Correlation between quantitative MRI features and functional assessment of myopathy

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Target audience:

Clinicians/researchers in study of myopathy and functional assessment of patients with myopathy.

Purpose:

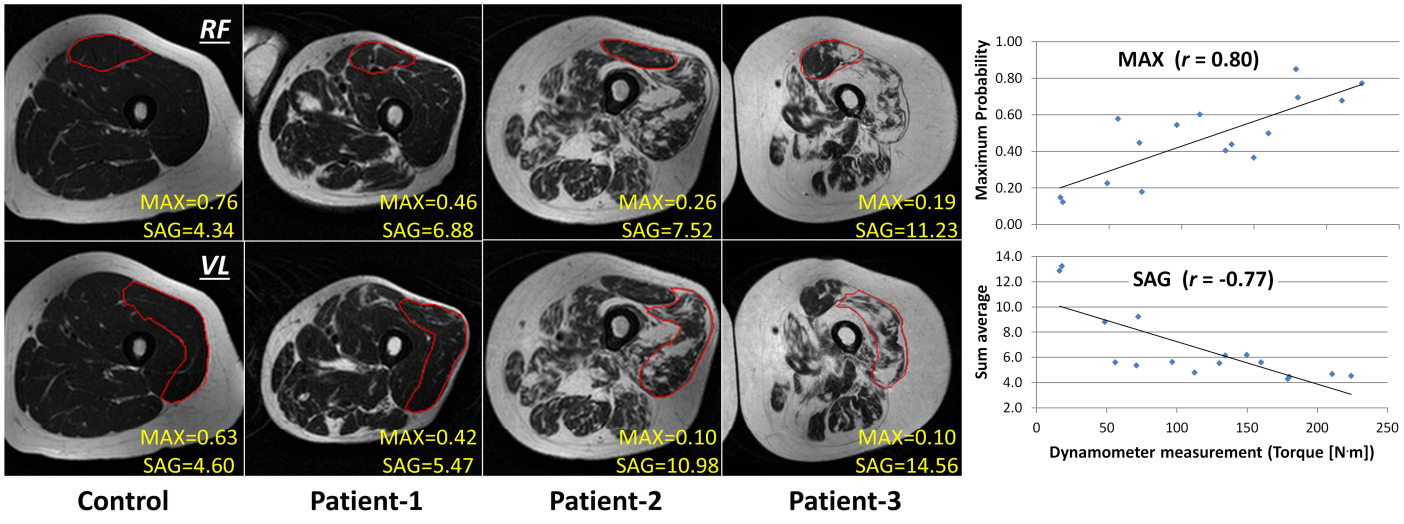
Hereditary inclusion body myopathies, typically manifested as neuromuscular disorders, are characterized by progressive muscle weakness and atrophy. The muscle strength in upper and lower extremities is usually measured using medical dynamometers to assess the disease progression and/or intervention efficacy. Such tests, however, may be time-consuming and subjective requiring validation with a standard; training/fatigue could also potentially confound the results when test is conducted over any length of time. Despite superior soft-tissue contrast and lack of ionizing radiation, the role of MRI in the study of myopathy has been relatively limited and subjective in nature. The feasibility of quantitative analysis of texture features based on MRI for diagnostic prediction in breast lesions has been previously demonstrated.[1] In this study, quantitative analysis of texture features in thigh MRI is investigated in different individuals with varying degrees of myopathy by correlating them with lower extremity muscle strength measured with isokinetic dynamometer.

Methods:

MRI and biophysical evaluation were performed on eight subjects consisting of controls (n=3; mean/range-age: 53/38-65 yr.) and patients (n=5; mean/range-age: 44/28-56 yr.) with myopathy. MRI was performed on a 3T scanner (Philips Medical Systems, Best, Netherland). Bilateral T2w thigh scan was performed in 25 contiguous axial slices with following parameters: TR/TE=6957/100 (ms) and voxel-size=0.8x0.8x5.0 (mm^3). Offline image processing including region-of-interest (ROI) drawing and texture analysis based on a diagonal spatial-offset Gray-Level Co-occurrence Matrix[2] (GLCM) were performed using Medical Imaging Processing, Analysis and Visualization (MIPAV; National Institute of Health, Bethesda, Maryland, USA) and custom program developed in Matlab (MathWorks, Natick, MA, USA), respectively, on exported Digital Imaging and Communications in Medicine (DICOM) images. The maximal muscle torques of the knee extensors and flexors were measured unilaterally using a dynamometer (Biodex System 3; Biodex Medical Systems, Shirley, NY, USA). With respect to knee extension, subjects were required to produce maximal contractions at angular velocity of 60˚/sec. Dynamometer measurements (n=16) were then correlated with imaging features obtained and averaged from a single mid-axial slice for each of 2 muscle groups that were segmented manually: rectus femoris (RF) and vastus lateralis (VL).

Results:

Mosaic images below show left-thigh MRI from 4 subjects with varying degrees of myopathy. Also shown with the images are the 2 muscle-group ROIs (RF and VL) along with the 2 GLCM texture features studied from the segmented muscle groups here: maximum probability (MAX) and sum average (SAG). The texture values averaged over the 2 muscle groups in each side for each of the 2 texture features were shown in separate scatter plots against the unilateral dynamometer measurements of muscle-contraction (torque) of the 2 muscle groups. Linear regression analysis showed a statistically significant correlation between each of the 2 texture features and the dynamometer measurements: r = 0.80 ($P < 0.0005$) and r = -0.77 ($P < 0.0005$) for MAX and SAG, respectively.



Discussion:

Muscle-loss and/or fat-infiltration are clearly depicted in MRI which makes it an ideal imaging tool in study of neuromuscular disorders manifesting muscle atrophy. Quantitative assessment of the degree of muscle atrophy using MRI and texture analysis could also potentially provide additional functional information regarding the muscle group(s) in question beyond a mere subjective impression of the disease severity. Such capability could serve as an invaluable imaging marker in study of the disease progression and/or treatment intervention in both clinical and research setting.

Conclusion:

This study demonstrates a feasibility of quantitative MRI features based on texture analysis as a means for potential functional assessment of muscle function by correlating with the muscle strength measured by isokinetic dynamometer.

References:

[1] Nie K, Chen JH, Yu HJ, et al. Quantitative analysis of lesion morphology and texture features for diagnostic prediction in breast MRI. Acad Radiol 2008;15:1513-25. [2] Castellano G, Bonilha L, Li LM, et al. Texture analysis of medical images. Clinical Radiology 2004;59:1061-9.