Total Body Fat Quantification in Newborn Infants by Magnetic Resonance Imaging

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Introduction
Recent advances in molecular biology and in vivo methodology are helping to redefine the role of adipose tissue in human and animals. Adipose tissue was originally perceived as a passive storage site, but is now considered a highly active, finely tuned metabolic tissue, exerting significant control on numerous biochemical and physiological processes both in health and disease. It is becoming increasingly important to determine body composition in neonates to further our understanding of the influence of environmental and genetic factors on health and disease. Body fat content in adults is known to be related to a number of diseases, while Barker hypothesised that infants who are small for gestational age are at increased risk of developing cardiovascular disease and type II diabetes in adulthood (1). However the relationship between body weight and fat content in neonates and therefore its effects on physiological factors is not clearly understood. Here we present the use of magnetic resonance imaging (MRI) as a fast, non-invasive method to assess total internal and subcutaneous body fat content.

Methods
Written informed consent was obtained from the parents of all the infants included in this study. Permission for this study was obtained from the Ethics Committee of the Imperial College School of Medicine, Hammersmith Hospital, London. A total of fifteen infants (9 males, 6 females), with a median gestational age of 38 weeks (range 36 - 41 weeks) and a median birth weight of 3.36 kg (range 2.27 - 4.34 kg), were studied. Eleven infants were classified as appropriate for gestational age (AGA) and four were intrauterine growth restricted (IUGR). Diagnosis of IUGR was made on the basis of weight below 10th centile and characteristic phenotype at birth (ie clinical signs of fetal malnutrition). All infants were scanned within 36 hours of delivery. Eight infants had a follow-up examination at six weeks of age.

A MRI protocol for body fat quantification, developed and validated in adults, was applied to neonates (2). Images were acquired using a Marconi 1.5T Eclipse system with a T1 weighted spin-echo sequence TR=600 ms, TE=16 ms, flip angle 90°, FOV=24 cm, 256x256 matrix using phase conjugate symmetry and a slice thickness of 5 mm. Babies lay in a supine position during natural sleep on a mobile platform within a 30 cm diameter coil. Whole body MRI data were acquired from twenty 5 mm thick transverse images with 5 mm gaps between slices. The platform was then repositioned to acquire two to three blocks of images depending on the baby's length. On average 48 images were acquired for each infant. Images were analysed using image segmentation software that employs a threshold range and contour following algorithm with an interactive image editing facility. All data are expressed as median and range. Differences between groups were tested for using the Student's unpaired T-test, and within groups using the Student's paired T-test. The level of significance was set at $p<0.05$.

Results
The results from this cohort of infants suggest that the majority of the infant's adipose tissue is stored subcutaneously (89.7%), with just 10.3% of total percentage body fat stored internally. Furthermore, most of this internal adipose tissue appears to be non-visceral, arising mainly from fat depots in the limbs and pelvis and relatively small percentage arising from abdominal depots. No significant differences were found in adipose tissue content between male and female infants (male 20.94 %, range 12.56-30.8 % vs female 23.16 %, range 19.37-30.07 %; p=0.38). IUGR infants had significantly smaller reserves of adipose tissue compared to those considered to be AGA (AGA 23.32 %, range 18.45-30.8 % vs IUGR 18.36 %, range 12.56-20.94 %; $p<0.05$). Interestingly although there was a significant difference in body fat content between AGA and IUGR infants, some of the IUGR infants had higher percentage body fat than some of those who were considered AGA.

There was a significant increase in body fat content from birth to 6 weeks (birth 22.89 %, range 12.56 - 30.8 % vs. 28.87 % range 16.25-36.38 %; $p< 0.01$), see Figure 1. One infant had a decrease in percentage body fat, despite an overall increase in body weight. No gender differences were observed in body fat content at six weeks of age.

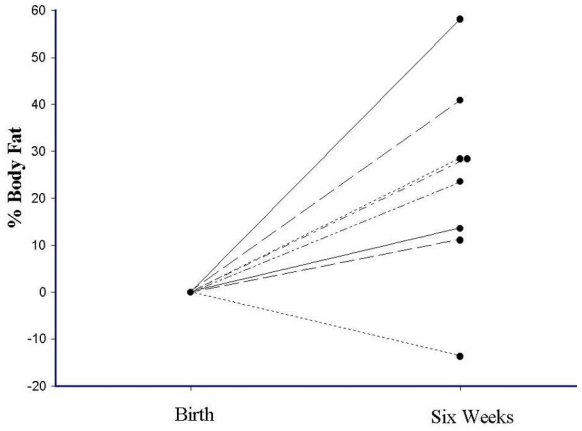

Figure 1. Percentage change in body fat content from birth to six weeks of age.

Discussion
There is a paucity of information regarding the effects of maternal and postnatal nutrition on neonatal adipose tissue distribution and its association with development. This arises from a lack of accurate *in vivo* methodology to directly assess infant body composition. Existing infant body composition data arises from post-mortem studies. Ziegler et al, reported a body fat content of c.a. 19.8% in infants 36-40 weeks gestation (3). Our measurement of total body fat content by MRI generally agrees well with post-mortem studies. Moreover, in this study we show that changes in percentage body fat can be readily detected. Interestingly although there was a significant difference in body fat content between AGA and IUGR infants, some of the IUGR infants had higher percentage body fat than those who considered AGA. This may indicate that some infants who are classified as AGA according to their weight may have not actually achieved their full growth potential. No significant differences were found between male and females at birth or at six weeks of age, suggesting that the differences in adipose tissue content seen between male and female adult subjects do not originate in early infancy. We will continue to follow-up the growth of these infants by scanning them again at 6 months and 1 year of age. This study opens up the possibility of assessing different dietary regimens, hormonal treatments and genetic factors on the developing infant in a fast, reproducible way.

Acknowledgements
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