From food to muscle: Dietary-induced effects on muscle in a longitudinal animal study

Claudia Fellner[1], Christine Hechtl[1], Roland Büttner[2], Okka H. Hamer[1], Christian Stroszczynski[1], and Cornelius Bollheimer[2]
[1]*Institute of Radiology, University Medical Center Regensburg, Regensburg, Germany,* [2]*Internal Medicine I, University Medical Center Regensburg, Regensburg, Germany*

INTRODUCTION:

Aggravating effects of obesity on the development of sarcopenia – an exceeding decline of muscle mass with aging – is currently discussed in the literature. In a recent study we were able to support this concept of "sarcopenic obesity" in an animal model with 16 months-old male rats. Therefore, the aim of this study was to investigate very early dietary-induced changes on muscle size and tissue composition in female rats.

METHODS:

Following a baseline MR examination at the age of 6 months, female Sprague-Dawley rats were allocated into 2 groups: one group received a lard-enriched diet containing 43 energy % fat while the control group was fed with a standard rodent chow (10 energy % of fat). Longitudinal observations at the age of 12 and 16 months were possible in the hitherto surviving 20 high fat fed rats (HFR) and 12 control rats (CR).

MRI and MRS of the rats were done on a clinical 1.5 T scanner (Magnetom Avanto, Siemens) using an 8-channel knee coil. T1-weighted SE images (TR: 450 ms, TE: 11 ms, voxel size: 0.4 x 0.4 x 2.0 mm^3) were acquired perpendicular to the M. quadriceps of both hindlimbs to assess the maximum cross sectional area (CSA) of this muscle. T2-mapping without and with spectral fat saturation (fs) was performed applying a multi-echo SE sequence (TR: 2800 ms, TE: 14-169 ms; voxel size: 0.4 x 0.4 x 2.0 mm^3) at the position of the CSA. T2 relaxation times were assessed in user-defined ROIs of color-coded maps over the whole CSA of the M. quadriceps. Furthermore, SVS 1H MRS (TR: 2000 ms, TE: 30 ms; voxel size: 12 x 6 x 7 mm^3) was acquired and total lipid (Lip_{ref}) was evaluated taking into account all lipid signals (Lip: 0.9-1.6 ppm, 1.9-2.6 ppm) relative to the water-signal of an external reference (Ref) according to the formula: Lip_{ref} = 100 (Lip/Lip+Ref).

All parameters were assessed for both hindlimbs and means were calculated for further evaluation. Statistical analysis for comparison of both diet groups, HFR and CR, and for age-related effects was done using the exact two-sided Mann-Whitney test; P-values below 0.05 were regarded statistically significant.

RESULTS:

The body weight of all animals increased significantly with advancing age. In doing so, the high fat diet resulted in a significantly larger increase than the control diet did (Table 1). In contrast to body weight, CSA of the M. quadriceps did not show any significant diet- or age-related change until the age of 16 months.

The lipid content of muscle varied over a wide range with a strong increase until the 12th month of age; although this increase was even more pronounced with high fat diet (Table 1, Figure 1), there was no statistical significant difference between boths diets. Both T2 relaxation times yielded relevant diet-dependent effects: Up to the age of 16 months, T2 relaxation times decreased significantly in CR, but not for HFR. Furthermore, T2 with fs were slightly lower than T2 without fs. These results seem to indicate that increased lipid content in muscle does also increase its T2 relaxation time, but is not the only reason for age- and diet-related changes.

	6 months all animals	HFR 12 vs. 6 mo., % change	CR 12 vs. 6 mo., % change	HFR 16 vs. 6 mo., % change	CR 16 vs. 6 mo., % change
n	32	20	12	20	12
body weight [g]	402 ± 40	*21.7 ± 11.2	*12.5 ± 5.8	*35.5 ± 14.7	*21.9 ± 10.9
CSA [cm^2]	1.46 ± 0.11	2.2 ± 3.2	3.2 ± 7.4	2.4 ± 5.0	-1.8 ± 8.5
T2 [ms]	31.8 ± 0.7	*-0.1 ± 2.3	*-2.7 ± 2.1	0.9 ± 3.5	-2.5 ± 2.8
T2 fs [ms]	31.5 ± 0.6	-1.5 ± 2.2	-3.0 ± 1.9	-1.4 ± 2.6	-2.2 ± 2.0
Lip_{ref}	0.21 ± 0.06	74.5 ± 64.3	53.4 ± 47.0	84.2 ± 86.5	56.8 ± 55.3

Table. 1: Results of high fat diet fed rats (HFR) and control rats (CR) at the 6, 12, and 16 months: Means and standard deviations for each group, age-related changes relative to baseline (6 months), *: significant differences (P<0.05) between HFR and CR of the same age.

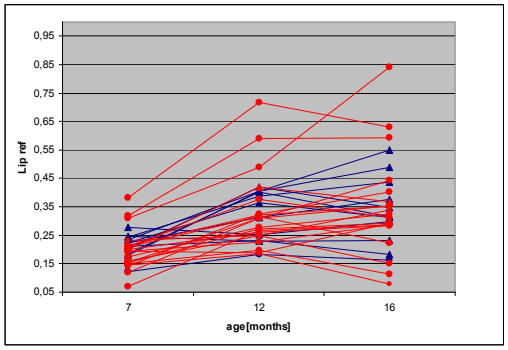

Figure 1: Individual time courses of the lipid content (Lip_{ref}) for high fat diet fed rats (HFR, red dots) and control rats (CR, blue triangles).

CONCLUSION:

Until the age of 16 months, increased accumulation of body weight in female rats with high fat diet relative to control animals is accompanied by a larger lipid content in quadriceps muscles – without changing the cross sectional area of the muscle. That means, no signs of sarcopenia were found in female rats at the age of 16 months, irrespectively of their nutrition. To further investigate the concept of sarcopenic obesity, this experiment has to be continued in still older female rats.

Acknowledgement: This work is supported by "Robert-Bosch-Stiftung", grant number: 32.5.1141.0030.0.