International Journal of Obesity (2009) 33, S74–S81
© 2009 Macmillan Publishers Limited All rights reserved 0307-0565/09 $32.00
www.nature.com/ijo

REVIEW

Preventing childhood obesity: what works?

LL Birch and AK Ventura

Department of Human Development and Family Studies, The Center for Childhood Obesity Research, The Pennsylvania State University, University Park, PA, USA

Rates of overweight in North American children and adolescents have increased dramatically since the 1970s. Childhood obesity has reached epidemic proportions and calls for prevention and treatment programs to reverse this trend have been made. However, the evidence base needed for effective action is still incomplete, especially for childhood obesity prevention programs. This paper focuses on primary prevention of childhood obesity and has three aims: (1) to briefly describe current primary prevention approaches for childhood obesity and the evidence for their impact; (2) to elucidate promising, but untested intervention strategies using an ecological framework and evidence from experimental and epidemiological research on factors influencing children's eating and weight status; and (3) to introduce a multiphase strategy for screening intervention components and building and evaluating potent interventions for childhood obesity. Most childhood obesity prevention programs have focused on school-aged children and have had little success. We suggest that, given these findings, prevention efforts should be expanded to explore other contexts in which children live as possible settings for intervention efforts, including the family and childcare settings. Given that 25% of preschool children are already overweight, intervening with children before school entry should be a priority. A review of experimental research on the developing controls of food intake in infancy and childhood suggests possible intervention strategies, focusing on parenting and aspects of the feeding environment. Epidemiological findings point to even earlier modifiable risk factors, including gestational weight gain, maternal prepregnancy weight, and formula feeding. However, the potential impact of altering these risk factors remains to be evaluated. In response to this problem, we suggest a new, multiphase method for accomplishing this, including screening intervention components, refining intervention designs and confirming component efficacy to build and evaluate potent, optimized interventions.
International Journal of Obesity (2009) **33,** S74–S81; doi:10.1038/ijo.2009.22

Keywords: child eating; childhood overweight; parent feeding practices; parent feeding styles; prevention; multiphase optimization intervention strategy

Rates of overweight in North American children and adolescents have increased dramatically since the 1970's,[1] leading to calls for action to reverse this trend. But effective action requires an evidence base and, unfortunately, the evidence base for how to prevent childhood overweight is still very incomplete (see Koplan *et al*.[2] for a review). Despite this problem, actions have been taken through implementation of both obesity prevention and treatment programs.[3] This paper will focus on primary prevention, rather than treatment, of childhood obesity, and how we can progress toward more effective prevention efforts (for a recent review of treatment programs, see Wilfley *et al*.[4]). Thus, this focus will be explored by three aims: (i) to briefly describe current primary prevention approaches for childhood obesity and the evidence for their impact; (ii) to elucidate promising but untested intervention strategies using an ecological framework and evidence from experimental and epidemiological research on factors influencing children's eating and weight status; and (iii) to introduce a multiphase strategy for screening intervention components, and building and evaluating potent interventions for childhood obesity.

Correspondence: Dr LL Birch, The Center for Childhood Obesity Research, 129 Noll Laboratory, The Pennsylvania State University, University Park, PA 16802, USA.
E-mail: llb15@psu.edu

Preventing childhood obesity: current approaches

Recent reviews of interventions to prevent obesity in children have shown that there are several common features of the current interventions available.[2,3,5,6] To date, the majority of prevention programs for childhood obesity have been conducted in schools with school-aged children and adolescents. A range of outcomes have been targeted, such as changing dietary patterns, increasing physical activity, decreasing sedentary behaviors and reducing weight status or weight gain. Although some interventions have tested single intervention components (for example, nutrition

education or environmental change), most have taken a 'kitchen sink' approach, in which several components are used in combination.

What do current findings tell us regarding what works to prevent childhood obesity? The short answer to this question is: 'not much.' Overall, school-based interventions have had little success; only about half of these interventions produce any significant change in eating behavior, physical activity or weight status, and the largest, most rigorous studies tend to be the least successful.[6] Of the interventions that have shown significant effects, the effect sizes are small relative to the current increases in population levels of obesity, making it unlikely that these interventions could meaningfully impact recent obesity trends.[6] Additionally, the confounding of several intervention components, combined with the weak study designs, do not allow for evaluation of the independent effects of, or the interactions between, intervention components. This information is essential to understand what works and does not work to prevent childhood obesity. Overall, current efforts have been limited in scope and focus, both in terms of the contexts for interventions (schools) and the age of children who are the targets of intervention (school-aged children).

Despite these limitations, the popularity of school-based interventions is not surprising; there are many benefits to the school environment as a context for intervention programs for children. Schools are a place where most children spend time; in 2005, approximately 90% of 5–19-year-old US children attended school.[7] Schools also provide contexts for the eating and physical activity behaviors that influence body weight, and provide staff and resources (for example, teachers and coaches) that can support the dissemination of interventions. However, as shown in Figure 1, schools are only one of several contexts for change. The ecological framework presented in Figure 1 shows that a child's weight status is influenced by the intake and expenditure patterns of that child, but these patterns are embedded within the larger ecology of the child's family, community and demographic characteristics. An implication of this framework is that preventive interventions should be implemented across the multiple contexts that can influence children's eating, activity and weight. In addition to schools, other contexts include home and family, community and healthcare settings.

Perhaps the most important limitation of school-based obesity prevention is the focus on school-aged children. By school entry, more than 20% of 2–5-year-old children are already at risk for overweight or overweight,[1] which suggests that a prime opportunity to prevent childhood obesity has been missed. During the first 5 years of life, children make a relatively rapid and dramatic transition from suckling to consuming the modified adult diet of their culture. During this period, they are learning more about food and eating than any other developmental period. By the time they enter school, children have consumed thousands of meals and snacks and have been exposed to thousands of food commercials and related marketing approaches. They have learned what is food and what is not; what, when and how much should be eaten; what foods they like and dislike; and many rules of cuisine for their culture.[9] Thus, combined with evidence regarding early learning about food and eating occurring during the first years of life, these trends suggest that infancy and early childhood are excellent opportunities for preventing obesity and should be a primary focus for obesity prevention.

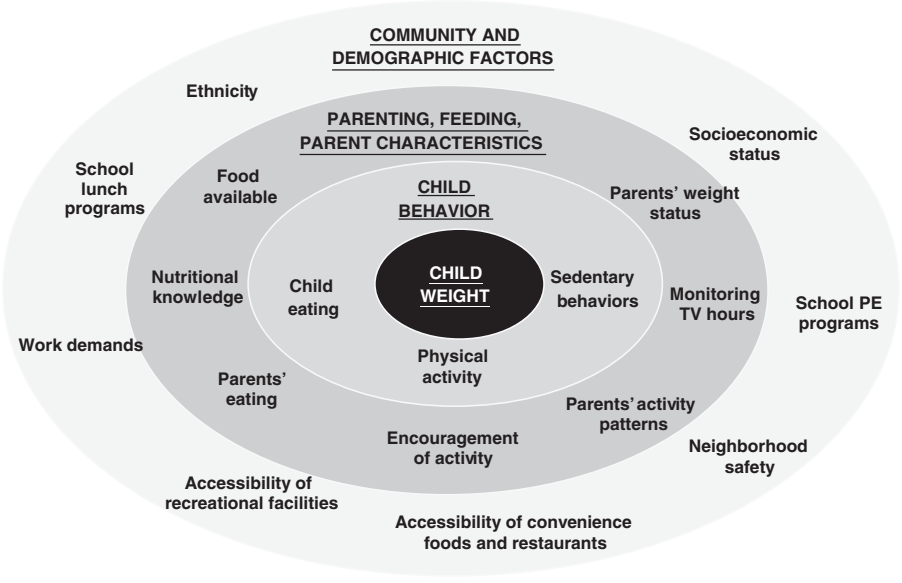

Figure 1 An ecological model for the etiology of childhood overweight. Adapted from Davison and Birch[8] and reprinted with permission from *Obesity Reviews*.

Few interventions targeting infants and preschoolers have been developed and evaluated; no programs focusing on infants and only six prevention programs focusing on preschoolers are cited in a recent review of early interventions.[10] Thus, primary prevention approaches for childhood obesity should be expanded beyond schools to explore a broader range of potentially influential contexts and settings and to include earlier and later developmental periods. For example, young adulthood is a time when maintaining a healthy weight may become a challenge for the first time in response to the lifestyle changes associated with entering into the world of work, living independently and beginning families of their own. The transition to parenthood and the first few years of children's lives hold great potential for preventing obesity in young adults and their children.

What does the research on children's eating behavior tell us about how to prevent childhood obesity?

Parents provide both genes and environments; the conjoint effects of these genes and environments influence the development of children's eating behaviors and weight status, especially during the first years of life. The research reviewed in this section focuses on how and what children are learning about food and eating, and how parents and caregivers shape this early learning, influencing children's diet quality and weight status. The findings provide insights regarding early risk and protective factors for childhood obesity, and reveal possible intervention targets and strategies that warrant further scrutiny.

Table 1 summarizes several of the early risk factors for childhood obesity that have been identified by epidemiological research. As shown in Table 1, many of these risk factors are present before the child is born, whereas others emerge during early parent–child interactions, but all have substantial roots within the family and home environment. These risk factors differ in important ways, including the extent to which they are potentially modifiable. For example, although maternal prepregnancy weight status and gestational weight gain are potentially modifiable through intervention efforts, family ethnicity and income level are, by nature, less so. These risk factors also differ in the strength of the evidence linking risk factors to outcomes. A limitation of epidemiological and prospective cohort studies is that they can identify groups or individuals at elevated risk, but do not provide evidence for cause and effect. Thus, epidemiological evidence is susceptible to spurious associations, and interventions based on epidemiological evidence alone are at high risk for failure because causal links between predictors and outcomes have not been established. To build effective interventions, causal evidence from experimental and properly designed longitudinal studies is essential to identify promising prevention strategies, and we will discuss this point in the third section of this paper: 'A phased approach to selecting potent intervention components and developing optimized interventions (multiphase optimization strategy)'.

Table 1 Risk factors for childhood obesity identified by epidemiological research

Demographics
Parental overweight
Obesogenic parental eating, activity patterns
High gestational weight gain
Rapid infant growth
Low income and education levels
African American, Hispanic, American Indian race/ethnicities
Physical activity behaviors
High levels of television watching, screen time
Low levels of physical activity
Short sleep duration
Eating behaviors
Formula feeding
Early introduction of solid foods
Low intakes of fruits and vegetables
High intakes of energy dense foods and high energy-density diets
Habitual 'food away from home' consumption
High intakes of sweetened drinks
Large portions
Frequent snacking
Parent's child feeding practices (for example, restriction, pressure)

Table 2 Potential obesity prevention approaches based on evidence for the influence of parents on children's eating and weight

1. Promote breastfeeding to reduce obesity risk, provide 'flavor bridge' experience with flavors of maternal diet
2. Offer healthy foods and use repeated exposure to promote acceptance
3. Provide guidance on age appropriate portion sizes, energy density of foods
4. Discourage the use of restrictive feeding practices
5. Discourage the use of coercive feeding practices
6. Find ways to reduce energy density of foods
7. Provide guidance on responsive feeding, recognizing hunger and fullness, setting limits, sharing feeding responsibilities with children
8. Promote 'do as I do' not 'do as I say': parents as positive models of eating

Evidence from longitudinal and experimental research on how parents' feeding practices influence children's eating and weight provides stronger, causal evidence for features of early parenting and parent–child interactions that should be targeted for early intervention. The evidence for several of these factors will be discussed in more detail below, and Table 2 provides a summary of these potential targets. Overall, this evidence illustrates that from conception through the first years of life, caregivers have substantial influence on the development of dietary preferences and patterns and, as will be illustrated below, this evidence can be effectively incorporated into the design and evaluation of early prevention approaches.

Genetic predispositions and early learning about food and eating

Infants learn vast amounts about eating and food over the first few years of life and are born with several predispositions that place constraints on both how learning occurs as well as what is learned. Infants are born with a preference for sweet tastes and an aversion for sour and bitter tastes.[11,12] At around 4 months of age, a preference for salty foods appears.[13] Infants are also predisposed to reject new foods (thus display neophobia when new flavors and foods are introduced)[14] and to be responsive to the energy density of foods.[15] From an evolutionary standpoint, these predispositions are adaptive: breast milk is sweet and familiar, whereas potential toxins are often bitter or sour and unfamiliar. As a substantial amount of growth occurs during the first year of life, the ability to respond to the energy density of foods and to compensate intake appropriately to ensure whether caloric needs are met is essential to infant survival.

However, in current obesogenic environments, characterized by the availability of large portions of inexpensive, palatable energy-dense foods, these predispositions may become an impediment to promoting healthy intake patterns in children. Neophobic tendencies and aversions for sour or bitter foods can make the introduction of certain healthful solid foods (vegetables in particular) difficult for parents. As infants have unlearned, predisposed preferences for sweetness and saltiness, parents typically need not do anything to help a child learn to like unfamiliar sweet or salty foods that can promote diets too high in sugars and salt, as these foods are readily accepted by children.

Preferences for other novel flavors and foods need to be learned. Fortunately, infants are also predisposed to develop preferences for food and flavors through associative conditioning, involving the association of foods with the contexts and consequences of eating, if given opportunities to try new foods. Although new foods may be initially rejected, if they are repeatedly presented to an infant or child, both consumption and preference for that food increase.[16] Breastfed infants are more accepting of foods at the first exposure and increase their consumption of and preference for to these foods to a greater extent over multiple exposures, compared with formula-fed infants.[16] It is hypothesized that this observation is attributable to the fact that flavors from the maternal diet are transmitted from mother to child through both amniotic fluid and breast milk.[17] Mennella and Beauchamp[18] have shown that when mothers repeatedly consume a certain flavor during pregnancy and lactation, their infants are more likely to readily accept and prefer foods with those flavors during the introduction of solids. Thus, the varied flavors present in the breast milk create a 'flavor bridge' for breastfed infants by familiarizing them with a variety of flavors in the maternal diet, reducing neophobia during the introduction of solids. Other work has supported the role of familiarity and experience in children's preferences, showing that when a food becomes more familiar, it is more likely to be preferred and consumed.[19]

Parenting, child feeding practices and children's eating

Parenting practices shape children's early experiences with food and eating; these child feeding practices may differ in the extent to which feeding is initiated by child cues, or by environmental cues, such as time of day. Feeding practices involve parental choices about which foods children are offered; when, how frequently and how much children are fed; and the social contexts within which feeding occurs. These parenting practices are shaped by parents' own experience with food and eating, and by what is traditional in their cultural group. Parenting practices are responses to environmental threats to parental goals for children.[20] A universal goal of parents across all cultures is to raise healthy children who are growing well. Historically, one of the main environmental threats to this goal has been food scarcity: food supplies were unpredictable, available food was unpalatable and lacking in variety, energy-dense, nutrient-rich foods were limited and conditions were unsanitary. Faced with this environmental threat, traditional feeding practices evolved that include (1) feeding children frequently; (2) offering large portions; (3) offering preferred foods; (4) offering food as a first response to crying or distress; and (5) coercing children to eat when food is available, even if they are not hungry. Additionally, in a context where food is scarce, 'bigger is better'; a plump, large for age child is a sign of child health and successful parenting.

In contrast to the food scarcity that has persisted through most of human history, the current threat faced by families in developed countries is an obesogenic environment. This type of environment encourages habitual energy intakes that are greater than habitual energy expenditures, an imbalance created by a combination of easy access to large portions of energy-dense and highly palatable foods, discouragement of free-living physical activity through the presence of labor-saving devices and normative participation in sedentary behaviors during leisure time. When traditional child-feeding practices that promoted child health when food was scarce are applied in obesogenic environments, they may result in overeating and accelerated weight gain by promoting children's (1) lack of responsiveness to satiety cues; (2) overeating in response to large portions; (3) learned preference for unhealthy, palatable foods as they are used as rewards and treats; (4) learning to eat in response to distress rather than hunger; and (5) learned dislike for 'healthy foods' if there is pressure to eat them. When a 'bigger is better' attitude about child growth persist as a traditional parenting attitude, parents may not realize the problematic nature of children's eating, activity and weight gain patterns. A growing body of evidence has confirmed the use of traditional feeding practices in the current obesogenic environments and that these practices are indeed associated with accelerated weight gain and higher weight status in children.

With respect to the effects of one traditional practice, coercing children to eat, when children are pressured by

parents to 'clean their plate' or offered a reward for finishing certain foods, children eat more within that meal setting, but appear to do so with a loss of responsiveness to caloric density cues in foods suggesting that external pressure to eat from parents creates children who attended to external, rather than internal, hunger and satiety cues.[21] Additionally, the use of coercion for eating 'healthy' foods leads to the development of dislikes for those foods; this practice has been associated with a lower preference or even learned dislike for foods that children are either rewarded for eating or are pressured to eat.[22,23] Retrospective studies have shown that the learned dislikes that result when children are coerced to eat a food persist in adulthood; young adults report dislike for foods that they had reportedly been coerced to eat as children.[24]

Intuitively, one effective parental response to the obesogenic environment would be to simply restrict children's access to palatable food as a way to limit their consumption, and decrease children's preference for and intake of those foods. However, the experimental evidence does not provide support for this view. For example, to assess the impact of restrictive feeding practices on young children's eating, Fisher and Birch[25] presented preschool-aged children with a situation where some foods were restricted and others foods were freely available. As a result of these experiences, children made more requests for the restricted food, commented more positively about it, selected it over the unrestricted food and ate more of it during those times when they had access to the restricted food.[25] Additionally, when children were left alone with free access to an array of energy dense, highly palatable snack foods (that is, things that parents often restrict children's access to), children whose mothers used restrictive feeding practices at home consumed more of the 'forbidden foods', despite reporting that they were not hungry.[26]

Feeding practices can influence 'how much' food children consume in several ways. As mentioned above, infants have an ability to attend to the energy density cues present in the foods they consume. Fomon *et al.*[27] have shown that when the energy density of formula is manipulated, infants adjust the volume of milk intake consumed. Early feeding practices may, however, work to either preserve or damper these predispositions. Limited evidence indicates that self-regulatory abilities diminish when children get older. In part, this may be attributable to parenting practices that focus children on environmental cues other than hunger and satiety for eating, such as 'time to eat' rather than hunger as a cue for meal initiation or 'cleaning the plate' rather than satiation as a cue for meal termination.[21] The evidence available reveals that by 3–5 years of age, many children show little evidence of the ability to adjust intake in response to changes in the energy densities of foods that are served in naturalistic meal settings.[28] Thus, in a manner similar to adults,[29] when the energy density of foods is altered, young children eat a consistent amount of food across meals, rather than a consistent number of calories. Although this can result in children eating too many calories when served energy-dense foods, this also implies that serving foods of lower energy density for children can help moderate children's energy intake, as shown recently by Leahy *et al.*[28,30]

The portion size of foods served to children also affect how much or little a child consumes.[31] Parents may serve children large portions of food to promote adequate intake or because they do not know what constitutes an age-appropriate portion for their child. Children respond to larger portions of food by consuming more of that food; at a single lunch, as well as across multiple meals, doubling the portion size of entrées resulted in increases in the average size of children's bites.[32] This led to a 25% increase in intake, despite the fact that children were largely unaware of any portion size manipulations. Although there has been some evidence that young children can self-regulate intake by compensating for between-meal variations,[33,34] this compensation may not be complete, and consumption of excess calories may accumulate in the long term when children are served large portions of energy-dense foods at successive meals.[35]

Survey data from the Feeding Infants and Toddlers Study recently revealed that infants and toddlers, 2–24-months old, are consuming too many calories and eating too much of the wrong kinds of foods. For example, reported caloric intakes of infants and toddlers in this survey exceeded energy requirements by 32 to 42%.[36] In all, 18–33% of infants and toddlers consumed no servings of vegetables, and 23–33% consumed no fruits on a daily basis.[37] Additionally, when vegetables were eaten, French fries were the most commonly eaten 'vegetable.' By 15–18 months, 20% of children reported consuming French fries at least once a day and by 19–24 months, 26% of children are eating French fries daily. The types and amounts of foods parents make available to children have been shown to be a significant determinant of what children consume;[38] the Feeding Infants and Toddlers Study suggests that many parents are making the wrong types of foods available to their children on a daily basis, decreasing the diet quality of children at a very young age and creating dietary patterns that may be detrimental to children's health and weight status.

Children come into the world with a set of predispositions (that is, preferences for sweet and salty tastes, neophobia and tendencies to learn to prefer energy-dense foods) that can challenge parents' ability to establish healthy intake patterns in their children. Traditional parenting practices can further undermine parents' efforts. However, research has shown that learned preferences for 'healthy' foods and appropriate intake patterns are possible, given appropriate feeding practices that work in concert with the child's predispositions. For example, if healthy foods have become familiar to the child,[16] if eating them is modeled by peers or adults model,[39] or they are paired with positive social contexts and physiological consequences,[40] children will be more likely to accept and prefer these foods. Additionally, if taught to attend to internal, rather than external, hunger and satiety cues, children can learn to better self-regulate intake by being more responsive to the energy density of foods

consumed.[41] As will be discussed in the next section, this evidence suggests several promising, but currently untested, intervention strategies.

A phased approach to selecting potent intervention components and developing optimized interventions (multiphase optimization strategy)

With respect to preventing childhood obesity, our evidence base regarding 'what works' is very limited. But, the evidence that is available reveals that early prevention may be our best opportunity because this is a time when children are primed to learn about food and eating and are very responsive to the influence of parents and caregivers. As summarized in Table 2, the current literature provides a set of promising avenues for early obesity prevention that need further exploration. New prevention efforts can be guided by existing evidence regarding the development of eating behavior in children. However, a systematic approach is needed for selecting effective intervention strategies and designing optimized interventions. Collins *et al*.[42] have recently proposed a phased strategy for developing optimized behavioral interventions. This strategy provides a phased approach to selecting and refining of intervention components, and for building and evaluating optimized interventions. The conceptual model for this approach is illustrated in Figure 2.

As illustrated in this model, Phase 1 of this approach is a 'screening phase', in which theory-guided, randomized experiments are conducted to select intervention components through confirmation of causal links between intervention components and outcomes. Candidate intervention components can be selected for the screening phase based on the existing literature; thus, candidate intervention components for preventing childhood obesity could be selected from the material presented in Table 2. In Phase 2, the 'refining phase', interactions among the components identified in Phase 1 are tested, interrelationships between components and relevant covariates are examined, and optimal dosage levels are selected, again using randomized experiments. Phase 3, 'the confirming phase', is a randomized intervention trial to evaluate the resulting optimized intervention. Note that the optimized intervention is built upon the findings of the first two phases, which provide essential information on the potency of intervention components, their interactions, relations to covariates, effective doses and modes of delivery before this confirming phase. As the screening and refining phases focus on selecting intervention components with strong evidence for effectiveness, the intervention evaluated in the confirming phase has a higher likelihood of success, because there is evidence regarding how and why intervention components work. A standard randomized trial can then be used to implement and evaluate the effectiveness of intervention.

Conclusion

Current school-based intervention efforts have not proven to be effective in reversing the rising rates of childhood obesity; additional approaches to the problem are needed. We propose an expansion of these efforts to include a focus on

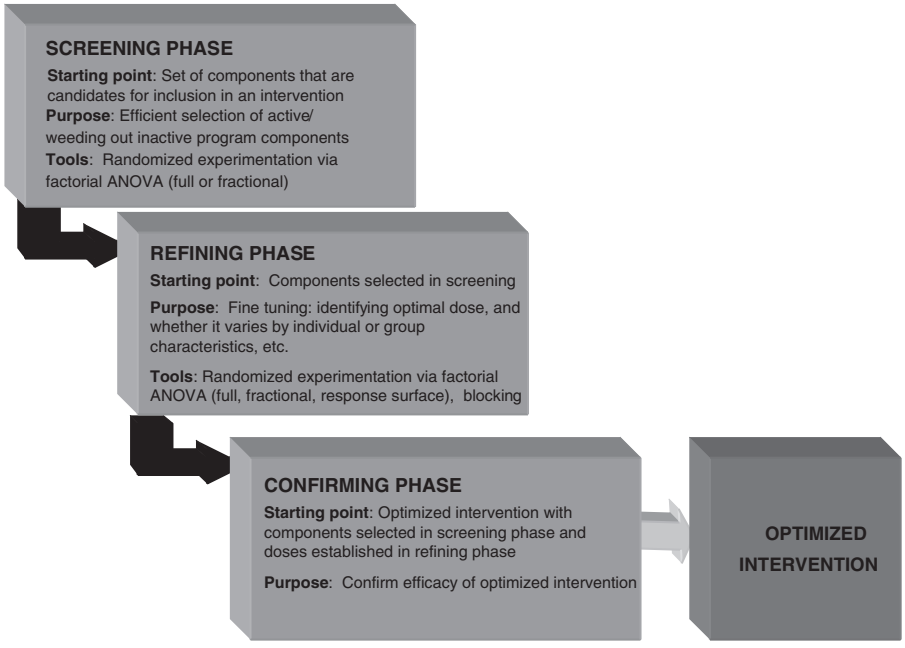

Figure 2 Outline of the multiphase optimization strategy (MOST). ANOVA, analysis of variance, SMART, sequential multiple assignment randomized trial. Adapted from Collins *et al*.[43] and reprinted with permission from *American Journal of Preventive Medicine*.

the period before school entry and the development of interventions that include parents and families in home and childcare settings. The existing research on the factors influencing the developing controls of food intake in infancy and early childhood suggests a number of possible targets for interventions with young children, parents or caregivers. As young omnivores, children are prepared to learn to eat a diet of whatever foods are available in their environment, and their innate ability to learn to like or to reject foods provides the needed flexibility. Children's predisposition to learn can be used to advantage if parents understand how their practices affect children's eating and weight, and that the impact of their feeding practices may either promote or undermine the development of eating behaviors consistent with higher quality diets and healthy weight status. If a feeding environment is created that supports children's opportunities to choose and try new foods in positive contexts and to make choices among healthy alternatives, without coercion, children can learn to like and eat those foods. When the child-feeding environment is restrictive or coercive, or when children are offered the wrong kinds and portions of foods, they develop preferences and eating styles that may increase their risk for obesity. These findings provide the evidence base needed for the development of behavioral interventions for the early prevention of childhood obesity, and we propose the use of a phased strategy to create optimized, potent intervention strategies for preventing obesity during the first years of life. However, in our the current obesogenic environment, it must be acknowledged that early prevention of obesity is only one essential step in developing effective prevention and treatment approaches to combat the obesity epidemic across the lifespan.

Conflict of interest

L Birch has received consulting fees from Kraft Foods and McCormicks and has received grant support from Dairy Management Inc. and the McCormick Foundation. The remaining author has declared no financial interests.

References

1 Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA* 2006; **295**: 1549–1555.
2 Koplan JP, Liverman CT, Kraak VI, Wishham SL. *Progress in Preventing Childhood Obesity: How Do We Measure Up?*. National Academies Press: Washington, DC, 2006.
3 Koplan JP, Liverman CT, Kraak VA (eds). *Preventing Childhood Obesity: Health in the Balance*. National Academies Press: Washington, DC, 2005.
4 Wilfley DE, Tibbs TL, Van Buren DJ, Reach KP, Walker MS, Epstein LH. Lifestyle interventions in the treatment of childhood overweight: a meta-analytic review of randomized controlled trials. *Health Psychol* 2007; **26**: 521–532.
5 ADA. Position of the American Dietetic Association: individual-, family-, school-, and community-based interventions for pediatric overweight. *J Am Diet Assoc* 2006; **106**: 925–945.
6 Jeffery RW, Linde J. Population approaches to obesity prevention. In: Crawford D, Jeffery RW (eds). *Obesity Prevention and Public Health*. Oxford University Press: New York, NY, 2005, pp 153–164.
7 Davis JW, Bauman KJ. School enrollment in the United States: 2006. US Census Bureau, Washington, DC, 2008. Accessed on 10 February 2009. http://www.census.gov/prod/2008pubs/p20-559.pdf.
8 Davison KK, Birch LL. Childhood overweight: a contextual model and recommendations for future research. *Obs Rev* 2001; **2**: 159–171.
9 Birch LL. Development of food preferences. *Annu Rev Nutr* 1999; **19**: 41–62.
10 Bluford DA, Sherry B, Scanlon KS. Interventions to prevent or treat obesity in preschool children: a review of evaluated programs. *Obesity (Silver Spring)* 2007; **15**: 1356–1372.
11 Desor JA, Maller O, Andrews K. Ingestive responses of human newborns to salty, sour, and bitter stimuli. *J Comp Physiol Psychol* 1975; **89**: 966–970.
12 Steiner JE. Facial expressions of the neonate infant indicating the hedonics of food-related chemical stimuli. In: Weiffenbach JM (ed). *Taste and Development: The Genesis of Sweet Preference*. US Government Printing Office: Washington, DC, 1977, pp 173–189.
13 Beauchamp GK, Cowart BJ, Mennella JA, Marsh RR. Infant salt taste: developmental, methodological, and contextual factors. *Dev Psychobiol* 1994; **27**: 353–365.
14 Pliner P, Hobden K. Development of a scale to measure the trait of food neophobia in humans. *Appetite* 1992; **19**: 105–120.
15 Fomon SJ, Filer Jr LJ, Thomas LN, Rogers RR, Proksch AM. Relationship between formula concentration and rate of growth in normal infants. *J Nutr* 1968; **98**: 241–254.
16 Sullivan SA, Birch LL. Infant dietary experience and acceptance of solid foods. *Pediatrics* 1994; **93**: 271–277.
17 Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. *Pediatrics* 2001; **107**: E88.
18 Mennella JA, Beauchamp GK. Experience with a flavor in mother's milk modifies the infant's acceptance of flavored cereal. *Dev Psychobiol* 1999; **35**: 197–203.
19 Birch LL, Marlin DW. I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. *Appetite* 1982; **3**: 353–360.
20 LeVine RA. Human parental care: Universal goals, cultural strategies, individual behavior. In: LeVine RA, Miller PM, West MM (eds). *Parental Behavior in Diverse Societies. New Directions for Child Development*. Jossey-Bass: San Francisco, 1988. pp 3–12.
21 Birch LL, McPhee L, Shoba BC, Steinberg L, Krehbiel R. Clean up your plate. Effects of child feeding practices on the conditioning of meal size. *Learn Motiv* 1987; **18**: 301–317.
22 Birch LL, Marlin DW, Rotter J. Eating as the 'means' activity in a contingency: effects on young children's food preferences. *Child Dev* 1984; **55**: 432–439.
23 Galloway AT, Fiorito LM, Francis LA, Birch LL. 'Finish your soup': counterproductive effects of pressuring children to eat on intake and affect. *Appetite* 2006; **46**: 318–323.
24 Batsell Jr WR, Brown AS, Ansfield ME, Paschall GY. You will eat all of that!: a retrospective analysis of forced consumption episodes. *Appetite* 2002; **38**: 211–219.
25 Fisher JO, Birch LL. Restricting access to palatable foods affects children's behavioral response, food selection, and intake. *Am J Clin Nutr* 1999; **69**: 1264–1272.
26 Birch LL, Fisher JO, Davison KK. Learning to overeat: maternal use of restrictive feeding practices promotes girls' eating in the absence of hunger. *Am J Clin Nutr* 2003; **78**: 215–220.
27 Fomon SJ, Filer Jr LJ, Thomas LN, Anderson TA, Nelson SE. Influence of formula concentration on caloric intake and growth of normal infants. *Acta Pediatr Scand* 1975; **64**: 172–181.

28 Leahy KE, Birch LL, Rolls BJ. Reducing energy density of an entree decreases children's energy intake at lunch. *J Am Diet Assoc* 2008; **108**: 41–48.
29 Rolls BJ, Bell EA, Castellanos VH, Chow M, Pelkman CL, Thorwart ML. Energy density but not fat content of foods affected energy intake in lean and obese women. *Am J Clin Nutr* 1999; **69**: 863–871.
30 Leahy KE, Birch LL, Rolls BJ. Reducing the energy density of multiple meals decreases the energy intake of preschool-age children. *Am J Clin Nutr* 2008; **88**: 1459–1469.
31 Rolls BJ, Engell D, Birch LL. Serving portion size influences 5-year-old but not 3-year-old children's food intakes. *J Am Diet Assoc* 2000; **100**: 232–234.
32 Orlet Fisher J, Rolls BJ, Birch LL. Children's bite size and intake of an entree are greater with large portions than with age-appropriate or self-selected portions. *Am J Clin Nutr* 2003; **77**: 1164–1170.
33 Fox MK, Devaney B, Reidy K, Razafindrakoto C, Ziegler P. Relationship between portion size and energy intake among infants and toddlers: evidence of self-regulation. *J Am Diet Assoc* 2006; **106**: S77–S83.
34 Birch LL, Johnson SL, Andresen G, Peters JC, Schulte MC. The variability of young children's energy intake. *N Engl J Med* 1991; **324**: 232–235.
35 Fisher J, Arreola A, Birch LL, Rolls BJ. Portion size effects on daily energy intake in low-income Hispanic and African American children and their mothers. *Am J Clin Nutr* 2007; **86**: 1709–1716.
36 Devaney B, Ziegler P, Pac S, Karwe V, Barr SI. Nutrient intakes of infants and toddlers. *J Am Diet Assoc* 2004; **104**: s14–s21.
37 Fox MK, Pac S, Devaney B, Jankowski L. Feeding infants and toddlers study: What foods are infants and toddlers eating? *J Am Diet Assoc* 2004; **104**: s22–s30.
38 Cullen KW, Baranowski T, Owens E, Marsh T, Rittenberry L, de Moor C. Availability, accessibility, and preferences for fruit, 100% fruit juice, and vegetables influence children's dietary behavior. *Health Educ Behav* 2003; **30**: 615–626.
39 Addessi E, Galloway AT, Visalberghi E, Birch LL. Specific social influences on the acceptance of novel foods in 2-5-year-old children. *Appetite* 2005; **45**: 264–271.
40 Kern DL, McPhee L, Fisher J, Johnson S, Birch LL. The postingestive consequences of fat condition preferences for flavors associated with high dietary fat. *Physiol Behav* 1993; **54**: 71–76.
41 Johnson SL. Improving Preschoolers' self-regulation of energy intake. *Pediatrics* 2000; **106**: 1429–1435.
42 Collins LM, Murphy SA, Nair VN, Strecher VJ. A strategy for optimizing and evaluating behavioral interventions. *Ann Behav Med* 2005; **30**: 65–73.
43 Collins LM, Murphy SA, Strecher V. The multiphase optimization strategy (MOST) and the sequential multiple assignment randomized trial (SMART): new methods for more potent eHealth interventions. *Ann J Prev Med* 2007; **32**: S112–S118.