FNCE

November 9, 2010

Early Infant Weight Gain, Childhood Obesity and Feeding Dynamics

Ines M. Anchondo DrPH, MPH, RD, LD, CSP
Pam Estes MS, RD

1. Adair LS, Martorell R, Stein AD, et al. Size at birth, weight gain in infancy and childhood, and adult blood pressure in 5 low- and middle-income-country cohorts: when does weight gain matter? *Am J Clin Nutr.* May 2009;89(5):1383-1392.

Study of data from 5 birth cohorts - Brazil, Guatemala, India, Philippines, South Africa (n=4335). Obtained weights at 0,12, 24,and 48 months, and in adulthood. Investigated relationship between early weight gain and blood pressure. Assessed weight gain with Conditional Weight (CW), which is the actual weight considering the expected weight given prior weights. Results showed individuals with higher CW had higher BP and higher odds of hypertension, CW predicted adult BMI (as expected), and no CW associated with adult BP after considering BMI and adult height. IA Notes: Excellent study about using a more organic definition of weight gain.

2. American Academy of Pediatrics Committee on N. Prevention of pediatric overweight and obesity. *Pediatrics.* 2003;112:424-430.

...few studies on prevention have been performed. The enormity of the epidemic, however, necessitates action using the best information available. Pediatricians need to proactively discuss and promote healthy eating behaviors for children at an early age and empower parents to promote children's ability to self-regulate energy intake while providing appropriate structure and boundaries around eating. Significant changes in growth patterns (eg, upward crossing of weight for age or BMI percentiles) can be recognized and addressed before children are severely overweight. Dietary practices should be fostered that encourage moderation rather than overconsumption, emphasizing healthful choices rather than restrictive eating patterns. Regular physical activity should be consciously promoted, prioritized and protected within families, schools and communities.

3. Baird J, Fisher D, Lucas P, Kleijnen J, Roberts H, Law C. Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ.* 2005;331(7522):929.

Metanalysis of 18 studies that assessed the relation between infant size and subsequent obesity, most showing that infants (youngest age was six months) who were defined as "obese" or who were at the highest end of the distribution for weight or body mass index were at increased risk of obesity. ES note: Little wonder that big infants become big children. The error is in diagnosing them as obese.

4. Eid EE. Follow-up study of physical growth of children who had excessive weight gain in first six months of life. *Br Med J.* Apr 11 1970;2(5701):74-76.

One of earliest attempts to define early rapid weight gain. Studied infant's weight gain at 6 weeks, 3 months, and 6 months. Defined 'excessive' or early rapid weight gain

at 6 weeks of age as weight for age at or more than 90th percentile. Divided sample into R=rapid weight gain (w/a > 90th percentile), M=average weight gain (w/a 'around' 50th percentile), and S=slow weight gain (w/a > 10th percentile). Followup was at 6 to 8 years of age, children were considered obese if their weight was more than 20% over 'expected' weight for height and gender and overweight if the 'expected' weight was 10% over 'expected'. There was no difference in type of feed. At follow-up 7.4% of children in the R group were obese compared to 1.9% in the S group. IA Notes: Comparing early weight gain at 6 months of life to an 'expected' ideal body weight gain calculated based on the child's height is similar to expecting a child to grow along a particular percentile. However, it is unclear whether the growth index used in this study reflected a statistical pattern of children's growth as the percentiles do. Children tend to grow predictably. However, they also make growth adjustments over time, especially in the early months.

5. Hamill PVV, Drizd TA, Johnson CL, Reed RB, Roche AF, Moore WM. Physical growth: National Center for Health Statistics percentiles. *Am J Clin Nutr.* 1979;32:607-629.

Growth is within normal limits by current standards when values follow central or intermediate percentiles. For the purposes of nutrition and health screening, measurements between the 10th and 25th, and the 75th and 90th %tiles may or may not be normal depending on the pattern of earlier measurements, genetic and environmental factors. Children whose weight-for-stature (or length) is below the 5th %tile or above the 95th %tile should be checked, followed up and possibly referred. ES note: This guideline is often used to define the upper and lower cutoffs for obesity and failure to thrive, respectively. However, note that the article says "followed." Presumably, the following is to determine whether children grow consistently at those extremes and, therefore, demonstrate the internal integrity of that growth pattern.

6. Horta BL, Gigante DP, Osmond C, Barros FC, Victora CG. Intergenerational effect of weight gain in childhood on offspring birthweight. *Int J Epidemiol.* Jun 2009;38(3):724-732.

Compared parents' early weight gain to their children's birth weight in a Brazilian birth cohort of 5,914 individuals followed from infancy until adulthood (848 women 525 men). Results showed women with the highest early weight gain between 0 to 20 months of life had heavier babies.The father's early weight gain was not associated to the child's birth weight. IA Notes: In a developing country, especially, babies who are born heavier have better chances of survival.

7. Kajantie E, Barker DJ, Osmond C, Forsen T, Eriksson JG. Growth before 2 years of age and serum lipids 60 years later: the Helsinki Birth Cohort study. *Int J Epidemiol.* Apr 2008;37(2):280-289.

Studied the Helsinki birth cohort of 1999 men and women who were measured 11 times between birth and 2 years of age. Mean age at follow-up was 62 years. Investigated the association between small body size at birth and early slow growth within first 2 years of life and CVD and stroke later in life. Results showed low BMI at birth associated with higher LDL, VLDL, etc. Low BMI at 2 years of age associated with higher triglycerides, higher atherogenic risk factors. In addition, the correlation coefficients between BMI at birth and at 2 years of age were 0.10 and 0.12. IA Notes: Changing the focus--the research questions--from looking at early weight gain and obesity to slow growth and health outcomes is instructive. In this case, results point to

undernutrition as a risk factor for disease later in life. Also note the low correlation between birth and 2-year BMI.

8. Legler JD, Rose LC. Assessment of abnormal growth curves. *Am Fam Physician.* 1998;58:158-168.

An important part of well-child care is the assessment of a child's growth. While growth in the vast majority of children falls within normal percentile ranges on standard growth curves, an occasional child demonstrates worrisome deviations in weight, height or head size. A single growth percentile value at any particular point in a child's life is only of limited usefulness to the physician. More important is the child's rate of growth. Children whose growth parameters are at the extremes of the growth curve but whose growth rates are normal are likely to be healthy. Conversely, accelerated or slowed growth rates are rarely normal and warrant further evaluation. This article addresses the initial steps to be taken when evaluating children with suspected growth abnormalities, the guiding principles that apply to all growth problems, and the most common growth curve deviations and approaches to their management.

9. Leunissen RWJ, Kerkhof GF, Stijnen T, Hokken-Koelega A. Timing and Tempo of First-Year Rapid Growth in Relation to Cardiovascular and Metabolic Risk Profile in Early Adulthood. *JAMA.* 2009;301(21):2234-2242.

A study of the association between early weight gain, CVD, and DM risk factors. A sample of 217 was assessed for rapid early weight gain(increase of 1 standard deviation). 87 individuals experienced early rapid weight gain. These same 87 were re-assessed for weight gain between birth and age 3 months. Results showed 65 individuals gained weight faster between birth and 3 months of life. There was a significant association between rapid weight gain in the first 3 months of life and lower insulin sensitivity, lower HDL, higher body fat percentage, and more central adiposity. IA Notes: Higher or lower levels of biological measures and outcomes doesn't mean abnormal (something wrong).

10. Martorell R, Horta BL, Adair LS, et al. Weight Gain in the First Two Years of Life Is an Important Predictor of Schooling Outcomes in Pooled Analyses from Five Birth Cohorts from Low- and Middle-Income Countries. *J. Nutr.* 2010;140(2):348-354.

Studied a total of 4,335 children from 5 birth cohorts from Brazil, Guatemala, India, Philippines, and South Africa. Investigated the relationship between early weight gain and schooling (years and grade failure rate). Weight gain was assessed as w/a z-score. Results showed 1 SD higher weight/age at birth (0.5 kg) was associated with .21 more years of schooling and 8% decrease in grade failure. A 1 SD increase in weight/age between 0 and 2 years of age was associated with .43 more years of schooling and 12% decrease in grade failure.

IA Notes: This shows there is a clear advantage of gaining weight in childhood, especially in developing countries. There are benefits to postnatal catch up growth.

11. National Center for Chronic Disease Prevention and Health Promotion. Overweight children and adolescents: screen, assess and manage [Web page]. Centers for Disease Control Website. http://www.cdc.gov/nccdphp/dnpa/growthcharts/training/modules/module3/text/page1b.htm. Accessed November 10, 2010. .

. Definition of Overweight "At risk of overweight" and "overweight" are the terms preferred to refer to children and adolescents whose excess body weight could pose

medical risks. Due to potential negative connotations associated with the term "obesity," "overweight" is preferred. Using the 2000 CDC growth charts, at risk of overweight for ages 2 to 20 years is defined as a Body Mass Index (BMI)-for-age between the 85th and the 95th percentiles. Overweight in children is defined as a BMI-for-age at or above the 95th percentile on the charts. BMI is weight in kilograms divided by height in meters squared (kg/m2).

12. Nazmi A, Gonzalez DC, Oliveira IO, Horta BL, Gigante DP, Victora CG. Life course weight gain and C-reactive protein levels in young adults: findings from a Brazilian birth cohort. *Am J Hum Biol.* Mar-Apr 2009;21(2):192-199.

Studied the relationship between CRP (C-reactive protein: chronically elevated levels predict cardiovascular outcomes) and early weight gain in men and women from a Brazilian birth cohort of 5,914 individuals. In 2004-05 77.4% of the cohort was availble for study for CRP levels. Results showed in males there is no association between CRP levels and early weight gain but in females weight gain was associated with higher CRP levels. Early weight gain was assessed by weight/age z-score. IA NOTES: These observational studies can not be transferred to other populations. Moreover, since this is an epidemiological study (an observational study), no cause and effect can be determined. At best, it is a hypothesis generating study. One of those hypotheses could be that CRP levels play a role in females that they don't in males, especially in the early years.

13. Ong KK, Loos RJ. Rapid infancy weight gain and subsequent obesity: systematic reviews and hopeful suggestions. *Acta Paediatr.* 2006;95(8):904-908.

This article is a systematic review of 15 studies (of 21 identified and examined) about early weight gain and risk of obesity later in life. Early rapid weight gain was identified as 0.67 increase in 1-year w/a z-score. Results showed a significant positive association (OR 1.26 to 4.55) between rapid early weight gain and increased risk of obesity later in life after considering all confounding factors. (60% of variance is explained by considering all factors). Only one study examined the predictive ability of early weight gain to later obesity risk. This showed the cutoff to be 9,764 g weight gain between birth and 2 years of age (0.77 z-score). This one study, however, only had 19% predictive ability even with a OR of 5.7. IA Notes - This meta-analysis study shows early weight gain is not a very good early marker for risk of obesity later in life.

14. Ong KKL, Ahmed ML, Emmett PM, Preece MA, Dunger DB. Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. *BMJ.* 2000;320(7240):967-971.

Investigated early infant weight gain and catch-up growth in 848 infants in Avon, UK. Early infant weight gain was defined as 0.67 w/a z-score increase between birth and 2 years of age. 0.67 is the distance between percentiles in the UK growth charts. Results showed 31% of infants gained 0.67 w/a z score. This was associated with lower weight, length and ponderal index at birth, taller father, and mothers who smoke during pregnancy and had themselves lower birth weight. Children who showed catch-up growth between zero and two years were heavier, taller, and fatter (body mass index, percentage body fat, and waist circumference) at five years than other children. IA Notes – Using 0.67 w/a z-score is arbitrary and has no frame of reference in US. In this study confounders such as maternal weight, prepregnancy weight, pregnancy weight, maternal and paternal height, maternal smoking, and parity were considered, but other mediating

variables need to be included (e.g. feeding dynamics, method of feeding, etc.) to better explain the relationship between catch-up growth and weight later later in life.

15. Plagemann A. Perinatal programming and functional teratogenesis: impact on body weight regulation and obesity. *Physiol Behav.* Dec 15 2005;86(5):661-668.

An essay about fetal programming, perinatal issues, and disease later in life. Fetal undernutrition, low birth weight, overnutrition, and caloric restriction after birth associate with obesity later in life. Overfeeding a LBW baby after birth may lead to obesity and increased risk of metabolic and atherogenic conditions. IA Notes - The issues in this review encourage feeding optimally.

16. Rose HE, Mayer J. Activity, calorie intake, fat storage, and the energy balance of infants. *Pediatrics.* 1968;41:18-29.

Infants show apparently constitutionally determined activity levels, energy intake and body type. In this observational study of 30 babies, the least active 4-6 month-old infants ate the least and were the fattest and the most active infants ate the most and were the leanest.

17. *Feeding with Love and Good Sense Videotapes and Teacher's Guide: The Infant, The Older Baby, The Toddler, The Preschooler*. Madison, WI: Ellyn Satter Associates;1989.

The classic feeding dynamics video, now on DVD. Vignettes get up close to real parents and children during feeding. Videos demonstrate positive and negative feeding and illustrate the elements of feeding dynamics. Four 15 minute videotapes. Available from Ellyn Satter Associates, www.ellynsatter.com

18. Singhal A, Cole TJ, Fewtrell M, et al. Promotion of faster weight gain in infants born small for gestational age: is there an adverse effect on later blood pressure? *Circulation.* Jan 16 2007;115(2):213-220.

A study of 153 Small for Gestational Age (SGA) babies considering the association between early weight gain and high blood pressure. Weight gain was considered to be excessive if children gained 1 or more w/a z score (standard deviation) in first year of life. Results showed children who gained 1 or more w/a z score between birth and 9 months, even when they were breastfed, had higher 3 mmHg BP (not abnormal BP, just higher by). Discussion asserts that a 2 mmHg reduction in blood pressure could prevent 100,000 deaths. IA Notes: This study is particularly important because this group of SGA children were pressured to eat and to gain weight. Also note that the children's blood pressures were higher but not abnormal. Moreover, calculations about mortality prevention were based on adults with HBP, not chilldren with marginally higher but still-normal blood pressure.

19. Stettler N, Kumanyika SK, Katz SH, Zemel BS, Stallings VA. Rapid weight gain during infancy and obesity in young adulthood in a cohort of African Americans. *Am J Clin Nutr*. 2003;77(6):1374.

300 African Americans born at full term were followed from birth to 20 y of age. 87 subjects (29%) showed an increase in weight-for-age of 1 SD between birth and 4 mo. 12 of those 87 had a BMI >30 at age 20 yr and 13 had a BMI >25. About half in each group had achieved their weight category by age 7. Conclusion: One-third of BMI >30 at age 20 y could be attributed to rapid weight gain in the first 4 mo of life. ES note: Without longitudinal data, it is hard to tell whether these Ss were truly obese at 20 years or just consistently large people. Without it, all this study really shows is that children who grow rapidly during the first four months have a tendency to be large as adults.

20. Stettler N, Stallings VA, Troxel AB, et al. Weight Gain in the First Week of Life and Overweight in Adulthood: A Cohort Study of European American Subjects Fed Infant Formula. *Circulation.* 2005;111(15):1897-1903.

653 European American formula-fed subjects. As 20 to 32 year old adults, 32% of them were overweight (BMI >25, z score 0) and 5.7% were obese (BMI >30 Z score +1 SD). Children who gained the most during the first 8 days and the first 112 days of life were likely to be "overweight" as adults. That is, their BMI was above average. The average 8-day WAZ (weight-for-age z score) was -0.14 (range -1.46 to 1.90), change in z score birth to 8 days was -0.14 (range -1.52 to 1.58), average 112-day z score was 0.37 (range -1.12 to 2.08) and change in z score was 0.34 (range -1.30 to 1.91). ES notes: Given the definition of overweight as anything above the median (, this study is likely to describe normal growth patterns. That is, large babies grow fast in their early months and tend to become large adults.

21. Stunkard AJ, Harris JR, Pedersen NL, McClearn GE. The body-mass of twins who have been reared apart. *New England Journal of Medicine.* 1990;322:1483-1487.

This Swedish twin adoption study indicates that identical twins reared apart had a weight correlation of 0.70 for men and 0.66 for women. This article also reviews other twin studies that have similar findings.

22. Zack PM, Harlan WR, Leaverton PE, Cornoni-Huntley J. A longitudinal study of body fatness in childhood and adolescence. *J Pediatrics.* 1979;95:126-130.

HANES (National Health and Nutrition Examination Survey) data showed children had a strong tendency to maintain their relative ranking in skin-fold thickness. 68-77% of children classified as obese in childhood were similarly classified in adolescence. 39 to 52% of lean children remained in that category in adolescence. Tracking for skinfold thickness was strongly correlated with tracking for height. ES note: The logic of this article is complicated by the authors' very common assumption that "obesity" (generally identified as W/H or BMI above the 95 percentile) is an abnormal condition. This article strongly supports children's ability to track and, indeed, indicates a tendency to slimming.

23. **z-score calculation**. Standardized Height and Weight Calculator https://web.emmes.com/study/ped/resources/htwtcalc.htm. Accessed November 5, 2010.

With input of child's gender, age (in months or by birthdate and evaluation date), and measurement (in cm for height and kg for weight), this calculator displays the gender and age specific percentile and Z-score of the measurement. The calculation follows that used by the National Health and Nutrition Examination Survey (NHANES). Standardized z scores are calculated by adjusting for the appropriate population, age and sex-specific levels for the normal population (provided by 2000 CDC growth charts). The CDC growth tables provide normal population using LMS estimation. In the LMS technique, three parameters are estimated: the median (M), the generalized coefficient of variation (S), and the power in the Box-Cox transformation (L). The child's z score is then calculated by using the following formula: zscore=((child's measure/M)**L-1)/(S*L);