), and was significantly reduced for an age > 40 years in all motion directions and for the intrinsic pressure ($p < 0.05$). Sex did not significantly affect the intradiscal pressure in any motion direction ($p > 0.05$). The intradiscal pressure at L4-L5 level was significantly reduced compared to the intradiscal pressure at L2-L3 level in all motion directions and for the intrinsic pressure as well as compared to the intradiscal pressure at L3-L4 level solely for the intrinsic pressure ($p < 0.05$). Intradiscal pressure-moment curves generally exhibited V-shaped characteristics for young, non-degenerated discs in flexion/extension and lateral bending, while being rather flat for older, more degenerated discs as well as bilateral axial rotation movements (Fig. 1). In general, the intradiscal pressure was significantly lower in axial rotation compared to flexion/extension and lateral bending ($p < 0.05$). In the overall collective ($n = 107$), no mutual effects of intervertebral disc degeneration, age, sex, and level were detected ($p > 0.05$), except significantly lower age for degeneration grade 0 compared to both grades 1 and 2 ($p < 0.05$), while there was no disc with grade 3 (severe degeneration) in the overall collective.

DISCUSSION: Increasing intervertebral disc degeneration and age as well as lower segmental level substantially reduce the intradiscal pressure of the lumbar spine. These factors therefore can be seen as key drivers for spinal pathologies involving the intervertebral disc by altering the load sharing situation within the spinal motion segment, particularly in the endplates and the annulus fibrosus. Sex, however, does not appear to have an effect on the intradiscal pressure. Effects of severely degenerated intervertebral discs (grade 3) could not be investigated in this study, since they usually do not have a nucleus pulposus anymore. However, it can be assumed that these discs do not maintain any load sharing capacity, further increasing the risk for spinal pathologies. In general, more degenerated discs exhibit low or even negative intradiscal pressure, questioning measurements in moderate or severely degenerated discs.

SIGNIFICANCE/CLINICAL RELEVANCE: This basic research study was performed under standardized conditions and includes a large data collective, allowing deep insight into effects of disc degeneration, age, sex, and segmental level on spinal load distribution, which are difficult to interpret from patient data or experimental studies with small sample sizes. Thus, the results of this study support clinicians in interpreting radiological findings and in optimizing surgical treatment strategies, e.g. for different age groups and segmental levels, and provide reference data for basic scientists.

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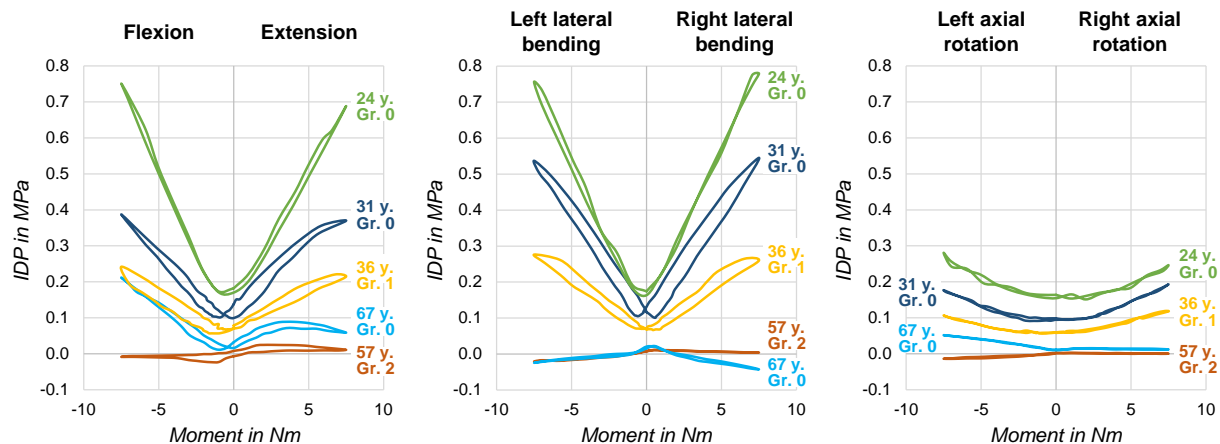


Figure 1. Exemplary intradiscal pressure-moment curves for different ages and intervertebral disc degeneration grades in the six primary motion directions.