The epidemiology of abdominal adiposity

De Lucia Rolfe, Emanuella

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Summary

Obesity has become a major public health problem, and its prevalence has increased drastically worldwide over the last decades among all ages. Access to high energy-dense processed foods and the adoption of a more sedentary lifestyle have probably contributed to this rise. This rapid rise could potentially lead to increased health care costs and challenging healthcare delivery, particularly in those countries where obesity coexists with under-nutrition.

Apart from overall obesity, the distribution of body fat influences health risk. Central adiposity, particularly visceral fat (VAT) may play a significant role in the development of obesity related co-morbidities such as diabetes and related cardiovascular complications. Different abdominal fat compartments, visceral fat and abdominal subcutaneous fat (SCAT), have very different metabolic consequences. Excessive VAT has been related to insulin resistance, while SCAT may have an independent antiatherogenic effect.

Intrauterine environment and rapid weight gain after birth have been identified as critical time periods for fat accumulation. Intrauterine growth restriction (IUGR) is known to alter the development of fetal adipose tissue and low birth weight has been related with a tendency to store fat centrally. It has also been observed that children with low birth weight who showed rapid catch up growth during the first two years of life had higher total body fat and central fat than other children by the age of five years. Very little is known about the time course for the development of VAT and there are no published data that have examined longitudinal changes in VAT and SCAT in the first years of life.

Accurate measures of abdominal fat compartment fat are essential for investigating the pathophysiology of obesity and its co-morbidities. Standard anthropometric measures such as waist, hip circumferences, skinfold thickness, and BMI are generally used to assess overall adiposity and fat distribution. However, these measures cannot distinguish between different fat compartments; may not capture body composition changes that occur with aging and may not adequately describe ethnic variations of these fat regions. Reference methods such as Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) are often not feasible in large-scale epidemiological studies and in paediatric research due to ethical and practical issues.

Ultrasonography (US) has been previously proposed as an accurate method to estimate fat distribution. It is a non invasive, reliable and reproducible technique for the determination of subcutaneous and visceral fat when compared to both CT and MRI techniques. Therefore, ultrasonography could be a

valuable tool for the assessment of possible risk factors associated with obesity and related metabolic disease. However, its validity in different age groups and ethnicity is yet to be proven.

The main aims of this thesis was to determine the validity of ultrasound measurements of abdominal fat depths compared to MRI or CT measures of visceral and abdominal subcutaneous fat in populations covering a wide range of ages (from infancy to adulthood). Secondly these ultrasound measures were applied to large scale epidemiological studies to identify possible early life factors that may influence the quantity of these abdominal fat compartments.

In Chapter 2, the ultrasound method has been proven to be a valid method for the quantitative assessment of abdominal fat compartments in an older Caucasian population when compared to MRI. The ultrasound measures were positively correlated with MRI measures of visceral and subcutaneous fat and the addition of ultrasonography to the prediction models significantly improved the estimation of visceral fat and subcutaneous fat in both men and women over and above the contribution of anthropometry.

In Chapter 3, the accuracy of the prediction models for estimating visceral and subcutaneous abdominal fat described in Chapter 2 was established amongst black South African adolescents using MRI as the reference method. Ultrasound visceral fat depth showed the strongest correlations with MRI visceral adipose tissue and significantly increased the estimation of visceral adipose tissue compared to standard anthropometry and DEXA alone. However, the predictions models described in Chapter 2 could not be extrapolated to black South African adolescents as this population had relatively little visceral fat thickness and greater subcutaneous fat compared to the elderly Caucasians.

In Chapter 4, estimates of central adiposity using anthropometry, DEXA and ultrasound were compared against measures of visceral and subcutaneous fat tissues determined by a single slice CT in 6 to 7 years old children. Subcutaneous abdominal fat thickness by US was highly correlated with subcutaneous adipose tissue measured by CT, while US visceral fat thickness was weakly correlated to CT visceral adipose tissue. DEXA abdominal region was only moderately correlated to CT visceral fat. Skinfold measurements showed the strongest correlations with CT in this population.

In Chapter 6, ultrasound measures of visceral and subcutaneous abdominal fat thickness were validated against MRI volumes of VAT and SCAT in 22 neonates. Ultrasound measures were found to be positively correlated with visceral and subcutaneous abdominal adipose tissues measured by MRI. US is therefore a reliable method and it could effectively rank infant abdominal fat distribution when compared to MRI measures.

In Chapter 5, cross-sectional associations between birth weight and adult central adiposity using DEXA and ultrasound were investigated in The Fenland study. There was an inverse association between birth weight and total abdominal fat and visceral fat, but not between birth weight and subcutaneous abdominal fat. These birth weight associations were dependent on adjustments for adult BMI, suggesting rapid postnatal weight gain, rather than birth weight alone, leads to increased central fat and likely associated metabolic disease risk.

In Chapter 6, ultrasound visceral fat thickness significantly increased by 20% between ages 3-12 months and showed weak evidence of tracking between these ages. US visceral fat thickness at both 3 and 12 months were inversely associated to skinfold thickness at birth, particularly after adjustment for current skinfold thickness; while US-subcutaneous thickness at 3 months was positively related to skinfold thickness at birth. US visceral depths at both 3 and 12 months were lower in breastfed infants compared to other infants. Both, antenatal and postnatal factors may contribute to the quantity of VAT and SCAT in the first year of life.

In conclusion, ultrasonography is a suitable, non-invasive and reliable tool for quantifying abdominal fat compartments from infancy and in different ethnic groups when compared to direct imaging techniques. This method could be therefore used to assess possible risk factors associated with obesity and related co-morbidities in a very early stage; and it could also help exploring the relevance of marked ethnic differences in abdominal fat distribution to metabolic disease risk.

Future research should replicate the findings of the validation work in different age and ethnic groups, particularly in other infant populations, as our validation results may be limited to populations with similar characteristics to those studied in this thesis. These studies should also assess whether ultrasonography could accurately monitor longitudinal changes in VAT and SCAT.

Overall, the findings of this thesis suggest that, during both intrauterine and postnatal periods, the accumulation of VAT and SCAT may be under different regulatory control. To further study the early life determinants of these abdominal fat compartments, longitudinal studies with more repeated measures are needed to identify critical periods of when these compartments develop and whether other factors such as different mode of infant feeding may modify the relationship between early growth parameters and these fat compartments.