Postprandial Hepatic Glycogen Levels following a Low v High Glycaemic Index Breakfast: A ^{13}C MRS Study

S Bawden[1,2], MC Stephenson[3], K Hunter[4], M Taylor[5], L Marciani[1], PG Morris[2], IA Macdonald[6], GP Aithal[1], and PA Gowland[2]

[1]NIHR Nottingham Digestive Diseases Biomedical Research Unit, Nottingham University Hospitals NHS Trust and University of Nottingham, Nottingham, United Kingdom, [2]Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, United Kingdom, [3]Agency for Science, Technology and Research, Singapore, [4]Unilever Discover, Bedfordshire, United Kingdom, [5]Faculty of Human Nutrition, University of Nottingham, United Kingdom, [6]School of Life Sciences, University of Nottingham, United Kingdom

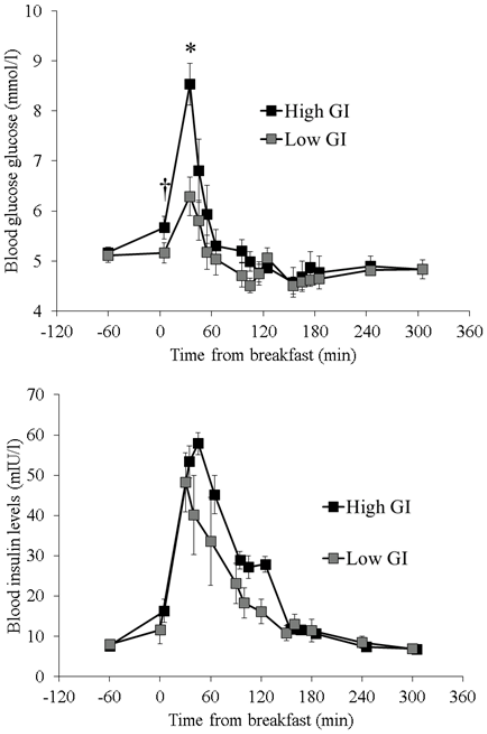

Figure 1. Blood glucose and insulin response *P<0.05, †P<0.01

Background: Natural abundance ^{13}C MRS provides the only non-invasive method of measuring liver glycogen levels *in vivo* and has been validated in clinical studies [1] . This method has been used to show postprandial liver glycogen responses, which increase steadily until reaching a peak with a subsequent decline [2]. Glycaemic index (food ranked according to the blood glucose response) is an important factor in the postprandial metabolic response and studies has shown significantly different muscle glycogen responses to a low (LGI) v high (HGI) glycaemic index test meals [3, 4]. The present study compared the liver glycogen response to a HGI v LGI test meal as part of a wider dietary intervention study.

Study Design: After obtaining ethical approval, 8 healthy males were recruited following informed consent (sedentary, non-smokers, no metabolic disorders, age=20.1 ± 0.4 years, BMI=23.0 ± 0.9 kg m^{-2}). Subjects were investigated using a two way randomized cross over study design with >4 week washout between test visits. During the test day subjects arrived at the test centre between 7:30 and 8:30 am and were asked not to eat anything from 10pm the previous evening. ^{13}C MRS were acquired from the liver at baseline, and hourly following consumption of a calorie matched LGI v HGI test breakfast (CHO =81%, Fat 7%=, Protein =13%). Blood samples were taken regularly throughout the test day to confirm the glycaemic response.

MR Protocol: All measurements were performed on a Philips Achieva 3T scanner. Natural abundance ^{13}C MRS were acquired using a PulseTeq surface coil with proton decoupling, which was placed on the abdomen over the liver. The coil position was marked for consistent placement. MRS were acquired using a $\pi/2$ AHP (2 kHz sweep to reduce fat signal and B_1 inhomogeneity effects) with narrow band proton decoupling as previously described (7 kHz bandwidth, 256 samples, TR=959, NSA=888, scan time = ~20 minutes) [5]. The area of the glycogen peak (~100.5ppm) and external reference (~170ppm) were calculated using in house software and the ratios used to determine glycogen levels. Glycogen concentrations were quantified by comparison with a liver phantom [6].

Result: Figure 1 shows the blood glucose and insulin response to each test meal (HGI significantly greater than LGI). Following the LGI breakfast, liver glycogen levels increased from baseline until 180 mins (significantly greater than baseline at 60 and 180 mins, P<0.05). After 180 mins levels began to decline to below baseline. The liver glycogen response was significantly more variable during HGI (CV=48%) compared with LGI (CV=20%) visits (P<0.001). During HGI, glycogen levels continued to rise after 180 mins and where significantly greater than the LGI visit (two way F-test, P < 0.05).

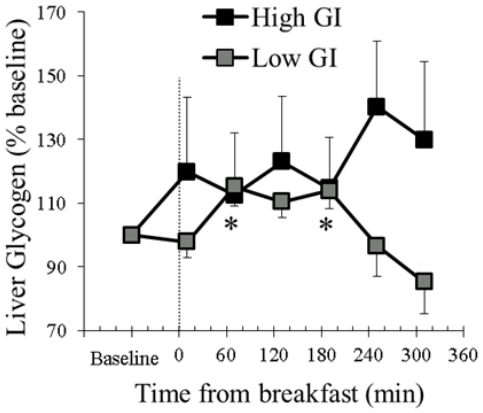

Figure 2. Changes in Glycogen levels *P<0.05

Conclusions: This study used ^{13}C MRS to show an increased glycogen storage following a HGI compared to an isocaloric LGI meal. The profile of changes in glycogen over time for HGI were similar to previous studies [7] with increases in hepatic glycogen for 300 mins. The differing response may be explained by the increased insulin levels following HGI which drives glycogen synthesis. Further studies should explore the overall metabolic response in the liver and muscle following LGI or HGI meals throughout the day and in patient groups.

Acknowledgments: We wish to thank Unilever and BBSRC for funding this study and the NIHR BRU for continuing support.

1.Taylor R. *et al.*, Magnet Reson Med (1992) 27, 13-20; **2**.Radziuk J. *et al.*, Diabetes-Metab Res (2001) 17, 250-272; **3**.Burke L.M. *et al.*, J Appl Physiol (1993) 75, 1019-1023; **4**.Wee S.L. *et al.*, J Appl Physiol (2005) 99, 707-714; **5**.Bawden S.J. *et al.*, Food and Function (2014) 5, 2237 - 2242; **6**.Stephenson M.C. *et al.*, NMR in Biomedicine (2013) 26, 1518 - 1526; **7**.Taylor R. *et al.*, J Clin Invest (1996) 97, 126-132;