Introduction

The obesity epidemic has spared no segment of the population, even infants and young children. In 2007-08, almost 10% of U.S. infants and toddlers were overweight. Recently, researchers have looked to events that occur in very early life, even before birth, to understand the causes of childhood obesity and identify factors that may be targeted for prevention. In this section, we outline parameters for normal growth in infancy, review prenatal factors that have been found to be associated with later obesity, and identify areas for intervention.

Subject

During well-child visits, pediatric clinicians use growth charts to document serial measures of weight and length, and screen for abnormalities in weight status. In the U.S., among children over the age of two, obesity is defined as a body mass index (BMI, weight in kg divided by height in m) above the 95th percentile for age and sex, compared with a reference population – typically the Centers for Disease Control and Prevention (CDC) 2000 growth charts. Overweight is a BMI between the 85th and 94th percentile.

In infants below 24 months, excess weight has traditionally been defined using weight for length percentiles compared with the CDC reference data. In the past few years, however, evidence is emerging that the World Health Organization (WHO) 2006 Growth Standard might be a better reference for healthy growth in infancy. WHO included only term infants who were breast-fed for at least 12 months, followed them longitudinally, and excluded data for children with excess adiposity and growth failure. Using the WHO Growth Standard fewer children are diagnosed with poor weight gain, and more with excess adiposity, than when using the CDC Growth Reference. Recent recommendations suggest the use of the WHO standard for infants below 24 months, with a BMI above the 97th percentile indicating excess adiposity. Since BMI reflects both lean and fat mass, however, BMI screening may result in misdiagnosis of individuals with higher or lower lean body mass.
than expected.

In addition to an infant’s weight at any given time, a rapid weight gain trajectory predicts later health outcomes including risk for high blood pressure and asthma. In a study of 44,622 children aged 1 month to 10 years with 122,214 length/height and weight measurements, Taveras et al. found that upward crossing of ≥2 major weight-for-length percentiles (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentile lines on the growth chart) in the first 6 months of life was not only common but was also associated with the highest risk of obesity 5 and 10 years later.

**Problems**

Obesity in infancy predicts obesity and related cardio-metabolic risk in later life. Also serious morbidity may occur even within childhood, including asthma, orthopedic problems, psychosocial adversity, high hospital admission rates, and increasingly, type 2 diabetes. Fat cell number, a major determinant of fat mass in adulthood, appears to be set in the first years of life. The fattest babies are not necessarily the biggest – babies born small for gestational age have reduced lean body mass, but are relatively fatter compared with appropriate-for-gestational age babies both at birth and in later life. Since the combination of low weight at birth and rapid postnatal weight gain is the strongest predictor of later disease risk, it is especially important to avoid ‘fattening up’ these small babies.

**Research Context**

Numerous animal experiments dating back decades show that perturbations before birth can have lifelong effects on health. Whereas early studies focused on under-nutrition in early life as a risk factor for cardiovascular disease risk, more recently research has focused on over-nutrition and excess adiposity. In humans, accumulating research demonstrates that maternal prenatal obesity, excess weight gain during pregnancy, gestational diabetes, and smoking during pregnancy predict later obesity and its adverse sequelae.

**Key Research Questions**

Current research into the developmental origins of obesity clusters around the following questions: 1) What factors in early life predict later obesity risk, and how much influence do these early life factors have compared with risk factors that occur later on? 2) What are the pathways and mechanisms by which early life exposures influence later health? 3) How can we intervene in these early life exposures to prevent or ameliorate risks for obesity and its adverse health effects?

**Recent Research Results**

Obese mothers tend to have obese children. Initially these associations were mostly studied as evidence for a genetic underpinning of obesity risk. More recently, numerous investigators have found evidence that the obese intrauterine environment itself programs body weight. Similarly, a number of epidemiologic studies have found that higher maternal gestational weight gain is associated with higher child weight in childhood and adolescence, and consequent risk for obesity and elevated blood pressure. Infants born to mothers with diabetes during pregnancy are heavier at birth, but then grow slower after birth and are often no larger during
the preschool years. However, even in early life they are likely to have more body fat, and beginning in mid-childhood these children are heavier than their peers who were not born to mothers with diabetes during pregnancy. Finally, although infants born to mothers who smoked during pregnancy are small at birth, they grow faster and have a higher risk for obesity in childhood and adulthood.

The question remains whether these intrauterine experiences actually program long-term weight regulation and disease risk, or whether they are solely markers for other, shared causes of both maternal weight and child weight. Shared genes and extra-uterine environment certainly account for some of the similarity in maternal and offspring weight. For example, parents and children tend to have similar diet quality and physical activity habits. Also, mothers who smoke, are obese, had gestational diabetes, or gained excessive weight during pregnancy are less likely to breastfeed, which itself predicts later overweight.

However, associations of these prenatal factors with child weight persist even after statistical adjustment for factors such as socioeconomic status, infant feeding, and child diet and physical activity. Furthermore, studies that compare siblings with discordant prenatal exposures but presumably otherwise similar genetic and extra-uterine experiences, provide additional evidence that the prenatal is a critical period for obesity risk. Also, these human findings are supported by abundant evidence from animal studies among rodents, sheep and primates.

Research Gaps

An optimal approach to understanding the role of intrauterine exposures for later health would be to conduct a well-powered randomized clinical trial, in which women are randomized to usual care or to an effective weight change intervention before and/or during pregnancy, and follow children longitudinally. No previous randomized trials have been performed of an intervention delivered before pregnancy. Trials to improve diet or other behaviours during pregnancy have generally included small numbers of women, and few have followed infants after delivery. To date, the limited data available suggest that studied interventions have not been successful in reducing rates of large for gestational age births. Ongoing studies with larger sample sizes are expected to provide additional information in the coming years.

Conclusions

Childhood overweight is common and an important predictor of later health. Numerous observational studies among humans and abundant experimental data from animals suggest that experiences before birth including intrauterine exposure to maternal smoking, obesity, excess gestational weight gain or diabetes can “program” trajectories of adiposity and metabolic health throughout life. Clear guidelines exist for each of these factors, including recommendations for optimal maternal BMI before pregnancy, gestational weight gain guidelines, advice against smoking during pregnancy, and recommendations for universal gestational diabetes screening.

What is less clear, however, is how to help women achieve these optimal behaviours.

Implications for Parents, Service Providers, and Policy Makers

All young women should be encouraged to maintain a healthy weight and abstain from smoking prior to pregnancy. During pregnancy, provider advice is an important predictor of healthful behaviours and of weight...
gain concordant with guidelines. Women should be counseled regarding the implications of their own weight and health status for their child’s health.

Pediatricians should identify and document prenatal and familial factors that are likely to increase a child’s obesity risk, including parental obesity and maternal smoking, excess gestational weight gain and gestational diabetes. All infants and children should be routinely screened for overweight and for rapid weight gain using standard measurement techniques and the appropriate growth charts. The postpartum period is an opportunity to promote healthful behaviors that may not only improve the mother’s long-term health and provide a role model for the infant’s future behaviours, but also may optimize the mother’s health entering subsequent pregnancies.

References


