Published in final edited form as:

J Nurse Pract. 2013 May 1; 9(5): . doi:10.1016/j.nurpra.2013.01.017.

Prepregnancy Body Mass Index and Feeding Practices in Relation to Infants' Growth

Nuananong Seal, PhD, RN and

Nuananong Seal, PhD, RN, is an assistant professor in the College of Nursing at the University of Wisconsin in Milwaukee

Marion E. Broome, PhD, RN

Marion E. Broome, PhD, RN, FAAN, is dean and distinguished professor in the School of Nursing at Indiana University in Bloomington

Nuananong Seal: nseal@uwm.edu

Abstract

Obesity has now emerged as 1 of the most serious public health problems facing American Indian (AI) children and adolescents. However, little is known about what factors contribute to the early development of obesity in AI children. This study explored the relationships between maternal prepregnancy BMI, feeding practices, and growth in AI infants. The findings of this study highlight the need for nurse midwives and pediatric nurse practitioners to increase AI mothers' awareness about their feeding practices, exclusive breastfeeding, and timing for solid food introduction.

Keywords

body mass index; feeding practices; infant; maternal prepregnancy BMI; obesity

Childhood obesity is recognized as a major public health problem in the United States and worldwide. Data from the 2007-2008 National Health and Nutrition Examination Survey, using measured weights and heights, showed that an estimated 16.9% of children and adolescents 2-19 years old were obese.¹ The 2007 PedNSS data indicated substantial racial/ethnic disparities in obesity and overweight prevalence for US children age 2 to 5 years.

Obesity prevalence was highest among American Indian (AI) children during 1998-2008.² Approximately 12.6% of AI infants (0-11 months) and 24% of toddlers (12-23 months) are at risk for overweight, compared with 10.9% and 17%, respectively, for infants and toddlers from the general population.³ In 2007, 19.5% of AI children 24-59 months old were obese (body mass index [BMI] 95th percentile).² These figures underscore the critical need for prevention efforts in AI children, particularly very young children.

Childhood obesity is a critical risk factor for associated comorbidities, including type 2 diabetes, cardiovascular disease, and high blood pressure.⁴ Children with obesity experience higher rates of hospitalization and greater use of medical services.⁵ In addition, childhood

© 2013 Elsevier, Inc. All rights reserved.

In compliance with national ethical guidelines, the authors report no relationships with business or industry that would pose a conflict of interest.

Disclosure: The opinions expressed in this article are those of the authors and do not necessarily reflect the views of Indian Health Services.

obesity is a predictor of obesity throughout life.⁶ Evidence indicates that a rapid rate of weight gain during infancy has been associated with obesity in childhood⁷ and adulthood.⁶ Because of these negative health consequences of early onset obesity, serious consideration must be given to the prevention of overweight and obesity in early periods of life, especially those in the high-risk groups, including the AI population.

Several potential factors, including maternal prepregnancy BMI, infant birth weight, and infant feeding practices, have been documented to be associated with the rise in children's weight.⁸ Evidence showed that mothers with a higher prepregnancy BMI were more likely to introduce solid foods to their infants early compared to their lower prepregnancy BMI counterparts.⁹ Early introduction of solid foods can influence an infant's body weight.⁹

Breastfeeding has shown a protective effect with respect to overweight in childhood.¹⁰ However, data from the Centers for Disease Control and Prevention (CDC) reported that the 3-month exclusive breastfeeding rate among AI women was below the national average (27% vs. 32%).¹¹

Little is known about obesity risk factors in AI children. Knowing about risk factors is essential for intervention development to decrease obesity in this population. The aim of this study was to determine the relationships between maternal prepregnancy BMI, feeding practices, and growth of AI infants between 14 and 20 weeks old.

Methods

Design

This study used an exploratory descriptive design with a total of 98 AI mother-infant dyads who visited an AI hospital-based outpatient clinic in a small US town. Institutional Review Board approval was obtained from the researcher's university review board, the Indian Health Services Institutional Review Board, and the Tribal Council. Confidentiality was guaranteed, with all findings reported in group format.

Sample

Eligible participants were invited to participate if they met all of the following inclusion criteria:

1. Mother self-identified of AI ancestry
2. Full-term (born between 37 and 41 weeks of gestation) singleton infant who was between 14 and 20 weeks old at entry to study. This age group was chosen because of the nature of the population in the setting, and it met the purpose of the study. From conversations with the nurse practitioner and pediatrician at the clinic, most mothers who attended the hospital introduced solid foods to their infants as early as 15 weeks old.
3. Infant did not have any health problems that would affect feeding
4. Mother spoke English (for communication during participation)

Data Collection and Procedures

Mothers and infants were contacted and screened for research participation by the researcher during their clinic visits. Those who met all the inclusion criteria were included in the study. Written informed consent was obtained from eligible mothers before participation. The mothers were asked to complete a self-administered demographic questionnaire and an infant feeding questionnaire. Additionally, the mothers who reported formula feeding were

asked to complete a take-home 24-hour milk intake survey and mail it back in a returned envelope provided. The mothers were given a \$25 gift card in appreciation for their time after completion of the survey.

The infants' current weight and length were measured by the same researcher using a hospital infant measuring board following the standard protocol for consistency.¹⁰ Infants were weighed to the nearest 10 g or half oz without shoes and wearing light underclothing or diaper. Infants wearing wet diapers had their diapers changed before measuring their weight. To measure recumbent length, the infant was placed supine on the infant measuring board. The infant's head contacted the fixed head-board. The researcher placed 1 hand gently but firmly over the knees to prevent the knees from flexing, with the infant's toes pointing directly upward, and another hand pulled the movable footboard to rest firmly against the infant's heels. The measurement was recorded to the nearest 0.1 cm. Infant weight for length (WFL) Z score, adjusted for age and gender, was then calculated using the Epi Info™ program, version 3.5.1 (www.cdc.gov/epiinfo).

Measures

Demographic questionnaire—The items include personal information about mother's age, highest educational level, income, prepregnancy BMI (kg/m^2) and tobacco and drug use, as well as infant's age, gender, birth weight, and length.

Infant feeding questionnaire—Information on infant feeding was collected using the Infant Feeding Practices Study II developed by the Food and Drug Administration in collaboration with the CDC. The items selected from the postnatal questionnaire for ages 4 months include: number of feedings per week for solid foods (ie, baby cereal and other daily foods), 100% fruit juice, sweet drinks, etc.; frequency of putting baby to bed with a bottle of formula or juice; frequency of feeding baby breast milk or formula when he/she cries; frequency of encouraging baby to finish his/her bottle; and frequency of finishing all of his/her bottle of formula for each meal. Each mother was instructed to identify the frequency using a 5-point scale as follows: 0 = never, 1 = rarely, 2 = sometimes, 3 = most of the time, and 4 = always.

Sources of the infant feeding information received by the mothers were also asked. The questions in the survey were based on the 1993/1994 Infant Feeding Practices Study. No validity and reliability have been reported previously. The questionnaires are available as a public use through the CDC website at <http://www.cdc.gov/ifps/>. Reliability of the scale for this study was a coefficient alpha of .70.

A 24-hour formula intake survey—The mothers whose infants consumed formula were asked to complete the survey. The actual amount of formula consumed per day by the infant was determined using a graphic of an infant feeding scaled-bottle completed by the mother.

Statistical Analysis

Statistical analyses were performed using the Predictive Analytics Software (PASW) version 18. Conformance to statistical assumptions was examined for all inferential tests and no violations were found. The relationships between demographics and all other study variables were tested. Pearson correlations were used to determine the relationships between maternal prepregnancy BMI, infant's birth weight, WFL Z score at birth, feeding practices, amount of 24-hour milk intake, and WFL Z score at age between 14 and 20 weeks. Likert scale data were used to analyze the responses from the infant feeding practice questions.¹²

General Linear Model (GLM) univariate was used to analyze the differences in mean birth weight, amount of 24-hour formula intake, infant feeding practices, and WFL Z scores of the infants with normal and higher BMI mothers. The potential covariates (infant's age and gender, maternal age, maternal prepregnancy BMI, education, and family income) were included as appropriate. Significance ($P < 0.05$) was determined at the 5% level of probability.

Results

Of the 116 eligible mother-infant dyads, 98 (84.5%) agreed to participate and completed the study. Fifty-nine (60.2%) mothers reported that they completely stopped breastfeeding their babies after the first month; 20.4% reported partially breastfeeding (breast milk and formula) for the first 6 weeks, then continued formula feeding; and 19.4% reported never breastfeeding. At the time of data collection, none of the mothers reported breastfeeding their infants. The primary reasons to stop breastfeeding in this group include didn't have enough milk, thought that their babies were not gaining enough weight, and breastfeeding was too inconvenient. The resources about infant feeding information accessed most often by the mothers came from the federal Women, Infants and Children program (92%); family member, relative, or friend (74%); and health professionals, including physician and nurse (69%).

Approximately 50% of the mothers had completed high school, and two-thirds (63%) had an annual family income less than \$20,000. Most of them had never married (61%), and 53% used tobacco. Two mothers reported gestational diabetes, but neither was prescribed medications. The infants' gestational age ranged between 37 and 42 weeks. Sample characteristics are presented in Table 1. The mean birth weights and lengths of infants were within the normal range. The infants' WFL percentile at age 14-20 weeks was also within normal, ranging between 15th and 95th. The mean birth weights and WFL Z scores at birth between male and female infants were not significantly different (all $P > .05$). However, male infants had greater mean 24-hour formula intake (37.2 oz.) than females (31.5 oz., $P = .04$).

Associations between WFL Z score at age 14-20 weeks and potential covariates that could influence infant growth, including infant's age and gender, maternal age, education, and family income, were examined. Infant's gender was positively correlated with WFL Z score at age 14 to 20 weeks ($r = .32$, $P = .03$). Boys had higher WFL Z scores than girls.

Family income was positively associated with infant weight at birth ($r = .31$, $P = .02$); however, the relationship disappeared at age 14-20 weeks. Maternal age and educational level were not associated with infant's growth ($P > .05$). In correlation matrix analysis, infant's WFL Z score between 14 and 20 weeks old was significantly associated with the number of cereal feedings and sweet drinks ($r = .40$, $P = .004$ and $r = .29$, $P = .04$, respectively). The frequency that a mother encouraged her baby to finish his/her bottle of formula was also significantly associated with the frequency that a baby finished all of his/her bottle of formula ($r = .31$, $P = .03$).

The relationships between maternal prepregnancy BMI, birth weight, WFL Z scores at birth and at age 14-20 weeks, and amount of 24-hour formula intake were examined and are shown in Table 2. Prepregnancy BMI was not significantly associated with birth weight, WFL Z scores, and amount of 24-hour formula intake ($P > .05$). The differences in means birth weights and lengths, WFL Z scores at birth and at age between 14 and 20 weeks, amount of 24-hour formula intake, and the number of solid food feedings per week between mothers with normal BMI (< 25) and higher BMI (≥ 25) are shown in Table 3.

Infants of higher BMI mothers tended to have greater WFL Z scores at birth and at age 14-20 weeks than infants of normal BMI mothers. In addition, infants of higher BMI mothers consumed more formula than infants of normal BMI mothers. Mothers with higher BMI tended to feed solid foods to their babies more often than their normal BMI counterparts. However, the differences were not significant ($P > .05$).

The differences in infant feeding practices between mothers with normal and higher BMI are presented in Table 4. Compared with normal BMI mothers, higher BMI mothers put their infants to bed with a bottle of formula or juice more frequently. Higher BMI mothers also tended to encourage their infants to finish their bottle of formula and feed formula to their infants more often when they cried than normal BMI mothers.

Discussion

This study is, to our knowledge, the first to investigate correlates of maternal prepregnancy BMI, birth weight, feeding practices, and growth at age 14-20 weeks in AI infants and to compare the feeding practices between normal and higher prepregnancy BMI mothers. The positive link between maternal prepregnancy BMI, birth weight, and growth of infants was found across a multiethnic European population,¹³ African Americans,¹⁴ and Hispanics.¹⁵ However, it was not known whether those relationships were also present in AIs because few studies have been conducted in this group.

Our findings indicated that infants of higher prepregnancy BMI mothers tended to have higher WFL Z scores at birth and at 14-20 weeks, as well as consume more milk than those of normal prepregnancy BMI mothers. However, the associations were not statistically significant. The findings are consistent with previous research in term of positive direction. A multiethnic birth cohort study found that infant's weight gain was associated with maternal prepregnancy BMI.¹³ Our findings suggest that a long-term observation of infant's growth pattern is essential to understand the relationships of these potential risks to obesity development of AI infants.

Given the high prevalence of overweight and obesity during infancy in AIs,² it is important to understand the associations between maternal feeding practices and infant's growth, on which there is no information in this population to date. Maternal feeding practices are a primary factor influencing infant's eating pattern and amount of milk intake.⁸ Maternal feeding practices, therefore, may play a role in infant's weight gain. Our findings indicated that, compared with normal BMI mothers, higher BMI mothers were more likely to feed solid foods (eg, baby cereal) and sweet drinks to their infant. Infant's weight gain was also positively associated with the number of cereal feedings and sweet drinks. This is a concern because a previous study revealed that early introduction to solid foods and sweet drink was associated with childhood overweight.¹⁶

The data yielded some interesting findings on which future research can be based. Most AI mothers stopped their breastfeeding as early as 4 weeks postpartum and introduced solid foods to their infants as early as 14 weeks after birth. These findings suggest that educating the mothers about the health benefits of exclusive breastfeeding is necessary. It is important to address the consequence of infant weight gain from the early introduction of solid foods and juice, as well as the practice of putting the infant to bed with a bottle of formula or juice. Studies indicated that infants who were put to bed with a bottle of formula or juice were more likely to develop dental caries in the toddler and preschool periods.¹⁷ AI mothers could be encouraged to extend their breastfeeding to at least 6 months postpartum and avoid putting their infants to bed with a bottle of formula or juice.

Limitations

The present study has some limitations, including a cross-sectional study design and a relatively small sample size. In addition, maternal prepregnancy BMI could have biased as a result of maternal self-reported weight and height.¹⁸ Further, there was limited information about the timing of solid food introduction. The infants of this study were primarily formula-fed; thus, we were unable to compare growth patterns of those with breastfed infants. We also did not ascertain if there were other people who might have been involved in feeding the baby. Additional larger and long-term studies that include both breastfed and formula-fed infants are needed to explore the relationships between maternal prepregnancy BMI, feeding practices, and growth of AI infants.

Nursing Implications

Our findings have important nursing implications for advising and supporting AI mothers about breastfeeding practice and infant feeding strategies. The American Academy of Pediatrics recommends exclusive breastfeeding to age 6 months and introducing solid foods at that time.¹⁹ Solid foods can be introduced between 4-6 months in infants who are formula-fed.²⁰ Introducing solid foods too early may increase the risk of overfeeding and being overweight.¹⁹ The mothers in this study quit their breastfeeding and introduced solid foods to their infants too early; this underscores the need for nurses to provide information, guidance, and support of breastfeeding to these AI mothers.

Nurse-midwives and pediatric nurse practitioners have critical roles to serve as educators and supporters for women during pregnancy and after giving birth. Nurses can help a new mother to learn about the importance of breastfeeding for her baby and herself and assist her to start and keep breastfeeding. There are many strategies for nurses to provide support, including listening to issues concerning breastfeeding and lactation problems, providing support materials and resources to help mothers initiate and sustain breastfeeding, and addressing common fears, concerns, problems, and myths.

Because nurses have an important role in promoting breastfeeding, they need to enhance their skills in breastfeeding support through education and professional networks. Examples of the resources from which nurses can learn about effective breastfeeding, challenging issues of breastfeeding initiation and continuation, and infant feeding strategies are included in the appendix. Breast milk meets the nutritional requirements for healthy growth of infants and provides a protective effect with respect to overweight in childhood.¹⁰ Encouraging AI mothers to exclusively breastfeed for at least 6 months may substantially reduce the risk of obesity in their children.

Acknowledgments

This work was supported in part by grant T32-NR7066 National Institute for Nursing Research, National Institutes of Health, Indiana University School of Nursing, and a Sigma Theta Tau International research grant.

Appendix

Examples of Resources and Networks for Nurses to Learn and Promote Breastfeeding

Web Sites	Information
http://www.ilca.org/i4a/pages/index.cfm?pageid=1	The International Lactation Consultant

Web Sites	Information
http://www.womenshealth.gov/Breastfeeding/	<p>Association (ILCA) is the professional association for International Board Certified Lactation Consultants (IBCLCs) and other health care professionals who care for breastfeeding families. ILCA membership is open to all who support and promote breastfeeding.</p> <p>Information about breastfeeding, such as benefits, guides, and where to find support. The site also provides funding sources and how to get involved.</p>
http://www2.aap.org/breastfeeding/	<p>Information and resources for families and health professions who want to learn more about breastfeeding, recommendations, and advocacy.</p>
http://wicworks.nal.usda.gov/infants/infant-feeding-guide	<p>Infant feeding guide provides an overview of topics related to infant nutrition and feeding and answers some common questions</p>
http://www.surgeongeneral.gov/library/calls/breastfeeding/calltoactiontosupportbreastfeeding.pdf	<p><i>Call to Action</i> describes specific steps people can take to participate in a society-wide approach to support mothers and babies who are breastfeeding.</p>
http://www.awhonn.org/awhonn/index.do	<p>The Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN) promotes the health of women and newborns and strengthens the nursing profession through superior advocacy, research, education, and other professional and clinical resources to nurses</p>

Web Sites	Information
	and other health care professionals.

References

1. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA*. 2010; 303:242–249. [PubMed: 20071470]
2. Polhamus, B.; Dalenius, K.; Borland, E.; Mackintosh, H.; Smith, B.; Grummer-Strawn, L. Pediatric Nutrition Surveillance 2007 Report. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2009. http://www.cdc.gov/pednss/pdfs/PedNSS_2007_text_only.pdf [Accessed March 14, 2013]
3. Touger L, Looker HC, Krakoff J, Lindsay RS, Cook V, Knowler WC. Early growth in offspring of diabetic mothers. *Diabetes Care*. 2005; 28:585–589. [PubMed: 15735192]
4. Centers for Disease Control and Prevention. [Accessed March 14, 2013] Overweight and Obesity Health Consequences. 2011. <http://www.cdc.gov/obesity/childhood/consequences.html>
5. Trasande L, Liu Y, Fryer G, Weitzman M. Effects of childhood obesity on hospital care and costs, 1999-2005. *Health Aff*. 2009; 28:751–760.
6. Stettler N, Zemel BS, Kumanyika S, Stallings VA. Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics*. 2002; 109:194–199. [PubMed: 11826195]
7. Stettler N, Kumanyika S, 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; 77:1374–1378. [PubMed: 12791612]
8. Burdette HL, Whitaker RC, Hall WC, Daniels SR. Maternal infant-feeding style and children's adiposity at 5 years of age. *Arch Pediatr Adolesc Med*. 2006; 160:513–520. [PubMed: 16651495]
9. Whitaker RC. Predicting preschooler obesity at birth: the role of maternal obesity in early pregnancy. *Pediatrics*. 2004; 114:e29–e36. [PubMed: 15231970]
10. [Accessed March 14, 2013] National Health and Nutrition Examination Survey III. Body Measurements (Anthropometry). <http://www.cdc.gov/nchs/data/nhanes/nhanes3/cdrom/nchs/manuals/anthro.pdf>
11. Centers for Disease Control and Prevention. [Accessed March 14, 2013] CDC's Breastfeeding National Immunization Data: Socio-demographic. 2005. http://www.cdc.gov/breastfeeding/data/NIS_data/2005/socio-demographic.htm
12. Boone, HN.; Boone, DA. [Accessed March 14, 2013] Analyzing Likert data. <http://www.joe.org/joe/2012april/tt2.php>
13. Mesman I, Roseboom TJ, Bonsel GJ, Gemke RJ, Van der Wal MS, Vrijkotte TGM. Maternal pre-pregnancy body mass index explains infant's weight and BMI at 14 months: results from a multi-ethnic birth cohort study. *Arch Dis Childhood*. 2009; 94:587–595. [PubMed: 19332418]
14. Stettler N, Tershakovec AM, Zemel BS, et al. Early risk factors for increased adiposity: a cohort study of African American subjects followed from birth to young adulthood. *Am J Clin Nutr*. 2000; 72:378–383. [PubMed: 10919930]
15. Kitsantas P, Pawloski LR, Gaffney KF. Maternal prepregnancy body mass index in relation to Hispanic preschooler overweight/obesity. *Eur J Pediatrics*. 2010; 169:1361–1368.
16. Hawkins SS, Cole TJ, Law C, Millennium Cohort Study Child Health Group. An ecological systems approach to examining risk factors for early childhood overweight: Findings from the UK Millennium Cohort Study. *J Epidemiol Community Health*. 2009; 63:147–155. [PubMed: 18801795]
17. Begzati, A.; Berisha, M.; Meqa, K. [Accessed March 14, 2013] Early childhood caries in preschool children of Kosovo-A serious public health problem. 2010. <http://www.biomedcentral.com/1471-2458/10/788>
18. Stewart AW, Jackson RT, Ford MA, Beaglehole R. Underestimation of relative weight by use of self-reported height and weight. *Am J Epidemiol*. 1987; 125:122–126. [PubMed: 3788941]

19. American Academy of Pediatrics Committee on Nutrition. Pediatric Nutrition Handbook. 6. Elk Grove Village, IL: American Academy of Pediatrics; 2009.
20. American Academy of Pediatrics. [Accessed March 14, 2013] Breastfeeding and the use of human milk. <http://pediatrics.aappublications.org/content/129/3/e827.full.html>

Table 1
Sample Characteristics of Mother-Infant Dyads (n = 98)

Characteristics	Mothers M (SD)	Characteristics	Infants M (SD)
Age (years)	25 (6)	Age (weeks)	17 (2)
Prepregnancy BMI(kg/m ²)	28.5 (8.3)	Gender (% male)	57.0
		Birth weight (lbs)	7.5 (1.0)
		Birth length (cm)	51.4 (2.6)
		WFL Z scores (birth)	0.40 (0.20)
		WFL Z scores (14-20 weeks)	0.59 (0.14)
		24-hour formula intake (fluid oz)	34.0 (8.1)

BMI = body mass index; WFL = weight for length

Table 2
Relationships Among Selected Variables

Infants (n = 98)	Mothers (n = 98) Prepregnancy BMI	
	<i>r</i>	<i>P value</i>
Birth weight	.19	.24
WFL Z score at birth	.21	.18
WFL Z score at 14-20 weeks	.20	.19
Amount of 24-hour formula intake	.24	.10

BMI = body mass index; WFL = weight for length.

Table 3
Mean $\pm$ SD for Selected Variables

	Mothers (n = 98)		<i>P</i> value
	BMI < 25 (n = 43)	BMI ≥ 25 (n = 55)	
	M (SD)	M (SD)	
Infant Outcomes			
<i>At birth</i>			
Weight (lb)	7.33 (1.11)	7.38 (1.19)	.28
Length (cm)	47.90 (4.96)	48.40 (5.08)	.32
WFL Z score	0.40 (0.08)	0.50 (0.11)	.21
<i>At 14-20 weeks</i>			
WFL Z score	0.24 (0.14)	0.36 (0.15)	.12
24-hour formula intake (fluid oz)	32.61 (9.82)	35.07 (9.54)	.08
Types and Number of Solid Food Feedings per Week			
Daily foods	1.13 (0.61)	1.16 (0.80)	.45
Baby cereal	1.79 (1.29)	3.24 (1.33)	.07
100% fruit juice	1.38 (0.87)	1.20 (0.50)	.29
Sweet drinks	1.25 (0.89)	2.36 (0.96)	.09

BMI = body mass index; WFL = weight for length.

Table 4
Differences in Infant Feeding Practices Between Mothers With Normal and Higher BMI

Frequency	Mothers (n = 98)			
	BMI < 25 (n = 43)		BMI ≥ 25 (n = 55)	
	Always	Most of the time	Always	Most of the time
Put baby to bed with a bottle of formula or juice	3	4	6	14
Encourage baby to finish Each bottle	2	3	3	12
Feed baby formula when he or she cries	2	3	5	9
Baby drinks all formula in bottle	4	7	5	10

BMI = body mass index.