Paul, Bartok, et al. Published in Advances in Pediatrics, 56(1), 2009. 107-133.

Opportunities for the Primary Prevention of Obesity during Infancy

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WEIGHT GAIN DURING INFANCY AND LONG-TERM EFFECTS

Are chubby babies healthy babies? Whereas most seem well during infancy, evidence is increasing that heavier babies have a poorer long-term health trajectory than their trimmer counterparts. Data have emerged over the past 2 decades that early life growth patterns and behaviors play an important role in the etiology of obesity, yet there has been very little focus on the primary prevention of obesity during infancy by the medical, behavioral health, and public health communities. A recent report from the National Health and Nutrition Examination Survey (NHANES) highlighted the need for very early intervention when it revealed that between 2003 and 2006, a staggering 24.4% of children aged 2 to 5 years *already* were overweight or obese (body mass index [BMI; calculated as the weight in kilograms divided by height in meters squared] 85th–94th and ≥95th percentiles, respectively) [1]. NHANES data also have described obesity (weight-for-length/height ≥95th percentile) among infants younger than 2 years (Fig. 1). Between the late 1970s and 2000, the prevalence of obesity among infants 6 to 23 months old increased by more than 60% [2]. Reports from the Centers for Disease Control and Prevention (CDC) Pediatric Nutrition Surveillance System [3] and a Massachusetts Health Maintenance Organization [4] similarly showed significant increases in the prevalence of overweight for infants and toddlers for all age groups since the 1980s.

The Institute of Medicine publication, "Preventing Childhood Obesity: Health in the Balance," stated that the prevention of obesity in children should

This work was supported by grants DK72996 and DK075867 from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Additional support was received from the Penn State Children, Youth and Families Consortium. Financial Disclosure and Conflicts of Interest: None.

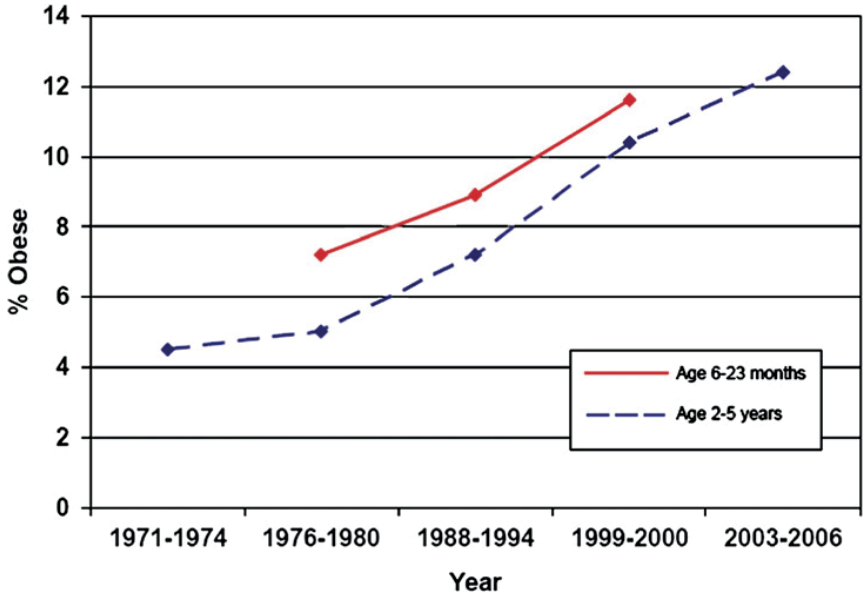

Fig. 1. Trends in infant (weight-for-length ≥95th percentile) and toddler (BMI ≥95th percentile) obesity. (*Data from* Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003–2006. JAMA 2008;299:2401–05; Ogden CL, Flegal KM, Carroll MD, et al. Prevalence and trends in overweight among US children and adolescents, 1999–2000. JAMA 2002;288:1728–32; and Koplan JP, Liverman CT, Kraak VI, editors. Preventing childhood obesity: health in the balance. Washington, DC: The National Academies Press; 2005.)

be a national public health priority [5]. More specific to younger children was the summary of the "Conference on Preventing Childhood Obesity," where it was remarked, "The prenatal period, infancy, and early childhood may be stages of particular vulnerability to obesity development because they are unique periods for cellular differentiation and development. This unique vulnerability might make it possible for actions taken at these stages to determine the future course of adiposity [6]." This statement has been magnified by the numerous studies demonstrating the association between rapid or accelerated infant weight gain and subsequent obesity [7–24], as well as hypertension [25–28], coronary heart disease [29,30], and type 2 diabetes mellitus [31,32]. Further, numerous studies have now shown that overweight infants and toddlers are at increased risk of staying overweight as they age [9,16,33–46]. It has been theorized that overnutrition in infancy adversely "programs" the components of the metabolic syndrome and the way energy is stored [47,48]. These relationships may be especially true for those born to overweight parents, as genetic and familial influences, combined with pregnancy weight gain, are strongly associated with obesity in offspring [19,34,35,49,50].

Whereas all of the concerns about infant growth and subsequent morbidity make a strong case for very early intervention, there is little evidence regarding what, if anything, works to prevent the development of obesity during the first

years of life although the extant literature provides some suggestions regarding potentially promising approaches [5,51]. Early intervention and prevention hold great promise for interrupting the vicious cycle of obese children becoming obese adults who subsequently have obese offspring themselves. The following sections summarize numerous aspects of infant life that affect weight status, the way information on this subject should be communicated with parents, and interventions that can be suggested to families to prevent the development of obesity, based on the currently available evidence.

OBESITY PREVENTION DURING THE NEWBORN PERIOD AND EARLY INFANCY

Role of clinicians in addressing infant weight gain

Many parents, grandparents, and clinicians propagate the belief that "a chubby baby is a healthy baby" despite evidence even in the short term to the contrary [52–55], and substantial long-term evidence as described earlier. During infancy, growth charts are typically used by health care providers to ensure adequate and proportional growth with respect to weight, length, and head circumference, but information is usually communicated to parents without significant explanation so long as the child does not (a) raise concern for failure to thrive, or (b) demonstrate disproportionate or very excessive growth on 1 of the 3 measurements.

In addition, there is often a disconnect between health care provider definitions of overweight and obesity and parents' interpretation of these terms [53,56–65]. Many parents believe heavier infant weight and appearance indicates good infant health and higher levels of parenting competence, particularly parents from poor or minority backgrounds [57,65–70]. In contrast, parents often perceive their children as picky eaters even when their weight gain is progressing normally [71], and infants and children perceived as too small often are given developmentally inappropriate nutrition, including the early introduction of solids or table foods [68,70]. The association of food with love in some cultures may also contribute to higher infant weight [72].

Potential intervention

Given the childhood obesity epidemic and the evidence that early upward crossing of major percentile lines on the growth curve is associated with later obesity [7–11,13–15,73], clinicians must pay closer attention to patterns of growth during early childhood and the way parents interpret infant growth. Providers must better understand healthy infant growth patterns and communicate this information regularly and accurately to parents. In addition, they must be familiar with early interventions that can prevent unhealthy patterns of weight gain in infancy and corrective interventions when problems are identified (Table 1).

Early feeding mode

Epidemiologic and experimental evidence has consistently indicated that breastfeeding offers modest protection against obesity later in life compared

Table 1
Potential interventions to prevent or address obesity during infancy

Opportunity	Intervention
Early infancy	
Growth monitoring	Educate parents about growth charts, percentiles, and their meaning
Infant feeding mode	– Support of breastfeeding as the preferred source of infant nutrition – Plot breastfed infants on the WHO growth chart, particularly when there are weight gain concerns – Educate parents on satiety cues – For bottle-fed infants, emphasize to parents that the volume of formula consumed should be child, not parent driven
Sleep	Educate parents on methods to lengthen sleep duration and soothe at night without feeding as a first response to nocturnal crying
Parental regulation of distress	– Respond quickly to crying early in infancy, but use alternative methods to soothe than feeding – Use nonfood items as rewards later in infancy
Introduction of solid foods	– Delay introduction of complementary foods until at least age 4 months – Avoid placing cereal into a bottle; complementary foods should only be fed with a spoon – Use repeated exposure to healthy foods as a response to normal infant neophobia
Later infancy	
Parent feeding style	Avoid coercive or restrictive feeding styles
Transition to cow's milk	Use low-fat cow's milk
Sweet beverage consumption	– Do not give juice to children $\leq$6 months old – Limit daily consumption of 100% fruit juice to $\leq$6 ounces (170 g) per day – Give 100% juice only in a cup, never in a bottle – Do not allow children to easily transport juice so that they will not steadily consume it throughout the day – Completely avoid fruit drinks and soft drinks
Transitional feeding and table foods	– Emphasize healthy dietary choices that have high nutritional value and low energy density such as fresh fruits, cooked vegetables, cheese, yogurt, whole-grain breads and crackers, and cereals – Avoid foods with added salt or sugar
Physical activity and sedentary behaviors	– Choose physical activities that are interactive, stimulating, easy to do, and incorporated into daily routines – Avoid television watching for children younger than 2 years – Keep televisions out of bedroom

with formula feeding [74–80], and both exclusivity and duration of breastfeeding strengthen this association [75,77,78,80–83]. There are several reasons or mechanisms by which this protection may occur. First, breastfeeding promotes self-regulation of intake by the infant, and breastfed infants regulate the volume of feeds in response to the energy density of breast milk [84]. In contrast, formula feeding is a more parent-driven feeding activity, with the regulation of intake directed by the parents rather than the infant. Compared with nursing infants, bottle-fed infants are fed on a more regular schedule and the volume of feeds is very consistent, suggesting that parents are driving intake patterns [85]. Subsequent research has shown that common bottle feeding practices, such as "emptying the bottle" and serving larger volumes of formula at feedings, are associated with excess weight gain in the first 6 months of life [86].

The composition of breast milk may also contribute to the protective effects of breastfeeding. Human breast milk contains hundreds of components serving nutritive and nonnutritive functions within the infant [87], both of which may affect short- and long-term growth patterns of children [88]. Interspecies comparisons suggest that the high lactose and cholesterol content of human milk supports growth of the central nervous system, whereas the high protein and mineral content of other species' milk (eg, cow's milk) supports substantial and rapid gains in physical size [88,89]. Recent experimental research in humans suggest that the high levels of protein and minerals in formula may stimulate excess physical growth later in infancy, with persistent effects even at 2 years of age [90].

Other "bioactive" components of breast milk may have potential roles in the regulation of growth and development of the infant [91]. Human milk contains growth-regulating components such as leptin, ghrelin, insulinlike growth factor-1, and adiponectin [92–94], and blood leptin levels in breastfed infants are comparatively higher to formula-fed infants [92]. Subsequent research focused solely on breastfed infants has shown that maternal milk leptin levels are negatively associated with weight gain during early infancy and through 2 years of age [95,96].

The sum of this early feeding experience for breastfed and formula-fed infants produces clear growth differences by feeding mode that persists for at least the first 2 years after birth [97]. Limited research assessing body composition has shown that growth differences are likely due to increases in adiposity in formula-fed infants between 6 months and 24 months old [98]. These growth differences were viewed historically as a sign that breastfed infants were not thriving, and the widely used CDC 2000 growth reference has been criticized as inadequate for monitoring the growth of breastfed infants because it is based predominantly on data from formula-fed infants in the United States. The creation of the World Health Organization (WHO) International Growth Standards, based on an international sample of healthy breastfed infants, has helped to support the perception of breastfeed infants' growth as the "reference" growth pattern and formula-fed infants' growth as deviant from this reference [99–101]. Of note, when comparing how breastfed infants' growth

trajectories track along the CDC versus the WHO charts across the first 2 years after birth, substantial differences in expected growth are apparent [101]. With this comparison, when using the WHO chart as the growth reference, a normal deceleration of growth for breastfed infants is easily apparent after age 2 months and a slower rate of growth is evident through the first year after birth. In contrast, when using the CDC chart as the growth reference, the average breastfed infant would cross below the 50th percentile at age 7 months and proceed further below the 50th percentile through the first year. Without reference to a growth chart for breastfed infants, some infants might come to attention for failure to thrive when in fact their growth is normal. Further highlighting this is the fact that at 12 months of age, the WHO median weight for age is 1.2 kg lower for females and 1.5 kg lower for males in comparison with CDC charts.

Potential intervention

The CDC Guide to Breastfeeding Interventions outlines evidence-based practices for promoting breastfeeding, and improving breastfeeding duration and exclusivity [102]. Optimal breastfeeding practices can be promoted through a variety of avenues, including the health care system, places of work/employment, the community, and broader society. Among the interventions that can improve breastfeeding rates are several changes that can be made within the health care system. Prenatal, intrapartum, and postpartum education to improve breastfeeding knowledge and skills is an integral part of the promotion of breastfeeding. In addition, access to professional support (eg, lactation consultants, nurses, physicians) when families experience problems is a critical component of a supportive health care system. Institutional changes within the hospital or clinical setting have been shown to improve breastfeeding initiation and duration rates. The changes may be discrete, such as not handing out formula promotion gift packs to families, or they may be comprehensive, such as becoming a designated Baby Friendly Hospital Initiative hospital [102].

For physicians who monitor the growth of infants, practice guidelines should emphasize the expected, natural, and health-promoting aspects of "slower" growth in breastfed infants during the second 6 months after birth and beyond. Physicians should reassure parents who may be concerned about their infant's performance on CDC growth charts that the growth patterns of breastfed infants are healthy. Plotting children on the appropriate WHO growth standard may provide both physicians and parents with needed reassurance.

For families choosing to formula feed their infant, parents should be given specific education aimed at reducing problematic bottle-feeding behaviors. For example, parents should be encouraged to feed their infants when they are hungry, rather than on a set schedule outside of the immediate newborn period. Parents should be instructed to be responsive to infant cues for satiety, rather than ensuring their infant finishes the bottle contents. Age-specific guidelines for how much formula should be dispensed at a feeding would help parents start the feed with an appropriate portion size for their infant. Finally,

encouraging parents to discern whether an infant is hungry or needing alternative soothing may reduce overfeeding of the bottle-fed infant.

Sleep

Short sleep duration may have other health effects other than fatigue. There is some evidence that it may be a contributor to the development of obesity. During the past 40 years, sleep duration in the United States has decreased by 1 to 2 hours per day whereas the prevalence of obesity has markedly increased [103–105]. It is estimated that children, a group with a rapid increase in the prevalence of obesity, are currently sleeping 1 to 2 hours less than they require, and that approximately 15 million American children are affected by inadequate sleep [106,107].

The link between short sleep duration and childhood obesity was first shown by a study of French 5-year olds, in which investigators found a significant risk for overweight among children who slept less than 11 hours per day [108]. Since the publication of that study, several investigations have shown that short sleep duration during early childhood (age 3–5 years) is associated with overweight, obesity, and higher body fat during school age [9,11,74,109,110]. Most recently, Taveras and colleagues demonstrated that sleep duration of less than 12 hours during infancy is a risk factor for overweight and adiposity in preschool-aged children [111].

There are several mechanisms by which shorter sleep duration may lead to overweight even among the youngest of children. The first 2 months after birth represent a critical period in the development of sleep patterns, a period during which feeding and sleeping are inextricably linked with infants waking every 2 to 4 hours, typically to feed [112–115]. These first months are also central for the development of normal circadian rhythms [116]. As a result of these rhythms, infants have periods of arousal from sleep, and how parents handle the infant's night waking represents a source of variability in infants' developing nighttime sleep patterns [117,118].

To evaluate different parenting styles and the impact on sleep, St. James-Roberts evaluated a "proximal care" model of parenting infants characterized by prolonged holding, frequent breastfeeding, rapid response to infant frets and cries, and cosleeping with infants at night with other approaches to infant care that have less parent-infant contact per day [117]. He found that the proximal care group of infants had more frequent night waking and crying at age 12 weeks. In another investigation, infants whose parents were present when their child fell asleep were more likely to wake at night than infants whose parents were not present, suggesting that infants who were able to self-soothe in the absence of feeding were more likely to sleep through the night [119].

The early development of sleeping through the night and its association with subsequent weight status is based on several findings. First, children who are unable to achieve a sleep duration of 6 hours by age 5 months have a much greater risk of short sleep duration and sleep problems later in childhood [120,121]. Second, relative sleep duration for age compared with norms for

age was shown to remain constant for approximately 90% of children in a recent longitudinal study of sleep in children [122].

Next, to understand a potential physiologic mechanism for a relationship between sleep and obesity, one might consider adult data that have demonstrated that sleep restriction results in a significant reduction in the anorexigenic hormone, leptin, and an increase in the appetite stimulating peptide, ghrelin [123]. Reduced leptin and increased ghrelin were associated with a significant increase in hunger and appetite. The relationship between short sleep duration, reduced leptin, and increased ghrelin was also found in another investigation with more than 1000 participants whereby the links were shown to exist independent of BMI [124]. Although limited data on this subject exist for infants and children, lower cord blood ghrelin levels have been linked to slower weight gain from age 0 to 3 months [125]. These findings suggest that efforts to increase sleep duration for children could result in lower ghrelin levels, which could limit rapid weight gain during infancy. The importance of research studying potential links between sleep and obesity in children is becoming apparent, and was emphasized in a recent editorial in the *Archives of Internal Medicine* [126]. There, Bass and Turek wrote, "It is now critical to determine the importance of a lack of sleep during the early formative years in putting our youth on a trajectory toward obesity and the metabolic syndrome–a trajectory that could be altered if sleep loss is indeed playing a role in this epidemic." In summary, the roots of short sleep duration can be found in infancy, and are linked to parenting practices surrounding sleeping and feeding with potential long-term consequences for weight status.

Two seemingly conflicting theories regarding the prevention of obesity intersect in the discussion of sleep. Whereas prolonged sleep duration may be protective for obesity, breastfeeding, which is also protective for obesity, is associated with shorter sleep segments, increased night waking, and reduced total daily sleep [121,127–130]. This shorter sleep duration can persist even after the child has been weaned [121,127]. Breastfed infants also may be more easily aroused from sleep than those that are bottle fed [131]. Further, more frequent night waking has been described as a source of distress for mothers and a cause for them changing from breastfeeding to formula feeding [121,132]. Clearly the relationship between sleep duration, breastfeeding, and weight status is complex, but interventions to promote longer sleep duration such as those now described could achieve objectives of breastfeeding promotion and obesity prevention.

Potential intervention

Because short sleep duration in infancy and childhood is linked to childhood obesity, interventions designed increase sleep duration during infancy may have long-term protective effects against obesity. Of note, some research suggests that sleep duration during infancy can be significantly lengthened with appropriate interventions, even for breastfed infants. An intervention developed by Pinilla and Birch was successful in increasing nocturnal sleep

duration in breastfed infants, who were taught to sleep for at least 5 consecutive hours by age 8 weeks [133]. In this study, parents in the treatment group were given a simple set of instructions to gradually lengthen intervals between middle-of-the-night feedings by performing alternative caregiving behaviors before feeding (eg, reswaddling, diapering, rocking). By age 3 weeks, treatment infants showed significantly longer sleep episodes at night, and by 8 weeks 100% of treatment infants were sleeping a 5-hour duration overnight, compared with 23% of control infants. Of note, Infants made up for the reduced nocturnal milk consumption with a larger early morning feed. One of the interventions described in the study, swaddling, has been shown to calm infants, reduce arousals during sleep, improve sleep efficiency, and reduce spontaneous awakenings [134,135]. In addition, other pediatric practitioners have expanded on these techniques in an attempt to calm and soothe infants, and improve infant sleep through the addition of "white noise," gentle rocking, and nonnutritive sucking [136,137]. However, like the use of pacifiers, the techniques described in this study should not be attempted until breastfeeding success is well established.

Whereas those who advocate for breastfeeding "on demand" may initially be averse to attempts to lengthen sleep duration, it is important to recognize that there is no uniform definition of "on demand" and mothers may interpret "feeding on demand" in a highly variable fashion. Thus, teaching mothers sleep-lengthening techniques may potentially enhance their ability to distinguish hunger cues from other distress cues, improve feelings of parental competence, reduce formula use, and increase the duration of breastfeeding.

Parental regulation of distress, temperament, and self-regulation of emotion

The ability to regulate behavior and emotion are important developmental tasks [138]. Moreover, the *inability* to successfully regulate one's emotional state characterizes many childhood problem behaviors [139]. The self-regulation of emotion may also have important implications for other areas of development such as physical health, more specifically weight gain. There are several possible reasons why emotion regulation may be important in understanding and potentially preventing abnormal weight gain. First, infant difficultness, a temperamental quality characterized by fussiness and difficulty soothing, has been related to rapid weight gain [140] and later body composition [141] in childhood, whereas negative child emotionality has been linked to adult body mass [142]. Next, studies of emotion and eating in adults show emotions, particularly negative emotions, to be related to increased eating, prompting theorists to hypothesize that obese individuals eat to reduce discomfort [143]. Finally, there is increasing evidence that mental health problems such as depression and conduct disorder are strong predictors of adulthood obesity [144]. This link may be biologic, as several central nervous system processes responsible for feeding regulation also are involved in regulating emotion

[145]. Taken together, these data suggest that the ability to self-regulate emotion may be an important factor in preventing obesity.

Developmental theorists agree that the soothing environment provided by the parent serves not only to alleviate immediate distress but also facilitates the infant's development of self-regulation [138,146]. Soothing a distressed infant models emotion regulatory strategies and demonstrates the effectiveness of various behaviors for reducing distress. Previous research has shown parental sensitivity, or contingent responsiveness to infant cues, predict infant crying and behavior [147]. That is, parents exhibiting high sensitivity had infants who cried less both concurrently and longitudinally. Furthermore, whereas some researchers have examined the effect of certain soothing techniques on reducing infant distress or supporting concurrent infant regulation [148,149], only one study has demonstrated the carry-over effect of parental regulation to infant self-regulation. Jahromi and Stifter found that mothers who were most effective in soothing their infants at 2 months had infants who cried less with immunization injections 4 months later [148].

Unfortunately from an obesity prevention perspective, many parents use feeding as a method to soothe a distressed infant, and this practice may have negative consequences for weight gain [150]. Using food to reward or punish behavior in children has similarly been associated with binge eating and heavier weight status when those children become adults [151]. Thus, whereas parent regulation of distress is important to the development of the child's ability to self-regulate his or her emotion, the use of food to soothe or reward may contribute to unhealthy outcomes.

Potential intervention

As feeding in infancy is predominantly under the control of the parent, using food in circumstances unrelated to hunger and sustenance may lead to children's understanding that food has other 'rewardlike' qualities. Infants may learn to eat in response to cues other than hunger, such as the presence of food, or their own emotional distress. This compromised ability to self-regulate their food intake may put them at risk for overweight. Given this evidence and that parents report using food to soothe their children [67], parental regulation seems to be a critical variable in the development of children's overall self-regulation skills.

One simple strategy parents can employ is to use nonfood items to soothe during early infancy and nonfood rewards for good behaviors during later infancy. Alternative soothing strategies for young infants, as discussed earlier in relation to sleep, can be applied during the day as well. For older infants, praise or rewards with stickers, toys, book reading, singing songs, playing, or visits to special places may be good alternatives to rewarding good behaviors with food.

As for the core issue of improving parental regulation, the results of 2 studies suggest that the effect of improving parental sensitivity may be most important for the highly reactive infant. In one study, an intervention focused on mothers

of irritable infants found that training mothers to respond contingently and appropriately to the fussing and crying of the infant improved maternal interactive behavior and infant self-soothing, exploration, and attachment [152]. In the second study, an intervention aiming to improve mother-infant attachment found the effect to be greatest for those infants who were highest in negative emotionality [153]. Taken together, these studies suggest that parents should (1) recognize that infant distress is a signal to act, (2) respond quickly as waiting does not reduce crying, and (3) use strategies such as rocking, presenting alternative activities, and providing a pacifier to reduce the crying and fussing. Not only does this ameliorate the infant's distress but, if applied consistently, will enhance the parent-child relationship, and demonstrate how the child might self-regulate his or her own emotions in the future. Promoting improved parental regulation of infant distress as well as less intense negative responses from the infant seems to be essential to the development of the child's ability to self-regulate. Furthermore, interventions that provide the parents with alternative strategies to using food to soothe may not only be practical and economical, but may directly prevent childhood obesity.

Introduction of solid foods

Timing of solid food introduction

The American Academy of Pediatrics (AAP) suggests that the introduction of solid foods should begin between 4 and 6 months because, in general, exclusive milk feeding is adequate to support growth until this time, and supplementary foods are not needed [154,155]. Others add that solids should not be introduced until an infant has good head and neck control and can sit with support [156]. Recent NHANES data suggest, however, that about 30% of breastfed infants and about 50% of formula-fed infants are consuming some infant cereal by 2 to 3 months [157]. Further, data from the Early Childhood Longitudinal Study showed that in a nationally representative cohort, children placed in child care before age 3 months were nearly twice as likely to receive introduction of solids before turning 4 months [158]. Also, many parents continue to add cereal to their infant's bottle, a practice not supported by the AAP because it can lead to excessive weight gain [159]. Related to the previous discussion about sleep and regulation of distress, one commonly attempted approach to improve infant sleep is to give infant cereal at bedtime, a practice that has not been shown to be effective at helping infants sleep despite the widespread belief that the early addition of solids promotes sleeping through the night [160]. Of note, the time when solids are first introduced may be related to increased caloric intake, rapid weight gain, and the subsequent development of overweight.

When the topic of the relationship between the timing of introduction of complementary foods and subsequent obesity has been evaluated in large, population-based studies, there has been minimal to little influence of this variable on the development of obesity [79,80]. However, several more focused studies have revealed important associations. Shukla and colleagues [161] found that

overweight status at 13 weeks was related to the extra calories provided by solid foods early in life, and overweight status at age 13 weeks persisted through 1 year. Von Kries and colleagues [11] similarly showed a relationship between the introduction of solids before age 4 months and the risk of overweight status between the age of 5 and 6 years. Others have further characterized this relationship by showing the association between increased rate of weight gain in the first 6 to 12 months after birth and early introduction of solids, particularly for formula-fed infants [158,162–164]. The analysis of the Danish National Birth Cohort by Baker and colleagues revealed perhaps the most intriguing data on this subject. Their regression analyses showed that the relationship between maternal obesity and greater weight gain during the first year could be nearly eliminated by breastfeeding for more than 40 weeks and delaying the introduction of complementary foods until after age 20 weeks [165].

Method of solid food introduction and the use of repeated exposure

Across cultures, dietary diversity is vast, but all infants begin life consuming the same food: milk. However, as omnivores, they are prepared to learn to consume the diet of their culture. Infants "come equipped" to prefer sweet and salty tastes, to be "neophobic" and reject new foods when they are first offered (at least those that are not sweet or salty), and to learn to like foods of the adult diet of their culture and ethnicity, via various associative conditioning processes that involve the pairing of food with the aspects of the social contexts and physiologic consequences of eating [166]. Given this set of predispositions, all normal infants will readily accept sweet and salty foods such as French fries and sweetened drinks. In contrast, many healthy foods such as pureed vegetables, infant cereals, meats, and dairy products, which are not high in sugar or salt, will be initially rejected by infants. These findings have revealed that infants typically need several opportunities to sample these new foods before intake will increase [167,168]. The liking for complex food flavors that are not dominated by sweet or salty tastes must be learned.

Potential intervention

In addition to delaying the introduction of complementary foods until age 4 to 6 months, parents should be instructed on the infant neophobic response to new foods. Parents often interpret the initial rejection of new foods as "she doesn't like it," and the food is not offered again. However, the infant's initial neophobic response is usually transient, and that infants', toddlers', and preschoolers' intake of new healthy foods will typically increase if the infant has repeated opportunities to taste them [167–170]. As few as 1 or 2 exposures [168] or as many as 5 or 10 exposures [169] may be needed, depending on the age of the child; and all foods will not be accepted by some children, despite repeated exposure. However, parents must be instructed that such repeated exposure is necessary if not sufficient for acceptance of new foods that are not very sweet or salty. Most of the healthy foods that are developmentally appropriate for infants and toddlers fall into this category, including most

vegetables, complex carbohydrates, and meat and dairy products. Although exceptions to these instructions are cases in which food aversions and dislikes develop when consumption is followed by nausea or vomiting, or when eating is coerced or unpleasant, parents need guidance on how to introduce new foods, to increase the likelihood that the child will learn to consume a variety of foods that will constitute a balanced diet promoting healthy weight gain.

In addition to repeated exposure to healthy foods, parents should be alerted to cues for fullness when feeding complementary foods. Pursed lips, closed mouth, spitting out food, turning of the head, and leaning back are examples of cues to stop feeding [156].

OBESITY PREVENTION DURING LATER INFANCY AND THE EARLY TODDLER YEARS

Parent feeding style

During the first years of life, infants and young children are learning an enormous amount about food and eating as they are being introduced to the adult diet of their culture. Growing children learn when to eat, what is food and what is not, how much to eat, and as a result of their experiences with food and eating, are developing food preferences and dislikes. The period from birth to 3 years is also a crucial one for the development of the controls of food intake, and the development of food preferences and eating behaviors [166]. There is evidence that early feeding practices are linked to patterns of food acceptance and the developing controls of food intake [166,171,172]. A feeding style using coercion is unlikely to be successful in the short term and can result in unhealthy weight status in the long term, as recent data suggest that maternal control of feeding during the first years after birth moderates infant weight gain [173,174]. Coercive feeding practices include tactics such as (1) pressuring children to finish their vegetables or (2) restricting their access to sweets and junk food, or using such foods as rewards [71]. In addition to promoting dislikes for healthy foods, and increased liking and wanting of restricted junk foods, coercive practices can also promote dysregulation of intake by promoting overeating, and learning to eat in response to the presence of food on the plate (as in "finish your vegetables") [175–177].

Potential intervention

When introducing solids, parents should be aware that new foods may be initially rejected, and should be advised to be patient, as learning to like new foods takes time. If parents offer new foods repeatedly, over a series of 5 or 10 days, many of these foods will eventually be accepted and even preferred [167–169]. However, pressuring or coercive feeding practices engender resistance and foster dislikes, and should be discouraged in favor of providing repeated experience in positive contexts. During the transition to table foods, parents can be effective positive models, promoting infant acceptance and liking for healthy foods by consuming healthy foods and avoiding "junk foods" at family meals. The use of positive feeding practices such as repeated exposure

and modeling are more likely to promote the establishment of healthy diets than the use of coercive feeding practices [178]. Parents should be advised to avoid pressure and restriction in feeding, and encouraged to put their efforts into promoting the liking and acceptance of table foods that are part of a healthy diet.

Transition from human milk or formula to cow's milk

Although consumption of human milk or infant formula may continue for over 1 year, most infants transition to cow's milk at age 1 year. As opposed to children 2 years or older, however, many do not recommend the use of nonfat or low-fat milk for children 12 to 23 months old [179–182]. This recommendation likely stems from concerns from years ago that infants consume a sufficient quantity of dietary fat and essential fatty acids for normal growth and development. However, as opposed to the evidence for infants younger than 12 months, the recommendation for 12- to 23-month-old infants is not evidence based [183].

The question of milk fat intake is important because the preference for high-fat foods develops early in life, and children still consume 20% to 25% of their calories from cow's milk between the ages of 1 and 2 years [184,185]. Further, a majority of preschool children drink whole milk, particularly those who are from minorities or low-income households [186,187].

Potential intervention

Reducing milk fat intake has been previously identified as a target for dietary fat reduction and obesity prevention in toddlers and preschool children [188–190], and reducing fat intake among infants and toddlers has been shown to be well tolerated without adverse effects on growth, nutrient intake, or development [191–193]. In contrast, high fat intake between 12 and 23 months of age has been associated with inhibition of the normal decrease in body fat between the ages of 2 and 5 years [194]. Given that contemporary diets for children older than 1 year typically contain a significant amount of dietary fat from nonmilk sources [195], the common advice to only use whole milk for children 12 to 23 months old is no longer necessary for infants who consume a well-balanced diet [186]. In fact, the 2008 AAP policy statement "Lipid Screening and Cardiovascular Health in Childhood" includes as its first recommendation the use of reduced fat milk for 12- to 23-month-old children [196]. Although studies of older children have suggested that consumption of dairy fat is not associated with weight gain [197], because each cup of whole milk contains 146 kcal compared with only 86 kcal per cup of nonfat milk [198], a change to low-fat or even nonfat milk could reduce energy consumption without adverse effects for infants.

Sweet beverage consumption

Over the past 3 decades, the percentage of daily calories obtained from soft drinks, fruit drinks, sweetened beverages, and fruit juice each have steadily increased among American children [199]. Among children 12 to 24 months

old, 100% juice and sweetened beverages account for the second and third greatest source of dietary calories, respectively, exceeded only by milk [185]. Although data have in general not supported a link between consumption of 100% juice and obesity unless consumed in excess [200], there is a strong association between sweetened beverages and soft drinks with obesity [201]. Further, as suggested by Skinner and colleagues [202], because early life diet preferences predict later preferences, the development of beverage consumption patterns before age 2 years is important for long-term consumption.

Regarding infant and toddler consumption of juice, the AAP has recommended that juice (a) not be given to infants younger than 6 months, (b) only be given to infants that can drink from a cup and never given in a bottle, (c) not be given in a fashion that allows for a child to easily transport it with easy consumption throughout the day, and (d) not be given in quantities greater than 6 ounces (170 g) per day [203]. Data from the Feeding Infants and Toddlers Study (FITS), a national dietary survey, demonstrated that many infants consume fruit juice before 6 months of age, and exceed the recommended amount of juice later during infancy and the toddler years [202].

Unlike fruit juice, the AAP has no formal policy statement or recommendation regarding the consumption of other sweetened beverages and soft drinks prior to school entry, but the Institute of Medicine has recommended the avoidance of high-calorie, nutrient-poor beverages [5]. Of note, consumption of sweet drinks has been associated with obesity even among preschool children [204,205]. In addition, in FITS, sweetened drinks and soda also were being consumed at the expense of milk in this sample of infants and toddlers [203]. Further, several investigators have suggested that reducing intake of sweetened beverages is one of the most important and promising obesity prevention strategies [204–207].

Potential intervention

Given the current evidence, adherence to the AAP policy regarding fruit juice is appropriate. Further, because they have no nutritional benefit and are associated with obesity and other morbidities, the use of sweetened beverages, soft drinks, and fruit drinks should be totally discouraged for infants and toddlers. Given the alternatives of milk, water, and the now increasingly available low-calorie flavored water, there are sufficient options for parents to give their young children.

Transitional feeding and table foods

The transition from the exclusive milk diet of infancy to a modified adult diet is completed by age 3 years, and during this early period children already have begun acquiring food preferences and aversions [166]. Children are learning a great deal about when, what, and how much to eat. Unfortunately, recent data from FITS revealed that energy intakes among typical infants and toddlers exceed requirements by 20% to 30% [208]. Of note, in FITS this excess already was apparent in infants aged 4 to 6 months, in whom intake exceeded energy requirements by 10%, suggesting that patterns of intake promoting excessive

weight gain and obesity were being established at an early age. In addition to consuming too much energy, from an early age (4 to 24 months) children consume significant amounts of developmentally inappropriate foods, high in energy density and low in nutrients, while consuming too few of the foods that should form the basis of a healthy weaning diet [195]. The high energy density of foods offered appeared to be the same ones that contribute to energy intakes that were in excess of energy requirements in other age groups studied [208]. For example, in children 7 and 24 months old, 18% and 33%, respectively, consumed no servings of vegetables during a given 24-hour period. Twenty-three percent of 7-month-old and 33% of 24-month-old children did not consume any fruits. Further, parents reported that French fries were the third most common vegetable consumed by infants 9 to 11 months old, and by 15 to 18 months were the most common vegetable consumed. The diets of infants in this age group may, not surprisingly, be deficient of key nutrients [209].

Potential intervention

The FITS findings underscore the need to provide parents with anticipatory guidance regarding the transition to a modified adult diet. The Start Healthy Feeding Guidelines for Infants and Toddlers provides excellent guidance on the nutritional needs of children younger than 2 years [210]. As opposed to giving children French fries, parents should be encouraged to meet these nutritional requirements with fresh fruits, cooked vegetables, cheese, yogurt, wholegrain breads and crackers, and cereals [156,211,212]. All of these foods should not have added sugar or salt.

Physical activity and sedentary behaviors

There is substantial epidemiologic evidence that regular physical activity is essential for good physical and psychological health and disease prevention among children and adults. However, to date the recommendations for infant and toddler physical activity (from birth to age 5 years) have not been evidence based. Rather, the guidelines developed by the National Association for Sport and Physical Education [213] were adapted from evidence accumulated among older children and adolescents [214]. The recommendations for infants suggest that they should be: (1) interacting with caregivers in daily physical activities that promote movement and exploration of their environment, (2) engaging in activities that promote the development of movement skills and large muscle activities, and (3) placed in safe settings that facilitate physical activity and do not restrict physical activity for prolonged periods of time. These recommendations suggest that toddlers should: (1) accumulate at least 30 minutes of daily structured physical activity, (2) engage in at least 60 minutes and up to several hours a day of unstructured physical activity and should not be sedentary for more than 60 minutes at a time except when sleeping, and (3) develop movement skills that are building blocks for more complex movement behaviors [213]. Nonetheless, because physical activity and sedentary patterns, much like feeding and sleeping behaviors, become established in the early years, there

is increasing support for promoting physical activity and reducing sedentary behaviors as soon as possible during the early infancy period [213,215].

Environmental risk factors associated with sedentary activities during the early infancy and toddler periods may predispose children to low levels of physical activity in later childhood. For example, restricting infants to car seats, swings, carriers, strollers, and small play spaces for long periods of time may limit motor development and delay physical activity such as crawling and walking [213,216]. Also, limited time for leisure activities and parent-child play, concern for neighborhood safety, and using television or computer games to occupy a child's attention may promote sedentary lifestyle during the first 3 years after birth [216,217]. Television viewing during the infancy and toddler years seems to be one particular sedentary practice that is an environmental risk factor for obesity development. It is reported that 82% of 1-year-old (11 average hours per week) and 96% of 2-year-old (15 average hours per week) children watch television or videos, and having a television in the bedroom elevates the risk of being overweight [218]. Also, Taveras and colleagues found that children who slept less than 12 hours per day and viewed 2 hours per day or more of television had an obesity probability at 3 years old of 17% [111].

Potential intervention

Although there is little debate that physical activity is important for obesity prevention, questions remain about how much and what types of physical activity during the infant and early toddler years is needed to prevent later obesity. In general, parents of infants should choose physical activities that are interactive, stimulating, easy to do, and incorporated into their daily routine, to reinforce the concept that physical activity is rewarding [213,215].

In addition, 2 existing programs offer possible blueprints for more extensive prevention efforts. The Infant Feeding Activity and Nutrition Trial is an early intervention to prevent childhood obesity that targets infants through age 18 months in Victoria, Australia. This program teaches parents about the development of positive diet and physical activity behaviors while reducing sedentary behaviors during infancy [219]. Parents in the program learn about age-appropriate physical activity behaviors, the risks associated with sedentary behaviors, and how parental modeling of physical activity and sedentary behaviors influences their child's behaviors.

The second program, Fighting Fit Tots, also aims to prevent obesity in the first years of life by promoting toddler physical activity and parent lifestyle education [220]. This program is currently being implemented in Lambeth, South London (United Kingdom) and consists of 11 weekly 2-hour sessions that include guided parent-child physical activity (eg, jumping, skipping, hopping, dancing, singing), snack (water and fruit), and parental education (eg, healthy lifestyle workshop) aimed at increasing physical activity behaviors, confidence, and decreasing BMI and waist circumference among children 18 to 30 months old.

Regarding sedentary behavior, one clear target for intervention is television viewing. Because most children watch television by age 2 years, educational efforts and interventions about limiting television/video viewing need to be implemented before this age to potentially impact overweight development. Of note, the AAP discourages television watching for children younger than 2 years, and suggests that televisions never be placed in children's bedrooms [221].

SUMMARY

Given the vast array of topics that are important to cover at infant health maintenance visits, extensive discussion about growth, growth charts, and healthy lifestyle may be challenging for providers. Nonetheless, obesity and its comorbidities threaten both individual patients and the health care system. To break the vicious cycle of obese children becoming obese adults who have obese offspring, preventing behaviors that lead to obesity must be implemented during the very earliest periods of life, the prenatal period and infancy. For pediatric care providers, there are numerous opportunities to intervene, and good communication with families about healthy growth and lifestyle are a promising beginning.

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