RAPID GROWTH FROM 12 TO 23 MONTHS OF LIFE PREDICTS OBESITY IN A POPULATION OF PACIFIC ISLAND CHILDREN

May Okihiro, MD, MS; James Davis, PhD; Lon White, MD, MPH; Chris Derauf, MD

Background: Rapid growth (RG) in early childhood has been associated with increased risk of obesity. The specific intervals when risk is highest have not been well examined and may help identify modifiable risk factors.

Objective: To determine the correlation between RG in consecutive time intervals during the first 2 years of life with obesity at 4–5 years.

Methods: This was a retrospective study of children attending the largest community health center in Hawaii. Children, aged 4–5 years, with a pre-kindergarten (PreK) well-child physical examination were included; data were abstracted from medical charts.

Analyses: Children were classified as overweight (BMI for age/sex 85–94%) or obese (BMI for age/sex ≥ 95%). Moderate and severe rapid growth was defined as an increase in weight-for-height z-score of .67–1.0 SD and ≥1.0, respectively. Relationship between RG and PreK obesity was assessed using logistic regression analyses.

Results: 389 children were included: 66% Hawaiian, 21.6% Samoan and 12.3% Filipino. At the PreK 19.6% were obese, and 20.9% were overweight. Severe RG from 12 to 23 months was strongly associated with PreK obesity (OR 4.36, 95% CI 1.85–10.27). Of children with severe RG from 12–23 months, 48% were obese at PreK compared with 16.7% of children with moderate RG and 19.3% of children without RG.

Conclusion: Rapid growth between 12 and 23 months, a key period of nutritional transition in toddlers, was strongly associated with obesity at 4 to 5 years of age in this high-risk population of Pacific Island minority subgroups. (*Ethn Dis.* 2012;22[4]:439–444)

Key Words: Obesity, Overweight, Child, Growth, Pacific Islander, Hawaii

From Department of Pediatrics (MO) and Biostatistical Core (JD), University of Hawaii John A. Burns School of Medicine and Pacific Health Research Institute (LW) and Department of Pediatrics, Mayo Clinic (CD).

Address correspondence to May Okihiro, MD; Department of Pediatrics; University of Hawaii John A. Burns School of Medicine; 1319 Punahou St., Suite 720; Honolulu, Hawaii 96826; 808.983.8387; 808.945.1570; okihirom@hawaii.edu

BACKGROUND

Childhood obesity is the most common chronic disease in childhood and a key risk factor for adverse health outcomes such as diabetes and cardiovascular disease.[1,2] Minority groups, including Native Hawaiians and other Pacific Islanders (NHOPI), are especially prone to obesity and its consequences.[3,4] NHOPI, a growing population in the United States, have adopted many aspects of the Western lifestyle and now suffer disproportionately from a high prevalence of obesity-related illnesses.[3,4] In addition, poverty has a major impact on the health and welfare of NHOPI families.[5] Consistent with studies on other ethnic groups, there is emerging evidence that obesity in NHOPI communities develops early in life.[6,7] Thus, the identification of discrete age intervals associated with the development of obesity, and the factors involved, may lead to strategies in the primary prevention of childhood obesity in these high-risk populations.

Studies have shown that fetal, infant and early childhood growth, are important determinants of subsequent obesity.[8–12] These studies have examined growth acceleration during various periods in infancy and early childhood and have shown a predictive relationship to obesity. The studies have utilized several methods, definitions and periods of study, with little standardization. This includes rapid growth and weight gain, as measured by change in weight-for-age or weight-for-length z-scores during the first year of life[9–11] through early childhood.[9,12] However, the relative contribution of growth during specific intervals in infancy and early childhood and the development of obesity have not been well examined.

Similar to conclusions reached in other studies of Pacific Island children,[13] we found that Native Hawaiian, Samoan and Filipino children attending the largest health center in Hawaii are at risk for obesity starting at a very young age.[14] By 2–5 years of age, 28.4% of the children in this population were overweight (12.8%) or obese (15.6%) as compared to 21.2% (10.8% overweight and 10.4% obese) of same age children nationally.[1]

We sought to understand factors associated with the early development of childhood obesity in this population and the time periods in early childhood when risk develops. Because early growth, and its impact on later obesity and cardiovascular risk, may be best assessed by measures that include both weight and length/height,[15,16] we sought to examine the impact of changes in weight-for-length z-scores in early life on future obesity risk. Accordingly, the objective of this study was to examine consecutive periods of rapid growth, defined as a change in weight-for-length z-scores over time, in the first 2 years of life in this high-risk population of NHOPI and Filipino children and determine the association with obesity at 4–5 years of age.

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METHODS

This was a retrospective study of Native Hawaiian, Samoan and Filipino children who utilized Hawaii's largest federally qualified community health center (CHC). This CHC serves 2 rural communities that are made up of a large concentration of Native Hawaiian and other Pacific Island residents. This area is impoverished – per capita income is among the lowest in Hawaii and unemployment is high.[17] In 2005 the CHC participating in this study provided health services to 26,936 patients; 51% were Native Hawaiian, 43% were aged <20 years and 76% had incomes ≤200% of the US federal poverty level.

Children meeting the following criteria were eligible for inclusion into the study: 1) Native Hawaiian, Samoan or Filipino; 2) lived in the CHC zip code; 3) born during one of 4 birth cohort periods (1981–1983, 1986–1988, 1991–1993, 1996–1998); 4) attended the CHC for their well-child care; and 5) had a pre-kindergarten physical examination (PreK assessment) at the CHC. The PreK assessment is a well-child clinical visit at age 4 to 5 years and is required by the State of Hawaii for school entry. The cohorts were initially selected to compare the prevalence of overweight by ethnicity over time.

An electronic list of eligible children was created using the CHC electronic clinical database. This included 5947 children of whom 81.3% were Native Hawaiian, 9.7% were Samoan and 9.0% were Filipino. A random sample of the eligible children was then generated using SAS software (version 9.1). Medical charts were manually reviewed. Data were abstracted for the PreK assessment and other clinical visits, from 2 days through 5 years of age, in which height and weight were measured together and recorded in the medical record. Weight and height were most commonly recorded together at well-child clinical visits, including the PreK assessment, when growth is routinely assessed. These well-child clinical visits are routinely scheduled at age 1 and 2 weeks; 1, 2, 4, 6, 9, 12, 15, and 18 months and; 2, 3, 4 and 5 years of age. While the measurements were not made under a research protocol, medical assistants follow a written protocol to standardize clinical measurements and must pass a proficiency review. Scales are professionally calibrated yearly. Race/ethnicity was used as a stratifying variable to compare obesity prevalence. Race/ethnicity was classified based on the parent or guardian's selection from a list of 28 categories at the time of CHC registration.

The CHC Research Committee and the University of Hawaii – Committee on Human Subjects approved the study.

ANALYSES

We examined associations between obesity at the PreK assessment and rapid growth during consecutive, distinct time intervals in the first two years of life: 2 days-5 months, 6–11 months, and 12–23 months. These age intervals were selected because they correspond to periods when growth is closely monitored through routine well-child visits. The intervals also correspond approximately to the developmental and feeding transitions from solely breast milk or formula feeding (birth–5 months) to the introduction of solid foods (6–11 months) to weaning of milk feeds and the shift to mostly table foods (12–23 months). Growth was calculated as the difference between the two data points that were closest to the start and end of the time interval, representing the longest possible duration of growth for the interval studied (eg, 2 days to 5 months). Of note, no data points were utilized for analyses for more than one time interval.

We defined rapid growth by change in weight-for-length z-score over time. When we operationalized rapid growth as changes in weight-for-age z-scores, the results were not significant. In addition, as noted above, weight-for-length may be a more appropriate assessment of overall growth, adiposity and future metabolic risk.[16] Growth acceleration was classified into one of two categories: moderate rapid growth and severe rapid growth. Moderate rapid growth was defined as an increase in weight-for-length z-score (WLZ) ≥.67 SD, but <1.0 SD over an age interval, such as 12 to 23 months. A change in .67 SD represents the difference between displayed centile lines on standard growth charts (ie, 25, 50, 75th centile lines). Several studies examining rapid growth and rapid weight gain in early childhood have used the .67 SD variable.[12,18] It is a simple and easy way that clinicians, monitoring weight and height using standard growth charts, can visualize growth acceleration. In an updated review of published reports on rapid growth in infancy, Ong and Loos[9] suggested that researchers studying rapid growth in childhood use .67 SD change in weight SD score as the standard exposure variable. In order to identify those children at highest risk for obesity, we also examined severe rapid growth, defined as a change in WLZ of ≥1.0 SD over an age interval.

The body size of infants and toddlers up to 23 months of age was defined by weight-for-age and weight-for-length percentiles based on Centers for Disease Control and Prevention (CDC) 2000 growth charts, using software available from the CDC.[19] Body size of children ≥2 years was categorized by body mass index (BMI), calculated as weight (kilograms) divided by height (meters) squared. Body mass index was converted into percentiles for age and sex, based on the CDC growth charts.[19] Children two years and above were defined as overweight if BMI >85th percentile but <95th percentile and obese if BMI ≥95th percentile.

Measurements were excluded from the analysis if the recorded height-for-age, weight-for-age, weight-for-length, or BMI z-scores were not biologically plausible, suggesting recorder or transcription error. This included a height z-score <−4.0 and >+4.0, weight z-score <−4.0 and >+5.0, weight-for-length z-score <−4.0 and >5.0 and BMI z-scores <−4 and >+5.0. This exclusion criteria is similar to that used by the CDC Pediatric Nutrition Surveillance System (PedNSS)[20] and accounted for .7% of the measurements in our study.

Initial analyses compared characteristics of the children in the total cohort to the subset that had multiple measurements between 2 days of age and the PreK assessment. Other descriptive analyses summarized the percentage of children obese at the PreK by WLZ and WAZ growth categories. These analyses were extended using logistic regression models initially adjusted for birth cohort, sex and ethnicity. The final analysis was a comprehensive regression model that also included overweight status from 12 to 23 months and growth during other age intervals. All analyses were conducted with SAS version 9.1 (SAS institute Inc, Cary, North Carolina).

Table 1. Percent of children with rapid growth and PreK obesity [a]

Age Interval (*n*)	SD Range	% Obese at the PreK Exam Weight-for-Height (*n*)
2 days–5 months (289)	<.67	21.6 (176)
	≥.67, <1.0	18.2 (22)
	≥1.0	23.1 (91)
6–11 months (270)	<0.67	22.8 (246)
	≥.67, <1.0	20.0 (10)
	≥1.0	28.6 (14)
12–23 months (325)	<.67	19.3 (274)
	≥.67, <1.0	16.7 (24)
	≥1.0	48.2 (27)

[a] PreK obesity is defined as BMI≥95% for age and sex.

RESULTS

PreK assessment data were available for 578 children; 54% were male, 64.2% were Native Hawaiian, 23% were Samoan and 12.8% were Filipino. Growth trajectory assessments from 1 day to 23 months, based on at least 2 clinic visits per time interval during the first 2 years of life, were available for 389 children. Comparison of data from this subset of infants and toddlers with the larger group of children showed that the groups were similar in ethnicity, sex and PreK assessment obesity prevalence.

The mean number of measurement points taken for each infant/toddler was 8.2 ± 5.0. The time between data points are presented below with the results shown as the calculated median days between points, with 25% and 75% quantiles presented respectively in parentheses. For time period 2 days–5 months, the median interval was 119 days (92 [25%], 138 [75%]). For 6–11 months, the median interval was 90.5 days (68, 103.5). For the encompassing time period between 2 weeks to 11 months, the median was 243 days (161, 282). Finally, for time period 12 to 23 months, the median interval was 185 days (120.5, 238).

Among the children in the infant/toddler subset, 20.1% were overweight (BMI 85–94%) and 22.7% were obese (BMI≥95%) at the PreK assessment. Children with moderate rapid growth from 12 to 23 months (WLZ of .67–1.0 SD) were not at higher risk for subsequent obesity, having a lower prevalence of obesity than those children who did not experience rapid growth (Table 1). In contrast, our initial regression model showed that children with severe rapid growth from 12 to 23 months (WLZ of ≥ 1.0 SD) had an increased risk of obesity at the PreK assessment, after adjusting for ethnicity, cohort and sex (OR 4.36, 95% CI 1.85–10.27) (Table 2). Of the children experiencing severe rapid growth from 12 to 23 months, 48.2% were obese at the PreK assessment compared with only 19.3% of those who did not experience rapid growth during this interval (Table 1).

Obesity risk for the 12 to 23 month interval was highest when we created the comprehensive regression model that also adjusted for growth during the other time periods and overweight status during the 2nd year of life (OR 4.98, 95% CI 1.84–13.49). Rapid growth from 2 days–5 months, 6–11 months and the combined interval 2 days–11 months (Table 2) were not significantly associated with PreK assessment obesity.

DISCUSSION

In this study of low-income NHOPI and Filipino children, we found a high prevalence of obesity at the PreK assessment. More than 20% of children were overweight and 22.7% were obese. This is significantly higher than the NHANES 2007–2008 Report that found 21.1% of children 2–5 years of

Table 2. Associations of rapid growth with PreK obesity [a]

Age Interval (*n*)	SD Range	Odds Ratio, (95% CI)[b] Weight-for-Height
2 days–5 months (289)	<.67	1.0 (reference)
	≥.67	1.12 (.61–2.10)
	≥1.0	1.17 (.62–2.21)
6–11 months (270)	<.67	1.0 (reference)
	≥.67	1.03 (.38–2.78)
	≥1.0	1.33 (.39–4.54)
2 days–11 months (333)	<.67	1.0 (reference)
	≥.67	1.35 (.76–2.38)
	≥1.0	1.44 (.79–2.62)
12–23 months (325)	<.67	1.0 (reference)
	≥.67	2.20 (1.11–4.37)
	≥1.0	4.36 (1.85–10.27)

[a] PreK obesity is defined as BMI≥95% for age and sex.
[b] Model adjusted for ethnicity, cohort and sex.

age were overweight or obese[1] (10.8% overweight and 10.4% obese) and a 2008 PedNSS report that found 14.8% of preschool children, 2 to 4 years of age, were obese.[20] We also found a significant association between rapid growth from 12 to 23 months and obesity at 4–5 years of age. This association was independent of obesity during the same age interval and growth in other intervals. This observation adds to our understanding of the developmental pathophysiology of obesity in early childhood. During this period toddlers are undergoing significant developmental changes such as learning to walk, talk and feed themselves. They are also transitioning nutritionally from primarily milk feeds and baby foods to table foods.

In this study of low-income NHOPI and Filipino children, we found a high prevalence of obesity at the PreK assessment: more than 20% of children were overweight and 22.7% were obese.

The association between growth from 1 to 2 years of age and obesity prevalence has not been well examined. Indeed, our study is one of few to examine growth during discrete, consecutive developmental time intervals in the first 2 years of life.[21–24] These few studies have demonstrated associations between rapid growth in the first few years of life and subsequent obesity and metabolic disturbance. However, the studies have generally focused on one continuous period in early childhood, such as growth from birth through 2 years, and have not considered the specific contribution of smaller consecutive time intervals.

The Barry Caerphilly Growth Study,[21] a longitudinal study found that the most important predictor of BMI among adults from Wales was weight at 5 years or increased weight velocity from 21 months to 5 years of age. The Delhi Cohort Study[22] examined the relationship between growth in early life and adult obesity in a large cohort of generally underweight children. The investigators found that increased BMI in the first 6 months of life and at 2 to 5 years of age was associated with adult obesity. The strongest effect on adult waist-hip ratio, an indicator of central obesity, was growth from 1–2 years. In contrast, a recent study of mostly White children from England[23] found that rapid weight gain in the first 9 months of life, and not growth from 9 to 19 months, was associated with increased adiposity. Finally, a retrospective study of children from Pennsylvania[24] took a different approach and examined the degree of weight gain from birth to 24 months that best defined risk of overweight at 6 to 8 years of age.[25] The researchers based risk on sensitivity and specificity using receiver-operating characteristic curves and found that infants at-risk for obesity gained at least 8.15 kg from 0 to 24 months. Although these studies are difficult to compare with our results, the common thread was an association between weight gain and BMI in early childhood and the subsequent development of obesity. Nevertheless, the populations have vastly different ethnic and socioeconomic characteristics making it difficult to generalize the results.

Prior studies have documented consistent associations between childhood obesity and infant growth from birth through one week,[26] 4 months,[10] 6 months,[27] and 12 months of life.[11] These studies have defined rapid growth using various criteria such as change in weight-for-age and weight-for-length z-scores as well as absolute weight gain analyzed as either a continuous or dichotomous variable. In contrast, our study, using both change in weight-for-length z-score and weight-for-age z-score, did not find an association between infant growth and obesity at the PreK assessment. It is unclear why growth from 12 to 23 months, and not infant growth, was predictive of obesity in this population. Teenage pregnancy is common in this community but low birth weight rates are not exceptionally high. Breastfeeding rates, anecdotally, are low. It may be that feeding behaviors are more uniform in the first year of life but vary more as children get older in this multi-cultural population. We speculate that factors related to the complex development of toddler eating behaviors and parental child feeding practices may have been involved in rapid growth from 12 to 23 months and subsequent obesity.

During the period of 12 to 23 months, toddlers typically wean from milk feeds and learn to eat foods shared by the family. In the course of this transition, toddlers develop taste and food preferences, food-related behaviors and the ability to self regulate energy intake.[25,28] Studies have shown that child-feeding practices shape these eating behaviors – the types and portions of foods served by caregivers, the frequency of eating and the social contexts in which eating occurs.[29,30] A caregiver's own experience with food and eating, and their cultural beliefs about issues such as food and body size also frame feeding practices and the food environment.[29,30]

Birch hypothesized that many low-income families learn to feed children frequently when food is available, in large quantities and in response to crying or distress rather than hunger.[28] Children learn not to respond to satiety clues but to clean their plate. Over the last 30 years the American food environment, especially of low-income communities, has quickly evolved into one where inexpensive, palatable, caloric foods, low on nutrient value, are easily accessible. The impact of cultural beliefs and a rapidly changing food and social environment, on the feeding practices and eating behaviors of NHOPI and Filipino families were not evaluated in this study. Nevertheless, the complex mix of factors related to culture, body size, poverty, food insecurity and food preferences in environments where obesogenic foods are now abundant, may play a major role in the development of early childhood obesity and are likely factors involved in our findings. Understanding the role of these factors in the early excess weight gain is an important next step in identifying potential modifiable risk factors suitable for intervention.

LIMITATIONS

We recognize several limitations of this retrospective report. Data was extracted from measurements taken during routine well-child visit appointments. As expected, actual visit dates were variable accounting for the difference in the data intervals as described above. In addition, methods for weight and height measurement were obtained through clinical measurement and not standardized research protocols. However, trained medical assistants, following a standard clinical protocol, performed all measurements. Finally, implausible values for height, weight and BMI were excluded.

Data on birthweight, mother's weight, gestational age and infant feeding method and intake were incomplete and not included in our analysis. Past reports have shown that adjustment for parental obesity and low-income status reduces the effect size of rapid weight gain on obesity but does not eliminate the effect.[9] In addition, we were not able to determine any meaningful results that could reflect differences in the three ethnic groups studied, due to the relatively small size of the Samoan and Filipino subsets.

Finally, we recognize that the analysis was limited to obesity prevalence at 4–5 years of age; we do not know how these data will translate to the status of the cohort in later life. Nevertheless, it is now generally accepted that understanding the development of early childhood obesity is critical to understanding the pathogenesis of adult obesity and related chronic diseases,[31] since the majority of obese children become obese adults.[32]

CONCLUSIONS

There is mounting evidence that rapid growth in infancy and early childhood is associated with obesity and related metabolic disturbances. This is the first study to show that rapid growth from 12 to 23 months is highly predictive of obesity at 4 to 5 years in a population of NHOPI and Filipino children with a high prevalence of early obesity. Given the retrospective design of this study, additional prospective studies are needed to validate our findings and to elucidate the factors leading to the rapid growth during this period. We speculate that child feeding practices in obesogenic environments may be especially important in low-income communities and cultures in transition, such as our Pacific Island and immigrant Asian communities. Understanding the impact of rapid growth in early childhood and the socioeconomic and cultural factors leading to increased obesity risk is crucial to designing effective primary prevention strategies.

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AUTHOR CONTRIBUTIONS

Design and concept of study: Okihiro, White, Derauf
Acquisition of data: Okihiro
Data analysis and interpretation: Okihiro, Davis, White, Derauf
Manuscript draft: Okihiro, Davis, Derauf
Statistical expertise: Davis
Acquisition of funding: Okihiro, Derauf
Administrative: White, Derauf
Supervision: Derauf