Determinants of children’s eating behavior\textsuperscript{1–3}

Silvia Scaglioni, Chiara Arrizza, Fiammetta Vecchi, and Sabrina Tedeschi

ABSTRACT
Parents have a high degree of control over the environments and experiences of their children. Food preferences are shaped by a combination of genetic and environmental factors. This article is a review of current data on effective determinants of children’s eating habits. The development of children’s food preferences involves a complex interplay of genetic, familial, and environmental factors. There is evidence of a strong genetic influence on appetite traits in children, but environment plays an important role in modeling children’s eating behaviors. Parents use a variety of strategies to influence children’s eating habits, some of which are counterproductive. Overcontrol, restriction, pressure to eat, and a promise of rewards have negative effects on children’s food acceptance. Parents’ food preferences and eating behaviors provide an opportunity to model good eating habits. Satiety is closely related to diet composition, and foods with low energy density contribute to prevent overeating. Parents should be informed about the consequences of an unhealthy diet and lifestyle and motivated to change their nutritional habits. Parents should be the target of prevention programs because children model themselves on their parents’ eating behaviors, lifestyles, eating-related attitudes, and dissatisfaction regarding body image. Pediatricians can have an important role in the prevention of diet-related diseases. Informed and motivated parents can become a model for children by offering a healthy, high-satiety, low-energy-dense diet and promoting self-regulation from the first years of life. Am J Clin Nutr 2011;94(suppl):2006S–11S.

INTRODUCTION
The development and long-term health of children are linked to nutritional habits from early life onward. The gold standard for infant nutrition is breastfeeding that can protect from infectious and chronic diseases. Meta-analyses of observational studies indicated that breastfeeding reduced the odds ratio for obesity more than did formula feeding, even after adjustment for confounding variables (1). Possible positive mechanisms include the learned self-regulation of energy intake, lower protein intake, and induction of low rates of infant weight gain as a consequence of the lower protein supply with breast milk than with standard infant formulas (ie, the early protein hypothesis).

This hypothesis is being tested in the European Childhood Obesity Project, which is a randomized double-blind intervention trial with >1000 infants in 5 European countries (Belgium, Germany, Italy, Poland, and Spain). During their first year of life, formula-fed infants were randomly assigned to receive infant formulas and follow-on formulas with higher or lower protein contents. Follow-up at 2 y of age showed that a lower protein supply with formula normalized early growth relative to a breastfed reference group and to the World Health Organization growth reference (2–4). The European Childhood Obesity Project will also provide information on eating behaviors and parental influence on infant eating behaviors in 5 European countries. It is well known that body mass index (BMI) and growth are influenced by genes, diet composition, and by parental control and feeding practices. The innate mechanisms that regulate appetite can be modified by experience (5).

Preventive programs on obesity recommend the systematic assessment of diet and BMI (6), but information about eating behaviors should also be collected. Changes in diet have led to a food environment labeled obesogenic. It is portrayed in marked contrast to the types of food environment in which humans evolved and to which they adapted biologically. In a previous article, mechanisms of taste development, parenting practices characterized by excessive control (restriction and pressure to eat), use of food to modify behavior, and neophobia were presented (7). In the present article, other determinants of children’s eating practices are discussed and advice is given to pediatricians to supervise the development of nutritional habits in children.

GENETIC DETERMINANTS OF FOOD PREFERENCES OF CHILDREN
Food likes and dislikes play an important role in food choices, especially in children. Preferences are shaped by a combination of genetic and environmental factors. A mixture of innate preferences and the ability to develop new preferences (ie, to learn what is nutritious and safe to eat) appeared to be fundamental in the past. There is substantial similarity in children’s preferences of food, which to some degree transcends cultural variations. High-fat and sweet foods are usually preferred by children of many countries, whereas vegetables are almost universally unwelcomed (8–10). This pattern of preferences suggests the existence of innate predispositions toward tastes. A preference for sweet taste, as measured by the observation of facial expressions, is universally present in neonates, along with an aversion to sour or bitter tastes (11, 12). This is the result of an adaptive process in

\textsuperscript{1} From the Pediatric Department, San Paolo Hospital, University of Milan, Milan, Italy.
\textsuperscript{2} Presented at the conference “The Power of Programming: Developmental Origins of Health and Disease,” held in Munich, Germany, 6–8 May 2010.
\textsuperscript{3} Address correspondence to S Scaglioni, Department of Pediatrics, University of Milan, San Paolo Hospital, Via A Antonio di Rudini 8, 20142 Milan, Italy. E-mail: silvia.scaglioni@unimi.it.

First published online November 16, 2011; doi: 10.3945/ajcn.110.001685.
which sweetness indicates the presence of valuable calories, whereas bitterness or sourness may signal the presence of toxins.

There is evidence for a strong genetic influence on appetite traits in children (13–16) and adults. Twin studies have provided a coefficient of heritability for food types, with indications of genetic influence on food preferences being strong for protein foods (coefficient of heritability: 0.78) and moderate for fruit (coefficient of heritability: 0.51), vegetables (coefficient of heritability: 0.37), and dessert foods (coefficient of heritability: 0.20) (17). Coefficients of heritability were obtained by using model-fitting techniques with the factors scores. Interclass correlations for each of the food types were compared between monozygotic and dizygotic pairs. In the past, the innate tendency to reject sour and bitter foods may have protected individuals from toxins. Now, this tendency contributes to the widespread dislike of vegetables in children and many adults and adds to the detriment of dietary quality. In a population-based sample of twins who were exclusively milk fed (18), the avidity of appetite that has been related to children’s obesity risk was studied. A genetic effect was large for slowness in eating (in 84% of subjects) and satiety responsiveness (in 72% of subjects) and moderate for food responsiveness (in 59% of subjects) and enjoyment of food (in 53% of subjects). Early feeding characteristics may be a precursor of later eating speed, which was recently shown to be heritable in 62% of 11-y-old twins (18). Moreover, feeding behavior in early life has shown robust associations with adiposity (19) and lower and higher risks of obesity.

Human and animal studies are consistent with inferences from evolutionary considerations that the strengths of defenses against fat loss are greater than those against fat gain. Many of the genes participating in these pathways have reciprocal effects on energy intake and expenditure, although different genes may have the primary roles in respective responses to weight gain or loss (20).

The interaction of genes and environment influences phenotypes for energy intake and expenditure and suggests that a renewed focus on family environment may provide information about other factors than genetic factors that contribute to familial aggregation of adiposity. The marked rise in obesity observed over the past 3 decades suggests that behavioral and environmental factors underpin the chronic mismatch between energy intake and energy expenditure. A few well-controlled studies with monozygotic twins have specifically addressed the genetic background of interindividual variation in response to overeating or energy restriction. Some individuals gain or lose weight more easily than others, but subjects who share the same genotype (monozygotic twins) respond in a similar way, which suggests that the responsiveness to diet is mediated by their genotype. Further evidence for gene-environment interactions comes from candidate-gene studies (21).

Genes involved in pathways that regulate energy expenditure and food intake may play a role in the considerable variation in the responsiveness to obesogenic environments and in the predisposition to obesity. Some individuals defend easier against a pro-pensity to accumulate fat mass and become overweight, whereas other individuals are predisposed to gain weight, possibly as a function of genotype. The genetic contribution to obesity is well established. Common obesity is polygenic and involves complex gene-gene and gene-environment interactions, and these interactions can produce multifactorial obese phenotypes. Candidate-gene variants for polygenic obesity appear to disrupt pathways involved in the regulation of energy intake and expenditure and include adrenergic receptors, uncoupling proteins, peroxisome proliferator activated receptor gamma, proopiomelanocortin, melanocortin 4 receptor, and a set of single nucleotide polymorphisms in the FTO locus. The FTO gene is predominantly expressed in the appetite-control areas of the hypothalamus and associated with satiety sensitivity and food responsiveness in children. Notably, the FTO gene has the strongest genetic influence for common obesity characterized thus far, and recent data showed that the FTO locus seems to confer risk of obesity through increasing energy intake and reduced satiety. Gene variants involved in pathways that regulate addiction and reward behaviors may also play a role in the predisposition to obesity. Understanding the routes through which the genotype is expressed will provide opportunities for developing strategies to intervene because the interaction between genotype and environment is potentially modifiable through behavior change (22). Meta-analyses of population-based, genome-wide association studies in adults have led to the detection of new genetic loci for obesity, especially those associated with early onset obesity (23, 24). The relation between gene and behavior was evaluated in the Helena study that recently showed that adolescents who met the daily physical activity recommendations may overcome the effect of the FTO rs9939609 polymorphism on obesity-related traits (25). This study showed that gene influence could be modulated by environment and behavior. The willingness of children to take new foods or specific foods has strong-to-moderate heritability that is modulated by cultural differences in early exposure to both taste and texture of foods and gives rise to different patterns of food acceptance (26).

PARENTAL INFLUENCES

Parents use nutrition practices that have evolved over thousands of years to promote patterns of food intake for children’s growth and health. However, in current eating environments characterized by inexpensive, palatable, energy-dense food, these traditional feeding practices can promote overeating and weight gain (27). There is substantial evidence of bidirectional interactions between parenting and the diet and weight status of children. The literature recognized 2 different but correlated parental conducts as follows: parenting style and parenting practice. The style described as authoritative, authoritarian, indulgent, or neglectful is the result of attitudes and behaviors of interplay with the child. The practice is a strategy of control used by parents such as a pressure to eat by promoting healthy food, usually fruit and vegetables, restriction by limiting access to sweets and fatty snacks, and the use of food as a reward. Despite the good intentions of parents, these practices are associated with negative outcomes; restriction is strongly correlated with children’s disinhibited eating behaviors (28). Restriction is also directly associated with children’s BMI. The overreactivity and irritability of parents are associated with more coerciveness in the feeding domain, whereas inconsistent and unpredictable parents are associated with more chaos. Especially the more parents are inconsistent, erratic in their eating schedules, and harder to predict regarding healthy compared with unhealthy eating patterns, the worse is the influence on their children’s disinhibited eating when parents use more restriction (29).

The role of mothers’ on feeding practices and children’s eating behaviors is described in many studies. Maternal restriction can
also promote overeating, especially in daughters. Girls who were already overweight at 5 y of age and who received higher levels of restriction had the highest tendency to eat in absence of hunger (30). Birch et al (31) showed significant increases of maternal control after and not before increases in weight gains of daughters but not in boys. This result could suggest that mothers are more worried about weight gains of girls than of boys. This particular attention to the weight status of girls reflects the current social value attached to female thinness.

The family meal represents an important moment of interaction and control. The presence of at least one parent during the evening meal is associated with a lower risk of poor consumption of fruit, vegetables, and dairy foods and a lower risk of skipping breakfast in adolescents (32). Children who described their parents as authoritative ate more fruit per day, fewer unhealthy snacks per day, and breakfast more days per week than did those who described their parents as neglectful (33). In addition, Pearson et al (34) showed that adolescents who attended family meals perceived more parental support for healthy eating, limitation of television use, and availability of fruit and vegetables at home every day. These results were supported by another study that showed a connection between mothers who skipped breakfast and omitted fruit, vegetables, or dairy products and the poor diet quality of children (35).

Another study focused on a new outlook on mother and child interactions. Children were classified into 3 types concerning temperament as easy, average, and difficult. In contrast, mothers were considered sensitive or insensitive regarding the weight status of children in early childhood. Children with a difficult temperament and insensitive mothers had a significantly higher risk of being overweight or obese during school age but not during early childhood (36).

To encourage a healthy attitude to food and prevent overweight, pediatricians should monitor children’s growths, dietary habits, and lifestyles and parents’ strategies (control or disinhibition). A child’s dietary practice should be investigated at different ages with particular attention to the overall diet quality (how many times, where, with whom the child consumes meals, and the variety of food) and self-regulation. A list of suggestions to check these fields is presented in Table 1.

**TABLE 1**

<table>
<thead>
<tr>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents’ information</td>
</tr>
<tr>
<td>Parental BMI</td>
</tr>
<tr>
<td>Any parental eating disorder</td>
</tr>
<tr>
<td>Mother dieting</td>
</tr>
<tr>
<td>Mother body-image perception</td>
</tr>
<tr>
<td>Parents’ own eating behaviors</td>
</tr>
<tr>
<td>Parental control and restraint</td>
</tr>
<tr>
<td>Perceived responsibility for child feeding</td>
</tr>
<tr>
<td>Perceived child appetite</td>
</tr>
<tr>
<td>Feeding practice at flexible or scheduled time</td>
</tr>
<tr>
<td>Parental feeding strategies when child refuses food</td>
</tr>
<tr>
<td>Parental feeding strategies</td>
</tr>
<tr>
<td>Control on portion size</td>
</tr>
<tr>
<td>Restriction of snack and palatable food</td>
</tr>
<tr>
<td>Pressure to eat healthy food</td>
</tr>
<tr>
<td>Disinhibition</td>
</tr>
<tr>
<td>Parental perception and concerns for child’s weight status</td>
</tr>
<tr>
<td>Use of food to change behavior</td>
</tr>
<tr>
<td>Behavior when child refuses food</td>
</tr>
<tr>
<td>Person in charge of feeding practice</td>
</tr>
</tbody>
</table>

**Child information**

| At infant age |
| Gestational age and birth weight |
| Infant feeding (breastfeeding duration and formula introduction) |
| Introduction of complementary feeding |
| Eating slowness or speed |
| Food refusal |
| At preschool and school age |
| Adiposity rebound |
| Dietary intake assessment at least once a year to get following information |
| No. of meals |
| Skipping breakfast |
| Frequency of intake of main food groups including dairy products, meat, fish, cheese, legumes, eggs, vegetables, fruit, soft drinks, fruit juices, cake, and junk food |
| Dieting |
| Nibbling |
| Variety or monotony of diet |
| Intake of high-energy-dense foods and food glycemic index |
| Neophobia or picky or fussy eating style |
| Food avoidance |
| Selective diet |
| Self-evaluations |
| Body satisfaction or dissatisfaction |
| Physical activity and sedentary behavior (eg, time spent watching television or playing at computer) |

**AWARENESS OF BMI**

A recent study conducted in the Netherlands revealed that a majority of parents failed to recognize overweight or obesity in their 5- and 11-y-old children. Children with normal weight were considered by their parents as a little too light or too light. Overweight children were regarded as normal weight, and obese children were considered normal or a little too heavy. The underestimation of overweight may impair the motivation of the parents to adopt weight control (37, 38). Warschburger and Kröller (39) showed that ≈40% of mothers did not recognize the overweight figures of children by looking at a panel of silhouettes, and more than one-half of the mothers were unable to recognize the increased health risk associated with overweight or obesity. In a cohort of 3000 Australian children and adolescents, Abbott et al (40) showed that >20% of parents underestimated, and only 1% of parents overestimated, the weight status of their children. Adolescent boys tended to underestimate their weight status more than did girls, whereas adolescent girls overestimated more than underestimated their weight status. Underestimation was greater by parents of overweight children that by parents of obese children, but still, <50% of parents identified their obese child as “too fat.” There was a greater recognition of overweight status in adolescents, with 83% of those who were obese reporting that they were “too fat”.

Children’s self-perceptions of BMI can also be influenced by their environments, especially by people who relate to them every day. Misperceptions of children and adolescents of their weight status, especially the underestimation of their overweight or
energy density is influenced by the ED of foods and beverages served: as the ED of meals increased, so did energy intake (48). Relatively few studies considered the dietary energy intake of children in the free-living environment. These studies have shown that young children adjusted their daily food intake in relation to ED, which suggests caloric compensation under free-living conditions (49).

Recently, it was shown that the ED of the self-selected diet of children increased over time without differences between children born at different risks for obesity, reached its peak during adolescence (50) and then declined during adulthood. This finding suggests that dietary ED may be a dietary trait more environmentally than genetically influenced (51).

There is evidence that the food environment that parents create at home shapes children’s food preferences and food-acceptance patterns, such that availability and exposure to foods can affect children’s food selections and intakes (52).

OBESOGENIC ENVIRONMENT

The marked rise in obesity observed over the past decades suggests that behavioral and environmental factors play a relevant role in the chronic modification of the balance between energy intake and energy expenditure. However, not all individuals become obese, which suggests that there is considerable variation in the responsiveness of individuals to obesogenic environments. Obesity is a polygenic disease that is due to complex gene-gene and gene-environment interactions that produce multifactorial obese phenotypes. Genes can interfere with the regulation of energy intake and expenditure (23).

Although not strictly a property of food itself, the extent to which a food is familiar has a strong effect on its acceptability. For many children and some adults, unfamiliarity is a reason to avoid a novel food. In terms of the adaptive origins of a preference for familiarity, it is plausible that familiar tastes provide an indication of the likely safety of the food being presented. Children like what they know, and they eat what they like. From the very earliest age, children’s experiences with food influence both preferences and intakes, and research suggests that the earlier and broader experiences with food are, the healthier is the child’s diet (53). Giving a novel food a familiar flavor (eg, adding tomato ketchup or curry) can also increase a child’s willingness to try it (54).

Children also vary in their total number of dislikes. Several dimensions have been identified as related to a higher number of food dislikes, including fussiness, pickiness, and neophobia, and there is an active debate about whether these are distinct dimensions. Food neophobia, or the dislike of novel foods, has attracted a good deal of attention. Although most children exhibit some degree of caution in response to unfamiliar foods, ∼20–30% of children are significantly neophobic. In a rare longitudinal study, Skinner et al (10) showed that food neophobia early in life was related to the number of foods disliked or never tried by age 8 y and negatively related to the number of foods liked. Parents who respond to their picky child’s limited diet and worry about their overall energy intake may give up and offer the child favorite foods and thus further reinforce the child’s avoidance of unfamiliar foods.

Moderate parent-child or sibling-sibling correlations have been observed, but these could be either genetic or environmental. Studies in schoolchildren twin pairs showed a strong genetic influence on neophobia, with model-fitting estimates of heritability at 78% (55, 56).

As reported by Whitaker et al (57), having parents who are both overweight is associated with an increased risk of child obesity compared with having parents who are both normal weight. Having an obese or severely obese parent was associated with a higher risk of child obesity, and this risk increased even more when both parents were severely obese. The association between the mother’s BMI and child’s BMI was stronger than the association between the father’s BMI and child’s BMI. This study supported the hereditability of a genetic predisposition to obesity, but the lifestyle of the whole family as to what, when, and how they eat can be decisive for the onset of their children’s overweight and obesity. To this end, Birch and Davison (58) identified dietary intakes and physical activity clusters of obesogenic and nonobesogenic families to confirm that the style of life of families was a predictor of obesity risk of children. Mothers and fathers who presented high dietary intakes and low levels of physical activity had daughters with higher BMI and skinfold thickness at 7 y of age compared with the values for daughters from nonobesogenic families. An Australian longitudinal study correlated some other familial habits to the BMI trends of children; more dinner consumption while watching television, less frequency of consuming breakfast, and more fast food consumption at home were associated with higher BMI z scores longitudinally and higher odds of overweight (59).
Upholding the relation between home-environment characteristics and child behavior, the study conducted by Spurrer et al correlated the habits of parents and children with physical activity and dietary quality. Toward physical activity, higher outdoor-playtime scores of children were associated with a higher frequency of maternal walking and participation in organized sports. Concerning food habits, there was a strong positive association between the amount of fruit and vegetables available at home and higher fruit and vegetable intakes of children; in contrast, greater quantities of fruit juice and muesli bars or breakfast bars kept in the home were associated with lower fruit and vegetable scores. The higher intake of sweetened beverages was correlated with routine home meals in front of the television, less frequent family meals, and the use of food as a reward for good behavior (60).

CONCLUSIONS

Food preferences are the product of an interplay between genetic and environmental factors that result in substantial individual differences in the extent to which children are suspicious and fussy about food in general and in their likes and dislikes for specific foods. The advantage of the malleability of human food preferences is that a dislike for a food can be reduced or even reversed by a combination of modeling and taste exposure. Parents should choose meal times, propose adequate food and portion sizes, and promote social interaction and role modeling for eating behaviors. Unfortunately, few parents receive any guidance in how to promote food acceptance. A challenge for future research to improve the eating patterns of young children is the development of effective interventions to be widely disseminated.

The goal is to motivate changes in parental nutritional practices and lifestyles. Pediatricians should survey the nutritional and behavioral habits of children, promote self-regulation, and suggest effective age-related strategies to parents. It is important to let parents know that children who are self-regulated in diet may better handle the current food-surplus environment.

The authors’ responsibilities were as follows—SS: development of overall strategy and draft of the manuscript; CA: data collection and interpretation of findings; and FV and ST: oversight of the entire project with input into the strategy and draft of the manuscript. None of the authors declared a conflict of interest.

REFERENCES