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## Research Article

# Infant Predictors of Childhood Overweight

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### ABSTRACT

Previous studies have identified numerous risk factors to be associated with early obesity, among them high birth weight and energy intake, low activity or energy expenditure, high maternal body mass index, rapid early infant growth, short duration of sleep, and overly controlling feeding styles. The aim of the present study was to examine these various factors as predictors of overweight in early childhood. Ninety-one mothers were observed feeding their infants at 12-months, with infants weighed and measured again at 36-months. Motor activity, sleep duration, and difficulty were also assessed. The results revealed that nearly all the factors showed some associations with higher BMI percentiles, such that multiple factors are at work in promoting early excess weight gain in the early years of development.

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### Introduction

Obesity in adulthood is associated with diabetes, atherosclerosis, heart disease, hypertension and certain types of cancer, among other maladies [1]. It is now generally acknowledged that if begun during infancy, obesity may persist through childhood and continue into adolescence and adulthood [2-4]. Using CDC growth charts and a criterion of greater than or equal to the 95<sup>th</sup> percentile, recent NHANES data suggest that 5% of US infant boys younger than 2-years-old are obese, and that 11.4% of infant girls are at that level, for an average of 8.1% [5]. The figures for high weight-for-recumbent length are even more alarming, as the national rate for infants (3 to 23 months) using WHO growth charts is now estimated to be 8.9% and for infants enrolled in WIC programs (see below) a disturbing 12.3% [6, 7]. As these amounts are at least twice what an epidemiologist might expect, such trends for infants suggest that increased attention be paid to the factors that may contribute to excess weight gain lest their prevalence rates for obesity in childhood be even higher [8].

Previous studies have identified numerous risk factors to be associated with early obesity, among them high birth weight, overfeeding, low activity or energy expenditure, high maternal body mass index, rapid early infant growth (e.g., from birth to 6 months), temperamental

difficulty, short duration of sleep, and overly controlling feeding styles [9-16]. Sadly, race/ethnicity may serve as an additional risk factor, given the disparities in overweight that are apparent between Hispanic children (18.5%), followed by African-American (16.8%), white (16.4%), and Asian (13.1%) as early as age 2 years, though rates for American Indian (24.75) greatly exceed all the groups [17]. While numerous studies have explored each of these factors, it is seldom the case that even two at a time are included on the same investigation. The aim of the present study was therefore to examine these various maternal and infant factors in a minority sample in the first postpartum year that could contribute to higher infant BMI-for-age at 36-months.

### Methods

Mothers were recruited at a local WIC center that served an urban community. WIC is the Special Supplemental Nutrition Program for Women, Infants and Children, a federal assistance program that provides health care and nutrition support for low-income pregnant and breastfeeding women, and children under the age of five (<https://www.fns.usda.gov/wic>). Although WIC heavily promotes breastfeeding among its clients, recruitment was restricted to mothers that had indicated to the WIC intake staff that they formula-fed their infants from birth. This decision was made at the study's inception to

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facilitate mothers' ability to record their infants' nutrient intake during feeding. The full protocol was approved by the Principal Investigator's university Institutional Review Board.

All the mothers were either Black or Latina, and as stated above, had formula-fed their infants from birth. Their mean age was approximately 27 years and while some mothers had a college degree, as a whole their level of education barely exceeded the ninth grade. Ninety-one mother-infant pairs were observed at home while feeding when their infants were 12 months old (M=368 days, SD= 23 days) using the Nursing Child Assessment Feeding Scale (NCAFS)-a rating scale of mother and infant behaviors coded during a feed [18]. Infant Difficultness was assessed with the Infant Characteristics Questionnaire [19]. Both instruments have been used with samples representing minority groups. In addition, infant motor activity and sleep duration was also measured over a 24-hour period using MicroMiniMotion-loggers™ (Ambulatory Monitoring, Ardsley, NY). Dyads were re-visited at 36-months, with the infants again weighed and measured. Anthropometric measures were taken twice by one of two home visitors using a portable digital scale (Model BD-585, Tanita Corp. of America, Arlington Heights, IL) and a Measure Mat (Model SMM 133, Hopkins Medical Products, Baltimore MD).

**Results**

At the time of the 12-month baseline assessment, 44% of the infant sample was at or above the 85<sup>th</sup> percentile of weight-for-length for age and sex while 22% were at or above the 95<sup>th</sup> percentile. As Body Mass Index (BMI) is a suitable referent for 2-year-old children and older, BMI for age and sex was used for subsequent analyses (Table 1). At approximately 36-months BMI for age and sex showed that 41% of the infants were at or above the 85<sup>th</sup> percentile. For the 95<sup>th</sup> percentile 23% of the 3-year-olds met this criterion.

**Table 1:** Descriptive statistics for the sample.

Variable	Mean	(SD)
Maternal age at recruitment (years)	27.11	5.84
Maternal weight at delivery (kg)	77.2	14.85
Infant birth weight (kg)	3.22	0.56
Weight/length by age & sex percentile (12 mo.)	70	28
Infant weight gain 3-6 months (kg)	1.82	0.95
Infant age at 1-year visit (days)	368	23
Number of feeds per day	7.89	2.59
Feeding sensitivity (1-16)	11.25	2.43
Infant difficultness (1-7)	2.25	0.56
Sleep (hours-minutes)	11' 34"	2' 34"
Infant motor activity (counts/24 hours)	10222	6,283
Infant age at 3-year visit (days)	1109	53
BMI by age & sex percentile (3 yr)	71	25

A regression analysis using the Statistical Package for the Social Sciences (SPSS 25, <https://www.ibm.com/products/spss-statistics>) was next conducted to predict BMI-for-age at 36 months, using the following as independent variables: infant birth weight, infant weight gain from 3-6 months, maternal weight, infant difficultness score, maternal feeding sensitivity score, number of feeds, and infant total motor activity and

total minutes of sleep at 12-months. As shown in (Table 2), the regression analysis revealed infant birth weight and the difficultness score as positively predictive of BMI-for-age at 36-months. In contrast, negative associations emerged for maternal sensitivity during feeding, minutes of sleep, and infant activity counts.

**Table 2:** Factors regressed onto BMI-for-age and sex at 36 months.

	Beta	t	p-value
(Constant)		2.02	0.07
Maternal weight at delivery	-0.176	-1.04	0.32
Infant birth weight	0.383	2.54	0.03
Infant early weight gain	0.019	0.09	0.92
Number of feeds per day	0.277	1.66	0.12
Feeding sensitivity	-0.422	-2.61	0.02
Infant difficultness	0.438	2.56	0.03
Minutes of sleep	-0.47	-3.02	0.01
Infant motor activity	-0.515	-2.84	0.02

**Discussion**

As stated previously, national rates of infant overweight, indeed, of infant obesity, have reached alarming levels, with recent figures derived with CDC growth charts suggesting that 8.9% of infants in the United States under 24-months-old are now in excess of +2 z-scores in terms of their weight for recumbent length [6]. While a prevalence as high as 12.3% has been reported for WIC infants, the results from this study are extremely alarming, as 41% of the infants were at or above the 85<sup>th</sup> percentile at 36-months and 23% were at the 95<sup>th</sup> percentile [7].

Families enrolled in WIC must be of low-income to be eligible for assistance, and low income has been tied to childhood obesity, but the present results suggest a sample at significant risk [20]. Although rates of childhood obesity are worrisome across all ethnic and racial groups, its prevalence appears to be higher in non-white children, and the present sample was comprised entirely of Black and Latina mothers [21]. Add on our restricting the sample to mothers who chose to exclusively use formula rather than breastfeed from the time of their infant's birth, and it is perhaps understandable that the overweight and obesity percentages were so high [22].

These results not only underscore the significance of obesity as a concern in infancy, but also indicate the multiple factors that may be at work in promoting early excess weight gain [23]. As overweight is the outcome of interest, feeding insensitivity as a causal factor has been a primary candidate [10, 16]. But for some time, factors such as heavier birth weight and rapid weight gain over the first postpartum months have been recognized as promoting early overweight, with lower activity level theorized as influential but inconsistently related [11, 13]. More recently, insufficient sleep, and infant difficulty have also been implicated [14, 15]. Notwithstanding the role of low income, minority status, and formula feeding, the fact that higher birth weight, temperament difficulty, and less sleep were associated with higher BMI at 36-months suggests them as suitable candidates for further exploration. However, the present results also indicate that regardless of any individual impact, their interactive contributions to early overweight and childhood obesity should continue to be examined.

## Conflicts of Interest

None.

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