Global and regional deformation of the knee cartilage after kneeling and squatting – Analysis of size, distribution and pattern with HR-MRI at 3T

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Purpose: Cartilage strain is discussed as potential cause for cartilage degeneration and subsequent osteoarthritis. This study evaluates the currently unknown dimension of global and especially regional cartilage deformation and its topographical distribution in knee cartilage (femur, patella, tibiae) after kneeling and squatting [1,2].

Materials and Methods:
The right knees of 10 healthy volunteers (5f, 5m) were examined before and after accomplishment of 90° kneeling or squatting for 10 min respectively, as well as after 90 min. of rest in a 3 Tesla scanner using a high-resolution cartilage dedicated FLASH-3D-WE-sequence (TR 14.2ms / TE 7.2ms / FA 15° / resolution 0.3²x1.5mm³ / matrix 512² / VOF 16 cm) [3]. Each exercise was performed on a separate appointment and after 1 hour of rest prior to exercise. Patellar, femoral and tibial cartilage were semiautomatically segmented and 3D reconstructed. Volume (Vol), mean thickness (mTh) and bone-cartilage-interface (BCI) were calculated for global (whole) cartilage plate and regional cartilage zones (according to IKDC). Thickness and thickness difference plots were generated for visualization of focal deformations. Voxel-based thickness, intra-reader segmentation and test-retest reproducibility was calculated by RMSA and statistics by t-test.

Results: Average voxel-based reproducibility for thickness was under voxel-size for local thicknesses <1mm. Segmentation reproducibility was 1%, test-retest reproducibility 2-4% for Vol/mTh and 1-2.8% for CBI. No significant change of BCI was found after exercise and after rest. Global parameter change was 2.1-4.9% Vol and 2.5-4.7% mTh after kneeling, 2.1-2.4% Vol and 1.4-1.8% mTh after squatting. Regional changes were much larger (figure A/B). No significant change was found after resting as compared to the baseline examination except. Thickness difference maps (figure C/D) revealed focal cartilage deformation after squatting in the lateral patella, anterolateral tibia and at the lateral aspect of the medial femoral condyle, after kneeling in the central regions of the patellar and lateral tibia cartilage and diffusely in the femoral cartilage.

Conclusion: Detected small global cartilage deformation laid within the magnitude of change after common daily exercise and sports [4]. This is consistent with biomechanical examinations. During the process of kneeling/squatting pressure on joint cartilage rises, but decreases with initiation of soft tissue contact of thigh and lower leg and by pressure release of the floor [5]. 3D-volumetry enable anatomy- and individuum-specific analysis by detailed depiction of regional deformation, while global parameters used to average out local changes leading to underestimation of changes. The data indicate areas of deformation across the joint surface and might serve as a base for comparison to degenerative changes in patients and as a database for the development of biomechanical models.

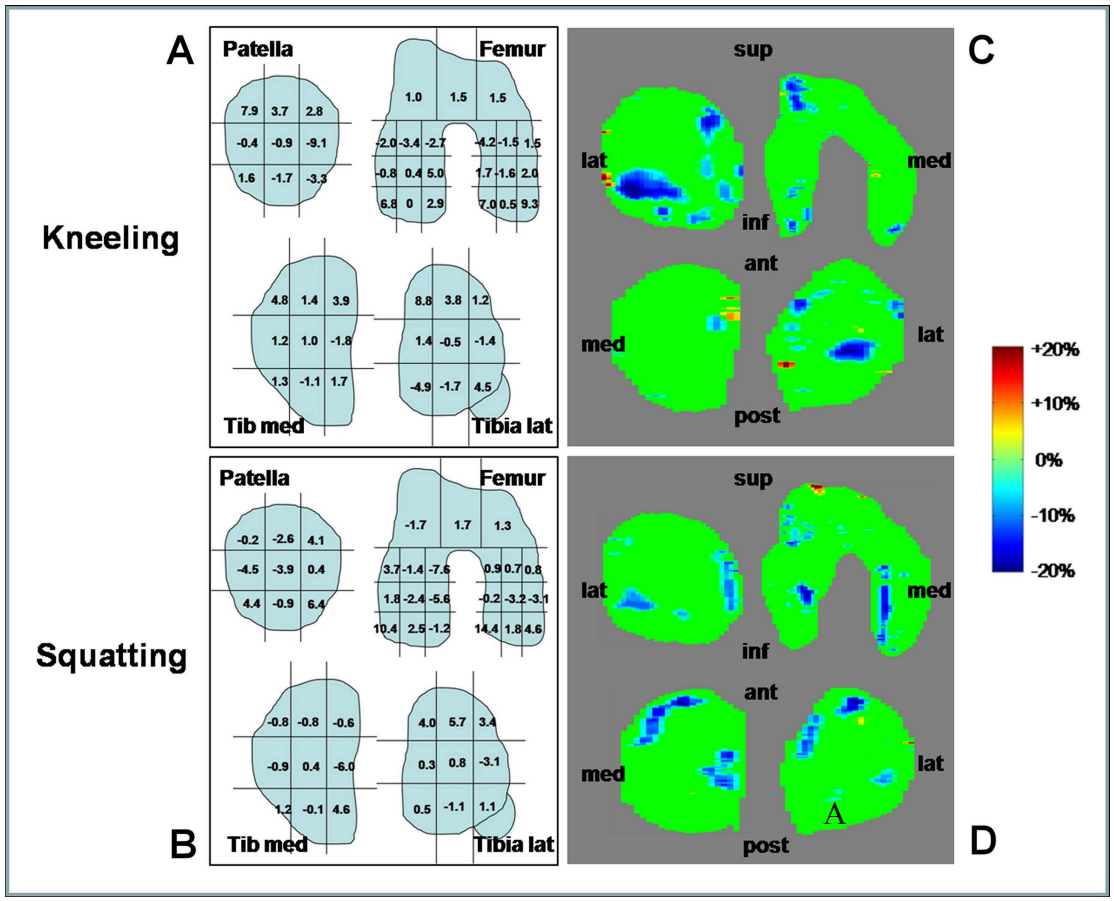

Figure
Deformation changes in percent (negative values – thickness reduction, positive values – thickness increase) after kneeling (A) and squatting (B) according to regional subdivision according to IKDC. Individual thickness difference maps (C – kneeling, D – squatting) reveal corresponding focal changes (color-coding in percent).

Literature:
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