

## Obesity in developing countries: a possible role of early nutrition

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**D**uring the past 30 years, it has become more accepted that growth retardation of a fetus or child is related to their state of health in adulthood, a concept commonly called the fetal origins hypothesis or the developmental origins of health and disease (DOHaD). The significance of DOHaD for developing countries is broad as countries with a high prevalence of undernutrition may be at risk for hosting a large population of adults at an increased risk for chronic diseases.

One of the earliest studies that supports DOHaD comes from data on the Dutch Famine of 1945 (1). A cohort of men born before, during, and after the Nazi-imposed famine in Holland was studied to determine the relationship between adult body weight relative to famine exposure during gestation. It was found that men who had been affected by the famine during early gestation were more likely to be overweight as adults compared to men who were exposed to the famine during the last part of gestation. Several other large epidemiological studies have reported an association between being born at-term with low birth weight and chronic disease in adulthood (2-7). Of particular interest has been the association between LBW and cardiovascular disease (CVD), hypertension, and

T2D. In one cohort of men and women born in the Hertfordshire region of England (8), men and women with lower birth weight were more likely to suffer from CVD than men and women with normal birth weight. Barker et al reported that a correlation exists between birth weight and CVD mortality in a cohort of 1,586 men born between 1907 and 1924. These findings have been confirmed in other cohorts throughout the world, such as England (9), Croatia (10), Sweden (11), and the United States (2). Potential mechanisms for DOAHD are lacking, but include abnormalities in the hypothalamic-pituitary axis that perturbs metabolism, central fat distribution, impaired fat oxidation, and abnormal control of energy intake.

The association between growth retardation and central adiposity is of particular concern since central or visceral adipose tissue (VAT) mass is a major risk factor for cardiovascular disease and diabetes (12-19). VAT mass increases the risk for Syndrome X as a result of increased free fatty acid (FFA) mobilization by VAT and the direct entry of FFAs into the portal vein, both of which are associated with hepatic and systemic insulin resistance (20). Low birth weight is associated with truncal fat mass, reflected by a high ratio of subscapular to tricep skinfolds (3). Similar associations between low birth weight and truncal adiposity have been found

in adolescents in the United States and the United Kingdom (21). Exactly why persons who were growth retarded deposit more centrally is not known, but is the focus of several studies. One possible explanation is that growth retarded persons favor fat deposition under stable dietary conditions, a hypothesis that is supported by evidence from a clinical study of stunted children in Brazil.

Data from a cross-sectional study of previously undernourished (stunted) children in Brazil found that stunted children not only metabolize fat at a lower rate, a known risk factor for obesity (22-24). In fact, when these children were followed for 4 years, the stunted children actually deposited more fat, as well as more central fat, compared to the healthy children. These findings highlight the fact that undernutrition, often accompanied by poor nutrition, limited maternal education, and undeveloped health care systems, is not an acute condition. Rather, undernutrition that results in growth retardation is a chronic condition with effects extending well beyond the recovery of body weight.

More recently, to corroborate our results from Brazil, our research group conducted several studies on the relationship between birth weight and energy metabolism and body fat distribution (25). Using a sample of adults from the Hertfordshire Cohort, we measured energy metabolism and body fat distribution in adults who were born either low or high birth weight. Our primary findings were that adults born with low birth weight had increased central fat mass and borderline significantly lower fat oxidation. We also conducted a retrospective cohort study of healthy children for whom we had data on body fat distribution, but not on birth weight (26). Questionnaires were mailed to the parents of these children asking for information on birth weight, gestational age, and maternal diabetes. All of the children whose parents responded to the questionnaire

were born with normal birth weight and full gestational age. We found that those with lower birth weights had higher central adiposity, independent of age, gender, race, and degree of sexual maturity. Results from these two independent studies add significant support to the findings we first reported from the study in Brazil that suggest undernutrition early in life predisposes people to developing chronic diseases and obesity later in life.

The fact that several studies on growth retardation and future risk for obesity support DOHaD has broad and significant implications for developing countries. First, it is well-documented that growth retardation (i.e. stunting) is highly prevalent in many developing countries, yet there are few, if any, resources directed at preventing stunting. Second, given that many countries are now beginning to experience the "double burden" of having a segment of their population that is either undernourished and overnourished, preventive efforts are best initiated earlier, rather than later. Third, there is abundant evidence that the nutrition transition occurring throughout the developing world will have negative effects on the diets and health of those lower income groups. It is also these same families and children that are most likely to have a history of growth retardation and stunting. Therefore, it is essential that ministries of health begin to coordinate programs designed to prevent what appears to be a risk factor for obesity. Given that most obesity treatments are not effective, prevention is the best course to take before the prevalence of obesity becomes a strain on the health and productivity of a country. Especially for countries where there has been a high prevalence of undernutrition, prevention programs targeted at the most vulnerable and national campaigns to promote a traditional, rather than Western or processed diet, will have far-reaching effects on keeping the prevalence of obesity low.

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