Can larger intramyocellular lipid (IMCL) content conserve glycogen during endurance activity and increase maximal performance?

M. Ith[1], M. Zehnder[1], E. R. Christ[2], K. Acheson[3], R. Kreis[1], J. Décombaz[3], C. Boesch[1]

[1]Dept.Clinical Research, University & Inselspital, Berne, Switzerland, [2]Dept. Endocrinology and Diabetes, University & Inselspital, Berne, Switzerland, [3]Nestlé Research Center, Lausanne, Switzerland

Introduction:

The relative contributions of intra-myocellular lipids (IMCL) and glycogen to the energy demands during exercise are still a matter of debate. In competitive sport, it would be particularly desirable to increase the contribution of lipid energy with the aim to spare muscle glycogen for the later part of a race. This study investigates the effect of different IMCL levels on the usage of IMCL and glycogen during sub-maximal exercise, and evaluates whether higher IMCL levels result in glycogen conservation and/or increased subsequent maximal performance.

Volunteers and Methods:

Eleven endurance-trained male athletes (mean ± SD age: 31 ± 6 years; body mass (BM): 74 ± 8 kg; VO2 peak: 63 ± 7 ml/min/kg BM; maximal workload (Wmax): 365 ± 29 Watts) were investigated twice in a randomized crossover design: preparatory diet (3 days) - depletion (3 h bicycle) - MRS ("session1") - distinctive diet period (low fat vs. high fat) - MRS ("session 2") - depletion (3 h bicycle) - MRS ("session 3") - 20-km time trial. While carbohydrate intake was identical on both occasions (7g/kg BM/d), two types of diet were given: low fat diet (LF: fat < 0.5g/kg BM during 2.5 days) and high fat diet (HF: fat < 0.5g/kg BM during 1 day followed by fat =3.5g/kg BM during 1.5 days). Depletion was achieved during a 3 h bicycle-ergometer exercise (50 % Wmax), the 20-km time trial (TT) was done on a racing bicycle (back wheel fixed to a magnetic brake).

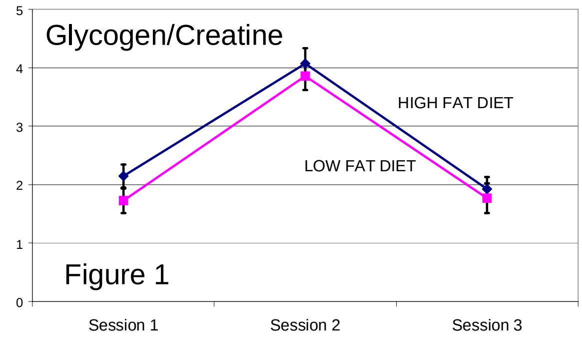
MRS: SIGNA 1.5 Tesla MR-system (General Electric); flexible, 13C/1H double-tuned coil (Medical Advance, Milwaukee WI) located over the m.quadriceps femoris. 1H-MRS: Acquisition (PRESS, TE 20 ms, 12 x 11 x 18 mm3 in m.vastus intermedius) and absolute quantitation of IMCL as described earlier [1]. 13C-MRS: pulse-and-acquire (11 x 11 cm2, adiabatic pulse, TR 165 ms, 3 x 4000 acquisitions), CW decoupling and NOE buildup (home-built second channel). Glycogen was calibrated by the signal area of creatine since the concentration of creatine is expected to be reasonably constant (demonstrated by 1H-MRS signals). Oxygen (VO2) and carbon dioxide (VCO2) were determined by volume and gas analysis (Vmax 29c, Sensor Medics/Netherlands).

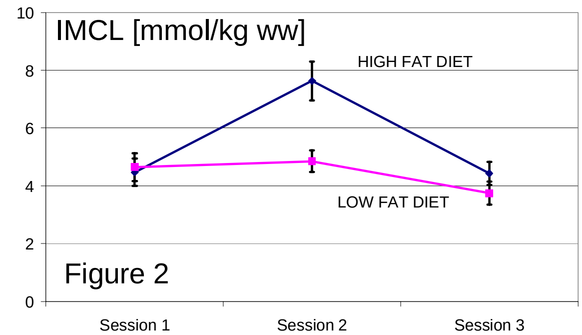
Results:

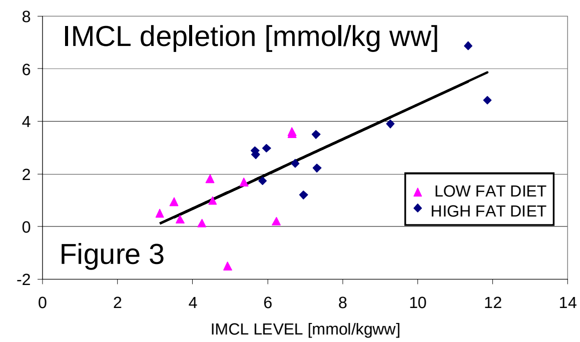
IMCL (Fig.1) and glycogen levels (Fig.2) were indistinguishable between both sessions of the crossover design after the first depletion (session 1, avg +/- sem). The distinctive diet led to significantly higher ($p < 0.001$) IMCL levels after HF compared to LF, whereas glycogen levels were comparable. Subjects reduced glycogen/creatine by the same amount during exercise, independent of the preceding diet (Fig.1), whereas IMCL utilization was significantly larger after HF ($p < 0.001$, 3.2 ± 1.6 mmol/kgww) than after LF (1.1 ± 1.6 mmol/kgww), leading to the same post exercise concentrations of IMCL after either diet ($p = 0.187$ at session 3). Fig.3 shows a strong correlation ($R = 0.81$, $p < 0.001$) between IMCL levels prior to and their depletion during the 3 h exercise. During the trial, average total fat- and CHO-oxidation as well as energy expenditure were the same after HF and LF diet. Fig.4 demonstrates that subjects were faster during the second, third, and last 5 km of the time trial, however, without reaching significance (velocity minus individual mean velocity, in order to compensate for individual differences in performance, avg +/- sem).

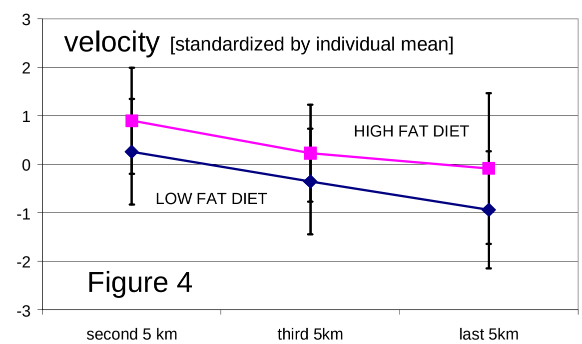
Discussion:

Starting from almost identical levels in the two cross over periods, carbohydrate intake leads to almost identical glycogen/creatine levels at session 2, whereas IMCL levels were significantly different after the two distinctive diets. During the second depletion period (session 2 – session 3), IMCL levels did not influence glycogen utilization. In contrast, a larger amount of IMCL was completely used and IMCL levels were depleted to the same levels, independent of the IMCL levels at session 2. Data in Fig.3 clearly demonstrates the fact that the higher the initial IMCL levels are, the larger is their contribution during sub-maximal exercise. Since total fat and carbohydrate oxidation were similar in both tests, it would appear that larger IMCL utilization is compensated for by lower contributions from blood energy substrates. There was a tendency toward better performance after the high fat diet, however, individual variations were larger than the improvement.









Conclusions:

Already a short (1.5 days) high fat diet modulates IMCL and influences fat metabolism. Above a certain level, IMCL seems to be used preferentially, i.e. large amounts of IMCL lead to larger utilization. Short term, higher fat intake tends to improve performance.

Reference: [1] C.Boesch et al Proc.Nutr.Soc. 58: 841-850 (1999).

Acknowledgments: Supported by Swiss National Fund (3100-065315.01).