

Age-referenced facet joint degeneration is associated with chronic low back pain whereas absolute grades are not: a population-based normative modeling study

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Introduction

Facet joint degeneration is strongly age-dependent and common even in asymptomatic adults, limiting the clinical interpretability of absolute degeneration grades. We derived level-specific age-expected facet joint degeneration equations and tested whether age-inappropriate degeneration is associated with chronic low back pain (cLBP) and pain intensity.

Materials and Methods

This cross-sectional analysis included 1,088 participants (18–72 years) from a population based study. Facet degeneration was evaluated on standardized MRI using Fujiwara classification at levels L1/2–L5/S1. In the asymptomatic reference cohort ($n = 353$), segment-specific age-expected degeneration was modelled to obtain normative values. Individual deviation from the age-expected trajectory was quantified using standardized residuals and categorized as below-expected, age-expected, or above-expected (± 1 SD) (Fig. 1). As a comparator, we additionally classified absolute non-age-adjusted Fujiwara grades based on reference distribution (± 1 SD). Associations with cLBP were evaluated using multivariable logistic regression, whereas pain intensity was analyzed using multivariable linear regression; both models were adjusted for sex, BMI, and pack-years.

Results

Age-adjusted residual-based classification revealed significant associations with cLBP, strongest at L4/5 (above vs below OR 3.45, 95% CI 2.00–5.93; $p < 0.001$; Fig. 2). Significant extreme-group contrasts were also observed at L5/S1 (OR 1.86, 95% CI 1.10–3.13; $p = 0.020$) and for the L1–S1 sum score (OR 2.39, 95% CI 1.36–3.98; $p = 0.003$). Associations with pain intensity were only significant at L5/S1 (above vs. below $\beta = 0.57$ (0.15–0.98); $p = 0.008$). In contrast, the comparator model using non age-adjusted Fujiwara values showed no significant associations with cLBP or pain intensity at any lumbar level.

Conclusion

This study establishes novel age-referenced normative equations for lumbar facet joint degeneration on routine MRI. Classifying degeneration according to deviation from age-expected trajectories identified significant and segment-specific associations with cLBP, whereas absolute grade classification showed none. Age-referenced interpretation may therefore enhance the clinical relevance of degenerative MRI findings, enable more standardized reporting of facet joint degeneration across age groups, and provide a basis for individualized risk stratification and targeted prevention.

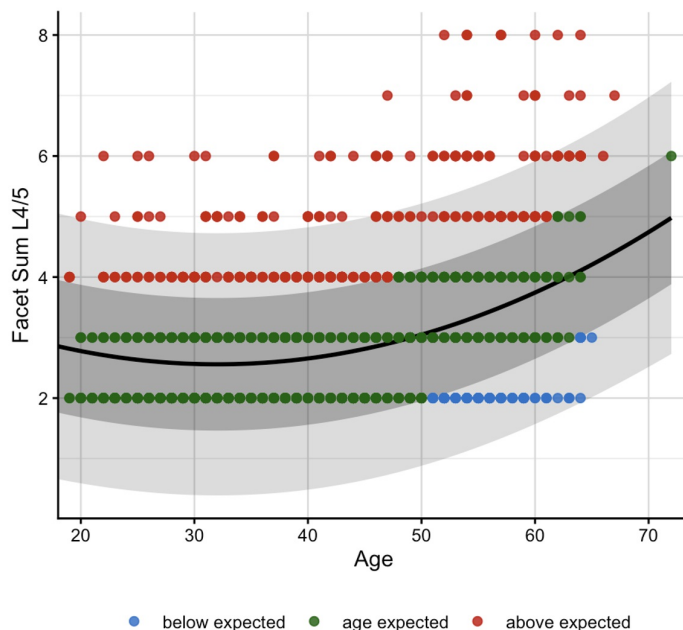


Figure 1: The quadratic regression expectation curve for Fujiwara grades (L4/L5; left + right joint) is shown in black. The green band indicates the age-expected range (± 1 residual SD), and the light gray band the 95% prediction interval. Dots represent observed L4/5 Fujiwara grades and are color coded by age-dependent classification (blue = below expected, green = age-expected, red = above expected).

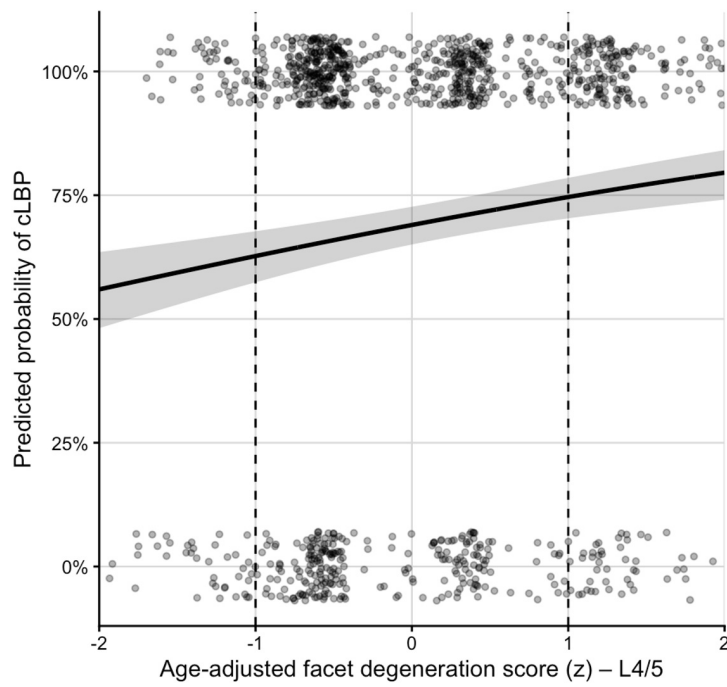


Figure 2. Predicted probability of cLBP as a function of the age adjusted L4/5 facet joint degeneration score (z). The solid line shows the fitted logistic regression model with 95% confidence interval (shaded). The z -score was derived from residuals of a quadratic age-degeneration model fitted in the pain-free cohort. Vertical dashed lines indicate cut-offs for below-expected ($z < -1$), age-expected ($-1 \leq z < +1$), and above-expected degeneration ($z \geq +1$). Jittered points depict individual outcomes (bottom = no cLBP; top = cLBP); vertical jitter reduces overplotting.