**ESSR Sports Imaging Subcommittee -** The interesting Paper 2023 Q1

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**Application of diffusion microstructure imaging in musculoskeletal radiology — translation from head to shoulders**

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***Background:***

Quantitative MRI techniques are increasingly applied to non-invasively assess the structural integrity of muscles. Using the DIXON technique fat fraction analyses are increasingly applied. Besides T2 relaxation time measurements (assessing primarily muscle edema) and Intravoxel incoherent motion (IVIM; assessing primarily muscle perfusion/ activation), also Diffusion tensor imaging (DTI) is increasingly applied for musculoskeletal tissues such as muscle. DTI was originally applied for brain imaging including tractography. DTI provides subvoxel microstructural information. The advanced quantitative imaging technique called “diffusion microstructure imaging” (DMI) was also initially applied in neuroimaging. DMI is a multicompartment technique that provides even more specific insights into the microstructural integrity compared to single compartment DTI. Compartments / Parameters evaluated are: (i) the free fluid (V-ISO), where molecules randomly move at the distance of their diffusion length; (ii) the compartment inside of muscle fibers with almost one-dimensional molecule diffusion due to tight membrane borders of the sarcolemma (V-intra); (iii) the compartment outside of muscle fibers (V-extra).

For quantitative fat fraction measurements a correlation of higher fatty infiltration of the rotator cuff muscles with reduced muscle strength has been demonstrated (e.g. supraspinatus fat fraction with abduction). The novel DMI technique however had never been applied for skeletal muscle tissue so far.

***Manuscript summary:***

Purpose of the study by Rau A et al. was to (i) to demonstrate the feasibility of DMI of rotator cuff muscles and provide an initial estimate of normal values, (ii) to assess the association with MR imaging- based Dixon fat fraction measurements, and (iii) to correlate DMI with isometric strength measurements in n=22 healthy volunteers (11 male, 11 female). The authors found higher

V-intra and lower V-ISO in all rotator cuff muscles of males compared to females. No statistically significant sex difference was found for V-extra and for the DIXON based fat fraction measurements the difference was also not significant. While fat fraction measurements did not correlate with strength measurements. Correlations were found for lower V-ISO and higher V-intra with greater muscle strength for nearly all rotator cuff muscles; for the Subscapularis muscle the correlation remained significant after adjustment for sex. There was a significantly different V-extra between the group with a lower external rotation strength/ internal rotation strength ratio versus the group with a higher ratio. The authors conclude, that since fat fraction measurements did not correlate with strength measurements but DMI parameters correlated significantly with strength measurements in young, healthy individuals, multicompartmental DMI measurements could provide more detailed information about rotator muscle composition, quality and function than fat fraction measurements particularly in young healthy individuals.

**Plus:**

- Transition from Neuroimaging to Skeletal muscle has nicely been demonstrated.
- Exemplary images are provided.
- Results are promising and may contribute to a more specific and individualized, quantitative microstructural muscle composition and function analysis with potential clinical implications.

**Limitations:**

- Only young volunteers.
- Small cohort and no pathological shoulders
- No histological correlation, only assumptions transferred to MSK radiology from Neuroradiology

**Comment:**

While fat fraction measurements may be particularly useful in the older population, they seem to fail in young healthy individuals. Rau a et al. have nicely demonstrated the transition of another promising quantitative technique from brain to muscle, that may overcome or be an add on to fat fraction measurements for skeletal muscle. Diffusion microstructure imaging could be used for therapy monitoring, particularly in young active patients. These frequently suffer from imbalance of the shoulder due to weakness of the external rotators. These imbalances may be detected and monitored. DMI may potentially support physical therapy and decision-making on return-to-play in athletes. However, further investigations in larger cohorts, pathological patients and in other skeletal muscle regions are required.