CERAMIDE IN HUMAN SKELETAL MUSCLE – COUPLING TO GLYCOGEN BREAKDOWN AND FIBER TYPE?

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Introduction: In a prior study ceramide muscle content was higher in endurance trained compared to untrained males at rest and significantly elevated in both groups after prolonged acute exercise (1), indicating a possible association between ceramide and glycogen breakdown. The present study aimed to investigate if exercise induced glycogen depletion influences muscle ceramide concentration in human skeletal muscle.

Method: Healthy male subjects (n=10, age 26±1 years, BMI 24.1±0.7 kg/m2, VO2max 4.5±0.2 L/min) participated in the study. The protocol utilised high intensity (intermittent) knee extension exercise to deplete muscle glycogen in m. quadriceps femoralis in one leg (DL) followed by a low carbohydrate diet (day 1). On day 2 prolonged high intensity knee extension exercise at 90% peak power output was performed simultaneously with the (DL) and the control leg (CL) to exhaustion. Muscle biopsies obtained before and after exercise were analysed by HPLC and mass spectrometry obtaining data on muscle ceramide concentrations. Histochemical methods were applied to determine fiber type and fiber type specific glycogen concentration and breakdown.

Results: Fiber type distribution between type I, I/IIa, IIa, IIa/IIx and IIx was 59.4±4.3, 4.6±1.3, 21.9±2.3, 6.8±1 and 7.3±1.9 %, respectively. Muscle glycogen was lowered (P<0.001) 50% by depletion, to 202±31 nmol mg-1 d.w. in DL compared to the basal level in CL (407±31 nmol mg-1 d.w.). During exercise on day 2 an additional 25% of muscle glycogen was broken (P<0.01) down in DL (110±31 nmol mg-1 d.w.) and a 65% glycogen breakdown was observed in CL (140±38 nmol mg-1 d.w.). Muscle glycogen after exercise was similar in DL and CL. The fibre type specific muscle glycogen breakdown followed a similar pattern as the overall glycogen breakdown, except that during exercise (day 2) glycogen was not utilised from the already depleted type I fibers in DL. Muscle ceramide concentration was not changed by depletion (56±4, 58±2 pmol mg-1 d.w.) or after exercise on day 2 (58±2, 59±2 pmol mg-1 d.w.) in either DL or CL, respectively. However, in DL the calculated difference in ceramide concentration by depletion ([Ceramide conc. in CL] −[ceramide conc. in DL]) was correlated to the breakdown of muscle glycogen in all fibers and in type II fibers during exercise (P=0.002, r²=0.78 and P=0.01, r²=0.64, respectively).

Conclusion: In conclusion these data demonstrates that muscle ceramide concentration was not influenced by exercise or glycogen depletion. However, the results do indicate a possible association between changes in ceramide concentration and skeletal muscle glycogen utilisation patterns and implies that fiber type may play a role in muscle ceramide metabolism.

References: 1 Helge et al. Exp. Physiol. 2004, 89: 112-19. Keywords: Skeletal Muscle Fatigue, Lipid Metabolism, Glycogen Stores