Comparison of the influence of a single exercise session on quantitative muscle fat fraction (FF) and diffusion (fractional anisotropy (FA)) imaging with MRI

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Introduction

We examined the influence of a single exercise session on quantitative muscle fat fraction (FF) and diffusion (fractional anisotropy (FA)) MRI measurements. Muscular exercise will result in glyocogenolysis and lipolysis as well as increased water influx into the muscle cells. We therefore expect to find a reduced relative fat fraction and lower fractional anisotropy after an exercise session.

Methods

For this ethics board approved trial, 10 healthy non-trained volunteers (3 men, 8 woman; mean age 24y) were scanned on a 3T (MR-Verio Siemens Medical, Germany) body scanner before and after a session of bilateral squats. Images were acquired at a fixed distance from the knee joint. FF were calculated from axial in- and opposed phase images using a 2-point Dixon (TR 20 ms, TE 2.45/ 3.675 ms, flip angle 15°) technique. Furthermore a diffusion-weighted imaging method using read-out-segmented echo-planar imaging (TR 4819 ms, TE 48/ 75 ms, flip angle 180°) was used [1]. All volunteers were scanned twice during one session: after the initial scan volunteers performed bilateral squats until muscular fatigue was reached. Scanning was repeated with identical parameters and positioning. Due to positioning problems during the scan the post-exercise dataset of one volunteer was unavailable and was therefore excluded from analysis. ROIs were drawn outlining the large muscles of the thigh (rectus femoris, vastus intermedius, medialis and lateralis, semimembranosus, semitendinosus, biceps femoris, sartorius, gracilis) using specialised open source software [2] and cross sectional area (CSA) was calculated for each muscle. The Dixon images were evaluated using an in-house developed evaluation tool (Matlab R2011a, The MathWorks Inc., Natick MA, USA) and the diffusion images with Brain Voyager QX (Version 2.4, Brain Innovation, The Netherlands).

Results

Before exercise on a muscle-by-muscle basis we found a wide variability in FF (6.09% to 14.7%) and FA values (0.28 to 0.53). Mean CSA per muscle was 946 mm^2 (279 – 2015 mm^2) and did not change during the exercise session. The results of the mean FA values and the FF data in % are shown in Table 1. There was no significant difference of the mean FA values before and after the exercise. In contrast we found a reduced FF of the four muscles of the quadriceps, the sartorius on both legs and of the Hamstrings before the exercise. Furthermore an increased FF in the left hamstrings after exercise and the gracillis for both legs was located. Changes in FF did not correlate to CSA.

Discussion

Our FA results are in good accordance with values shown in a previous study [3] for lower leg muscle. Contrary to our expectations FA values pre and post exercises were almost identical. Fractional Anisotropy measurements have been applied to muscle tissue manly for research question but have the possibility to be used as well for clinical questions [3, 4, 5]. FF measurements are increasingly used in trials of quantitative MRI in neuromuscular disorders [6, 7], but no change in FF due to exercise was demonstrated to date. Our expectation of an increased water inflow resulting in an increased CSA and lowered FA was not fulfilled. We therefore propose that the reduced FF might be caused by lipolysis. Spectroscopic analysis of muscle fat composition during exercise might elucidate this question.

Conclusion

In conclusion, a single exercise session might influence the apparent muscle fat measurements. Trials using MRI as surrogate outcome parameter in neuromuscular disease should therefore take care to avoid strenuous tasks in their participants before the MRI scanning session.

	pre exercise				post exercise			
	right leg		left leg		right leg		left leg	
	FA	FF	FA	FF	FA	FF	FA	FF
Rectus femoris	0.32	7.09	0.29	8.85	0.33	6.68	0.33	8.06
Vastus medialis	0.28	6.09	0.28	7.16	0.29	5.45	0.29	6.41
Vastus intermedius	0.32	6.98	0.31	6.42	0.32	6.62	0.32	6.23
Vastus lateralis	0.37	7.51	0.33	6.70	0.36	6.96	0.33	6.40
Semimembranosus	0.46	8.30	0.31	8.70	0.47	8.14	0.29	9.93
Semitendinosus	0.53	9.62	0.39	7.64	0.53	9.23	0.38	7.69
Biceps femoris	0.50	7.80	0.40	8.24	0.51	7.55	0.38	8.48
Sartorius	0.37	12.42	0.38	14.70	0.39	11.30	0.37	12.82
Gracilis	0.49	8.64	0.36	10.19	0.48	8.84	0.35	10.85
Quadriceps	0.32	6.92	0.30	7.28	0.33	6.43	0.32	6.78
Hamstrings	0.49	8.57	0.37	8.19	0.50	8.31	0.35	8.70

Table 1: Comparison of mean FA (Fractional Anisotropy) values and mean FF (fat fraction) (given in %) before and after exercise.

References

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