Determinants of Adiposity Rebound Timing in Children

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Objective Adiposity rebound (AR) or BMI (body mass index) rebound refers to the increase in BMI following the minimum BMI in early childhood. Early AR (before age 5) is predictive of adult obesity. To determine how 4 domains – demographics, maternal BMI, food security, and behavioral characteristics – may affect timing of AR.

Study design A total of 248 children, ages 2.5-3.5 years, in Latino farmworker families in North Carolina were examined at baseline and every 3 months for 2 years. BMI was plotted serially for each child and the onset of BMI rebound was determined by visual inspection of the graphs. Given the ages of the children, all rebounds were detected before age 5 years and were deemed "early," whereas other children were classified as "nonrebounders." Classes were then compared in terms of the 4 domains with the use of bivariate analyses and linear mixed models.

Results A total of 131 children demonstrated early rebound, 59 children were nonrebounders, and a further 35 had inconclusive data. Parents of early rebounders were less likely to have documentation permitting legal residence in the US. Mothers of early rebounders were on average 3 BMI units heavier. Sex, household food security, diet quality, caloric intake, and daily activity did not differ between classes. In multivariable analysis, female sex, limited maternal education, increased maternal BMI, and increased caloric intake were significant predictors of early rebound.

Conclusion High maternal BMI was the strongest predictor of early BMI rebound, but increased caloric intake also was significant. Limiting excess calories could delay premature AR and lower the risk of future obesity. *(J Pediatr 2017;184:151-6).*

The prevalence of obesity is high among children across the US, but Latino children experience disproportionate risk. In the 2011-2012 National Health and Nutrition Examination Survey study, the risk of obesity was approximately double for 2- to 5-year-old Latino children compared with all children in this age category.[1] Children of Latino farmworkers may have even greater rates of obesity.[2,3]

Typically, body mass index (BMI) increases throughout the first year of life and declines to a nadir around age 6 years. The second rise in BMI following this minimum marks the beginning of the adiposity rebound (AR). In 1984, a French study first noted that early rebounders (before 5.5 years of age) had substantially increased adiposity at age 16 years compared with children who rebounded later.[4] The association between early AR and subsequent obesity has been demonstrated repeatedly,[5-9] and increased fat deposition has been confirmed with dual-energy x-ray absorptiometry scans.[10,11] Early AR also is linked to other components of the metabolic syndrome, including insulin resistance,[12] diabetes,[13] dyslipidemia,[12,14] and elevated blood pressure.[12,14]

Although the onset of AR initially was attributed to an increase in fat mass,[4] recent research suggests that AR coincides with a cessation of fat mass decline and an increase in lean mass.[15,16] An increase in fat mass actually may lag behind 2-3 years, particularly for boys.[17] Therefore, a more accurate term for AR would be "BMI rebound." The term AR should thus be construed to represent an increase in BMI, with an understanding that increase in fat mass may lag behind the increase in lean mass.

This study sought to determine the extent to which modifiable risk factors for obesity and other characteristics influence the timing of AR. We hypothesized that children with risk factors for obesity, such as a high caloric intake and sedentary lifestyle, are more likely to rebound early.

Methods

This analysis included 248 families enrolled in the Niños Sanos study, a longitudinal 2-year study of dietary and physical activity patterns of young children of Latino farmworkers in North Carolina. Eligible participants were self-identified Latinas with a co-resident child aged 2.5-3.5 years and at least 1 member of the

AR	Adiposity rebound
BMI	Body mass index
DQI	Diet Quality Index
WAPCT	Weight-for-age percentile

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household engaging in farm work during the previous year. Children with special healthcare needs limiting physical activity were excluded.

A site-based sampling plan with a large contact base was developed to recruit participants.[18] "Sites" are organizations or locations with which members of the target community are associated, such as Head Start programs and community health centers. Community data collectors also conducted door-to-door recruitment in Latino neighborhoods and farmworker camps and contacted previous study participants.

A bilingual data collector screened for inclusion criteria, explained study procedures and incentives, and invited eligible families to take part. All participants provided signed informed consent. The Wake Forest School of Medicine institutional review board approved the study, and a certificate of confidentiality was obtained from the National Institutes of Health.

Study staff interviewed participants at baseline and every 3 months for 2 years. All interviews were conducted in Spanish in participants' homes or another preferred location between April 19, 2011, and July 30, 2014. Compensation of $10 was provided for each interview. Children's weight was measured with a Tanita model BSB800 digital scale (Tanita Corporation of America, Inc, Arlington Heights, Illinois) capable of determining weight to the nearest 0.1 kg. Height was determined twice with a portable stadiometer with the child shoeless. If the 2 measurements differed by more than 0.5 cm, another measurement was taken and the 2 closest values were averaged.

Physical activity data were collected with Actical accelerometers (Mini Mitter Company, Inc, Bend, Oregon) at baseline, 3, 6, 9, 12, and 24 months. Each device was attached to an elastic belt positioned above the child's iliac crest.[19] The parent and child were oriented to proper placement and usage of the device and written instructions with illustrations also were provided. Children were asked to wear the belt for 7 days and only remove the device for swimming, bathing, and sleeping. A successful wear day was defined as including at least 8 hours of wear data. Eighty-five percent of children provided at least 5 days of data including a weekend day.

Dietary data were collected by bilingual staff members using three 24-hour recalls during a 7-day period, including 1 weekend day and 2 weekdays. The Nutrition Data System for Research software (version 11, University of Minnesota, Minneapolis, Minnesota) was used.[20] The first recall was conducted face-to-face, and subsequent interviews were conducted by telephone or in person when possible. Mothers were given a printed serving size guide, and the interviewer measured the size or volume of their child's usual bowl, plate, and cup to help facilitate calculation of serving sizes. For children enrolled in preschools or daycares, food intake data were collected directly from the caregivers.

BMI at every observation was plotted for each child. Onset of AR was determined via visual inspection. Visual inspection has advantages over the use of polynomial models.[21] If the minimum BMI occurred after age 5 years or at the last observation, there was no indication of early rebound. If the minimum BMI occurred before age 5 years, the remaining data points were examined to determine whether sufficient rise in BMI had occurred to constitute a definitive rebound. We stipulated that, after the minimum, BMI must increase at a rate of at least 0.2 units per year, determined by linear regression of the remaining points. This threshold was set to account for the possibility of measurement error and random fluctuation, based on the recommendations of other studies.[6,11]

If the AR occurred before 3.5 years of age, the child was classified as having a very early rebound. Children whose BMI increased steadily since the first observation were assumed to have already rebounded. If rebound occurred between the ages of 3.5 and 5 years, the child was said to have an early rebound. Given the timeframe of the study, all rebounds were identified before age 5 and were therefore very early or early. Children without evidence of rebound were considered nonrebounders. A subset of children had growth data that could not be classified, because of insufficient data. We specified that at least 4 observations were necessary to make a classification and that at least 2 observations had to occur after the minimum to establish a trend. Representative growth trajectories for each classification are shown in **Figure 1** (available at www.jpeds.com). Although some studies suggest girls' BMI rebounds earlier than boys' BMI,[5,9] because of conflicting evidence,[22] overall growth curve similarities, and the loss of statistical power when dividing the sample by sex, boys and girls were not considered separately.

Standard Centers for Disease Control and Prevention growth charts were used to determine age- and sex-specific BMI percentiles for children.[23] Overweight was defined as BMI ≥85th percentile but <95th percentile and obese as ≥95th percentile. Normal BMI was defined as <85th percentile.

Food security was measured at baseline and quarterly for each household by the use of a Spanish-language adaptation of the 18-item US Household Food Security Survey Module.[24] Food security was graded 1-4 for participants, with 1 = very low, 2 = low, 3 = marginal, and 4 = secure.

The Revised Children's Diet Quality Index (DQI),[25] specifically developed for use among preschoolers, was used to evaluate quality of children's dietary intake at baseline, 12 months, and 24 months, using data from the three 24-hour food recalls at each time point. This index uses 13 dietary components, such as added sugar and fat intake, to determine diet quality. The range of possible total scores extends from 0 to 90, with greater values indicating greater quality.[26]

Accelerometers were initialized with 15-second time periods known as epochs, which provided data to determine minutes spent performing activities of varying intensity.[19] Epochs with fewer than 12 counts of activity were labeled sedentary, and epochs with more than 714 counts were classified as moderate/vigorous activity. The total number of epochs in each category was divided by the number of observation days to derive average minutes per day for each activity.

Mothers' height and weight were measured using the same procedures as their children. Mothers reported their own age and the child's age and sex. Mothers reported their current employment and marital status, and education, in terms of years completed. If the mother reported either parent moved from