Title: 3D Water-Fat MRI Detection of Developmental Maturity in Fetal Fat Compartments

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Structured Abstract:

Introduction: Fetal fat development is reflective of the energy balance within the fetus; therefore, assessment of abnormalities in fetal fat development may provide insight into the metabolic health of the fetus. As fat cells develop, they grow from water-based fibroblast cells to lipid-based adipocytes, a process which can be detected by water-fat MRI using proton density fat fraction (PDFF) quantification.
It is also known that fetal fat develops in different regions at different gestational ages. Fat begins to develop in the head first, then extends to the thorax and limbs, then finally the abdomen. If these compartments develop at different rates, they will also have different lipid contents at a given time point. The objective of this study was to detect differences in the lipid content of the cheeks, thorax, upper arms, forearms, abdomen, perirenal, thighs, and lower legs using water-fat MRI.
Methods: 17 volunteers with singleton pregnancies and gestational ages between 29 and 38 weeks were recruited from low-risk and high body mass index (BMI) clinics and imaged in a wide-bore (70 cm) 1.5T MRI (GE MR450w). During an approximately 30 min MRI exam, 3D water-fat MRI (Quantitative IDEAL) was used to image fetal fat during maternal breath hold. Fetal fat compartments including cheeks, upper arm, lower arm, thorax, abdomen, upper leg, lower leg, and kidneys were manually segmented using 3D Slicer (v.4.7.0-2016-12-06). The PDFF was measured after eroding the compartments with a 4-neighbour erosion to reduce partial volume effects. The mean PDFF of the different compartments were compared using a repeated-measures one-way ANOVA with multiple comparisons.
Results: Significant differences were found between the compartments, notably: cheeks vs. forearms ($p<0.0001$), cheeks vs. abdomen ($p<0.0001$), cheeks vs. kidneys ($p<0.0001$), cheeks vs. lower legs ($p<0.0001$), thorax vs. abdomen (0.0025), upper arms vs. abdomen ($p=0.0001$), and abdomen vs. thighs ($p=0.0087$).
Discussion and Conclusion: The differences in the PDFF between the fetal fat compartments demonstrate that water-fat MRI is sensitive to the changing lipid content of fat through development. The PDFF in the cheeks was significantly higher than that in the lower limbs and abdomen, as it develops before these other regions. At the opposite end, the abdomen had a lower PDFF than the upper limbs and cheeks, as it develops relatively later in gestation. Future work will include multiple readers and more participants, and examination of brown fat in addition to gestational age effects on PDFF. In conclusion, water-fat MRI can be used to detect differences in the developmental maturity of fetal fat compartments, and care should be taken interpreting the PDFF from separate compartments.