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PEDIATRIC HIGHLIGHT

Role of parents in the determination of the food preferences of children and the development of obesity

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The role of parental behaviour in the development of food preferences is considered. Food preferences develop from genetically determined predispositions to like sweet and salty flavours and to dislike bitter and sour tastes. Particularly towards the second year of life, there is a tendency to avoid novel foods (neophobia). Food aversions can be learnt in one trial if consumption is followed by discomfort. There is a predisposition to learn to like foods with high-energy density. However, from birth genetic predispositions are modified by experience and in this context during the early years parents play a particularly important role. Parental style is a critical factor in the development of food preferences. Children are more likely to eat in emotionally positive atmospheres. Siblings, peers and parents can act as role models to encourage the tasting of novel foods. Repeated exposure to initially disliked foods can breakdown resistance. The offering of low-energy-dense foods allows the child to balance energy intake. Restricting access to particular foods increases rather than decreases preference. Forcing a child to eat a food will decrease the liking for that food. Traditionally, educational strategies have typically involved attempts to impart basic nutritional information. Given the limited ability of information to induce changes in behaviour, an alternative strategy would be to teach parents about child development in the hope that an understanding of the characteristic innate tendencies and developmental stages can be used to teach healthy food preferences.
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Introduction

As weight gain occurs when the intake of energy exceeds its use, an understanding of the origin of food preferences is essential if advice is to be offered that leads to the control of weight. In the last 20 years, the incidence of obesity has increased markedly in both children and adults. One approach to this problem is to consider the development of food preferences in the young, in the hope that healthy patterns of eating can be encouraged and that dietary patterns established in childhood carry on into adulthood. An obvious implication of attempting to encourage healthy eating at an early age is that the parent inevitably has a key role. The role that parents play in the development of a child's food preferences is reviewed to distinguish beneficial and unhelpful behaviour.

It is estimated that about 7% of the entire population of the world is obese. Over a third of all Americans have a body mass index (BMI) greater than 27, and 1% are severely obese having a BMI over 40 kg/m^2.[1] Such is the rate of the increase in the prevalence of obesity that it is often associated with words such as 'epidemic'. In the UK,[2] children were measured when aged 7/8 y and again after 1 and 2 y. There was a noticeable increase in obesity over that time so that one in five was overweight at 9 y and one in three at 10 y of age. From 1974 to 1984, the incidence of obesity and overweight changed little in British children. However, from 1984 to 1994, the rate for English boys increased from 5.4 to 9.0% and for English girls from 9.3 to 13.5%, with a larger increase being found in Scotland.[3]

In the Bogalusa Heart study, the development of atherosclerotic plaques and the associated cardiovascular risk were reported to have already begun to develop in young adults.[4] A particularly worrying finding has been a marked increase

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in the incidence of type II diabetes in children and adolescents,[5] a disorder associated with obesity. Syndrome X consists of a constellation of risks including visceral fat, insulin resistance, dyslipidemia and hypertension. The presence of visceral fat has been found in children as young as 6–7 y.[6]

The American Dietetic Association[7] recommended a three prone attack on obesity: health promotion; the appraisal and reduction of risk factors; the treatment and rehabilitation of those already obese. Potentially, parents have a role in all three of these aims. The parental influence is particularly important given the increased risk of becoming an obese adult if you are overweight as a child. In considering the development of food preferences, we must consider initially the underlying genetic predisposition and then explore the ways in which early learning influences these predispositions. How does the environment allow the expression of a genetic predisposition? In particular, how can parents encourage the development of a beneficial dietary style?

Genetic predispositions

It is well documented that overweight children are more likely to have overweight rather than underweight parents,[8,9] an association that reflects both genetic and environmental influences. Behaviour genetic analyses have concluded that genetic similarity explains about 50–90% of the phenotypic variation in the adiposity of members of a family.[10,11] However, the nature of the conclusions of the behaviour genetic approach must be kept in mind. The findings do not reflect a fixed relationship; rather the findings are a snapshot of a particular group, at a particular time that live in a particular way. Rather than reflecting an inevitable importance of genetics, a high heritability score may simply reflect a limited variation in the environment. For example, if the majority eat a very similar diet, then the impact of that environmental feature will be limited. Factors such as watching television, using cars and labour saving devises in the home all reduce energy expenditure; however, as they are the norm, they have a limited ability to explain variation in weight. The findings of behaviour genetics do not preclude a very large environmental impact in the future if new effective strategies are developed and selectively followed.

An important question is the nature of gene environment interaction and the extent to which those with a genetic predisposition to become overweight seek particular environments, for example a high intake of fat. It has been noted that little is known about the environment and the patterns of behaviour that interact with a genetic predisposition;[12] the environmental factors that allow for the expression of genes that predispose to adiposity need to be established. Studies have tended to examine variables such as the BMI rather than mediating behaviour; there have been few attempts to consider the genetic bases of most obesity-associated behaviour.

An obvious prediction, with the description of the human genome, is that the study of the interaction between specific genes and environment will remain a hot topic. Perusse and Chagnon[13] reported 28 genes or chromosomal regions that were linked with body fat or its distribution. As the function of all genes is discovered, this list is likely to grow. Those with a genetic tendency to gain weight are likely to select particular environments, for example one associated with a high fat intake or low activity. A major challenge is to understand those family environments that, when they interact with a genetic predisposition, promote childhood obesity.

Innate taste preferences

Based on the examination of the facial expression of newly born human infants, there appears to be an innate preference for sweet and salty flavours and for the avoidance of bitter and sour tastes.[14,15] Such preferences have been hypothesized to reflect an evolutionary background where sweetness predicts a source of energy, whereas bitterness predicts toxicity. In contrast to adults, children typically prefer sweeter tastes, they have a strong liking for sweetness and a dislike of bitter tastes. They also eat more of the foods they like best.[16] A preference for sweetness and sugar intake are both lower in the adult rather than the adolescent.[17]

At the start of life, food preferences are at least partially influenced by biologically generated internal cues. The ingesting of a sweet drink leads to the release of endorphins.[18] Adults often report an optimal sucrose concentration that is viewed most favourably, that is it is possible for a food to be too sweet. In contrast, a child selects the most intensely sweet solution available.[19] There is strong evidence that inbred strains of mice show differences in their preference for sweet carbohydrates, although it cannot be assumed that this would generalize to other types of carbohydrate. Two single genes have been described in mice that influence the preference for a sweet taste,[20] and although less researched there is evidence for genes influencing fat preference. Care should, however, be taken in extrapolating from these findings; an attraction for sweetness and obesity are not necessarily associated. Hill and Prentice[21] found that diets high in fat rather than carbohydrate were more likely to result in obesity; a finding typical of many epidemiological studies that report an inverse relationship between the intake of sugar and fat. A high intake of fat was positively associated with indices of obesity, whereas a high intake of carbohydrate was negatively related. In this respect, no differences were found when simple as opposed to complex carbohydrate were considered.

An adverse facial expression in response to either a sour or a bitter taste is present at birth, although an inhibition of the intake of bitter tasting food occurs later.[22] Sensitivity to bitter taste is a heritable trait and those who taste and do not

taste phenylthiocarbamide (PTC) or 6-*n*-propylthiouracil (PROP) have been distinguished. Throughout life the ability to taste these substances is associated with food preferences. It has been reported that PROP tasters are more likely to reject the bitter compounds found in cabbage, broccoli, Brussel sprouts, beer and coffee.[23] Individuals who perceive PROP as extremely bitter are more sensitive to sweet tastes[24] and the texture of fat.[25] There is genetic variation; about 70% of the population are tasters of PROP and have more fungiform papillae on their tongues. PROP tasters are more likely to dislike a sweet taste and are more sensitive to the bitter taste of caffeine and quinine.

At birth, salt neither produces a distinctive facial expression or a greater intake of water, although by 4 months a preference for a salty taste develops.[26] In a similar manner to sweetness, children compared with adults prefer a stronger salt taste. Mothers who during pregnancy suffered with morning sickness, and were presumably dehydrated, produced children with a higher preference for salt.[27]

With any consideration of basic taste preferences, it should be remembered that the taste of food is only one factor and in addition a combination of visual, olfactory and tactile stimuli are important. A task for the coming years is to identify genetic markers that will facilitate our understanding of genetic predispositions that interact with dietary experiences and environmental events to produce patterns of eating.

Macronutrient intake

A study of twins demonstrated a genetic role in the intake of specific macronutrients, daily caloric intake and meal frequency.[28] Heritability in part accounted for the intake of carbohydrate (64%), fat (47%) and protein (58%). It appears that there is a genetic contribution not only to the size of a meal but also to its nature. This study found no influence for the shared environment, for example the family. The author pointed out that this finding did not conflict with reports that the family has an influence. The actual food items consumed will vary from family to family, but they will tend to result in a pattern of macronutrient intake associated with genetic predisposition. A related analysis demonstrated a genetic tendency to consume alcohol, soda, milk and coffee, whereas the intake of diet soda and fruit juice was influenced by a common family environment.[29] Faith *et al*[30] reported that 24–33% of the variance in energy intake in a laboratory study, using monozygotic and dizygotic twins, could be explained by genetic influences.

A review that considered the heritable contribution to food preferences concluded that the selection of macronutrients was, in part, heritable.[20] Genes that mediate the consumption of sweet-tasting carbohydrates have been isolated and a preference for fat or protein is to a lesser extent genetically determined.

When a wide range of particular food items has been considered, the conclusion has been generally that the heritable component is low. There are isolated reports that a liking for some food items, for example spicy foods, orange juice and sugar in tea and coffee, have a genetic background but this was a very small proportion of the number of foods considered.[20] It seems that a preference for particular foods is largely a reflection of cultural background and individual experience.

Neophobia

The tendency to reject novel foods has been termed neophobia (fear of the new) and is particularly marked from about 18 to 24 months of age. Even children who have been good eaters often begin to reject new foods at this stage. Such a response can easily be seen as having evolutionary importance if it discourages the consumption of items that might be poisonous at the stage when the child is begining to walk, as such the tendency has survival value. Parents need to understand that neophobia is normal and it is unnecessary to assume that their child is a poor eater. Neophobia is a powerful influence in both humans and other omnivorous animals with children tending to be more neophobic than adults,[31,32] and younger children being more neophobic than older children.[33] Neophobia is limited during infancy but increases in early childhood after which it declines becoming minimal in adulthood.

The 1-y olds have been found to refuse a novel food a median of 11 times, although it has been reported to vary from zero to 89 times per meal.[34] In addition, the number of times children refused food varied markedly from meal to meal. It is clear that at the stage of transition from a liquid to a solid diet food refusal occurs commonly.

Gene environment interaction

From birth these innate taste preferences and behavioural tendencies begin to be modified by experience. Rapidly the infant learns which items are considered to be food in their culture and they develop likes and dislikes and understand when, what and how much they should eat. At about 6 months of age, a sole diet of milk is no longer adequate for the human infant, although our understanding of the transition to the consumption of solid foods is limited. There is a three-stage process. Initially, there are biological tendencies to consume pleasant tasting and familiar foods. However, children rapidly begin to learn to associate taste with both the physiological and social consequences of eating. This learning process results in the development of beliefs and attitudes about food that may dominate adult life.

Food acceptance in childhood

The perceived taste of a food is a good indicator of an individual's willingness to try that food. Adults typically state that their choice of food is most often guided by how

food tastes and children, in particular, reject foods based on perceived likes and dislikes.[35] Birch[36,37] found that sweetness and familiarity were the major determinants of the food preferences of young children. Children aged 3–5 y categorized foods according to whether they were familiar and/or sweet.[38] In a Swedish study, the main reason given for a child's dislike was 'distaste' and the major reason for liking was 'good taste'.[33]

It has been proposed that there are four main reasons for rejecting potential food items:[39,40] disgust (grasshopper, urine); danger (liquid soap, dangerous mushrooms); inappropriate (paper, leaf); unacceptable combination (ketchup with cookie). The interviewing of children from 3.5 to 12 y allowed the description of the development of food rejection.[41] Rejection in the youngest children was based on sensory characteristics, in particular taste. At a later age, food began to be rejected on the basis of anticipated dangers. Younger children were unaware of the possibility of the contamination of food. The older children and adults rejected foods based on where it came from or what it was. When children from 1 to 5 y of age were studied,[42] the youngest children tended to accept all items as potential food. The acceptance of dangerous and disgusting items decreased with age. Almost all children accepted combinations of food that would not be accepted by adults. A feature of childhood is learning what to eat and what not to eat.

The range of foods that were liked and disliked by 4 y-old children fell into four groups, vegetables, desserts, meat and fish, and fruit.[43] Liking for foods in one of these groups tended to be independent of liking for foods in the other groups. The authors concluded that food preferences could not simply be explained as a reflection of a simple factor such as sweetness, saltiness or fattiness. The assumption sometimes found in the literature that food preferences reflect a liking for some underlying taste was not supported; rather food preferences reflected a more complex cognitive structure.

Overcoming neophobia

Simple exposure to a novel food item will decrease the neophobic response in both 2-y olds[44] and adults.[45] Although the reports are mixed, it has been found in both infants[46] and students[47] that the consumption of a new food increased the acceptance of similar foods. Although exposure to a novel food is a useful approach, the effect may not be rapid and as many as 10 exposures may be required before a change in liking results.[47] Birch[48] allowed preschool children to observe other children eating the vegetables that the observing children did not like. Older rather than younger children were more effective in persuading children to try new foods and mothers were more effective than strangers.[49] Similarly, observing the mother eating a novel food has been found to make it easier for a child to sample it.[49] Thus, simply offering a role model increased the likelihood that vegetables would be eaten in future.

There is, however, evidence that to obtain significant changes in the food preference of a child, the food must be tasted. When children were allowed to repeated look at or taste novel foods, mere looking was insufficient to produce enhanced taste preferences.[50] It was suggested that a taste preference is established only when a novel taste is not followed by a negative gastrointestinal consequence. Another strategy is to combine a familiar and liked flavour, for example sweetness or tomato ketchup, with a new taste.[51]

Tuorila *et al*[52] gave both novel and familiar foods to adults under three conditions; only visual information, vision and smell, and thirdly vision, smell and taste. Increasing sensory experience increased the liking of familiar foods and decreased the liking of novel foods. However, novel foods that were more like familiar foods were more likely to be viewed positively.[53] They were interested in the acceptance of a novel taste (puréed carrot) by infants who had previously experienced a range of tastes that included many vegetables but not carrot. Exposure to fruit, carrots alone or a variety of vegetables resulted in an increased acceptance of puréed carrot. Those who had been exposed to a variety of vegetables were also more likely to eat another novel food, puréed chicken. The results were interpreted as evidence that familiarity with a variety of flavours increased the acceptance of novel foods. Interestingly, the inherent preference for sweetness did not prevent an experience of fruit increasing the liking of less-preferred vegetables. The implication was that parents should expose their children to a wide variety of tastes to encourage the acceptance of novel foods: that is familiarity with diverse flavours increases the readiness to experience novel tastes.

Given the role of parents in bringing food into the home, they play a major role in determining the foods to which a child is exposed repeatedly. In itself, simple exposure is a major factor in encouraging consumption.

Energy density

Birch and Fisher[54] reviewed the literature on the influence of energy density on the food intake of children. They concluded that when macronutrients were substituted to reduce the energy content of foods, children tended to adjust for the missing energy. The phenomenon is clearest when the carbohydrate content is manipulated to change energy density, although there was also evidence of a compensatory increase in food intake when the fat content had been manipulated. The compensation for a decrease in energy density is not macronutrient specific, that is if the amount of fat in the diet is decreased, there is no tendency to replace fat as such. Thus, the child will attempt to manipulate energy intake to compensate for a previous meal of lower than usual energy density, so that the total energy intake does not fall. However, an attempt to compensate for energy intake may result in a change in the macronutrient composition of the meal, for example the removal of carbohydrate from a meal may result in a subsequent higher intake of fat.

As illustration of these phenomena, Birch[55] gave a preload of either water, aspartame or sucrose to children aged 3 and 5 y. When offered *ad libitum* consumption of a range of foods, there was evidence of calorie compensation. There was also a suppression of intake following aspartame, although this was less than after a carbohydrate preload, demonstrating an effect postabsorption. When the impact was considered of a carbohydrate and fat preload, on the lunch consumed by groups aged 4–6, 18–26 and 61–86 y, the ability to compensate at lunch for the earlier energy intake was observed in all three age groups.[56]

The ability to demonstrate these mechanisms depends on the opportunity to adjust your food intake; with children, parental control may prevent this happening. It has been suggested that without the freedom to respond to the energy density of the meal, the child is deprived of the opportunity to learn to control energy input. Although by restricting intake parents may in the short-term decrease energy input, in the longer term they will tend to produce a child unable to compensate for an energy-dense meal. The attractive high-energy-dense foods that are often offered to children can make it difficult to compensate. Parents could help by offering a range of foods, some of low-energy density.

In adults, the ability to compensate for earlier energy intake is imperfect and is especially poor if the preload is a liquid.[57] Children are better than adults in responding to preloads by adjusting to subsequent intake,[58] although older children, aged 9–10 y, were found to eat a similar lunch irrespective of the preload.[59] It appears that compensation for energy consumed as a liquid can be demonstrated in children aged 4–5 y, but for unknown reasons the effect may disappear with age. At least with older children, parents can help by not giving too many calorie-containing drinks between meals.

As a generalization, infants and young children have the ability to adjust their food intake both across and within meals: in this way, they have the potential to maintain a relatively constant intake of energy. Although there is a tendency for meal size to depend on energy density, and although energy intake varies from meal to meal, given the opportunity by their parents, over time it can tend to average out. In preschool children, the ability to regulate caloric intake, meal to meal, is related to their adiposity. Those less able to regulate caloric intake tend to be heavier.[60] The report that children can be taught to improve their regulation of caloric intake is an important observation.[61] Preschool children were given a drink offering either 3 or 150 kcal, 20 min prior to lunch. The consumption of a smaller lunch after the more caloric drink was taken as evidence of self-regulation. After a 6-week role-play exercise to make them aware of internal cues of hunger and satiety, more children were able to self-regulate and ate less lunch after a caloric drink. Again, parents can help by talking to their child to ensure that they are aware of bodily cues. The instruction to clean the plate is unhelpful.

Learned food preferences

As humans are omnivores, they are genetically predisposed to associate foods with the consequences of eating. There is a readiness to learn to like or dislike foods, depending on the context in which they are eaten and whether they produce a satisfying subjective experience or alternatively discomfort. There is, for example, something satisfying about a high-energy-dense food. When children ate yogurts with novel flavours that varied in their fat content and hence energy density, their preference increased for flavours paired with the high but not low-energy-dense yogurt.[62] The ability of energy density to influence conditioned preferences may contribute to the preference for foods containing high amounts of fat, although a similar phenomenon has been reported with carbohydrate. Thus, flavour and the consequences of a nutrient influence taste preference. The tendency to learn to prefer energy-dense foods can be seen as having been adaptive at times in our history when food was scarce, particularly for young children requiring energy to grow. Today when energy-dense foods are readily available, this tendency predisposes to obesity.

Thus, an association with a high caloric density can create taste preference; we tend to like foods that result in satiety. However, social learning is also known to have a powerful effect. We model our food intake on those around us, particularly those whom we respect. Jansen and Tenney[63] considered the relative importance of these two mechanisms by considering the consumption of novel yoghurt drinks with high or low energy, with and without a teacher who was also drinking and praising the product. A preference for the taste was greatest in those taking the higher energy drink at the same time as the teacher. It was concluded that a preference for energy-rich foods was most easily established in the presence of an important adult. Based on these findings, it is easy to suggest that the observation of a parent eating and enjoying energy-dense foods will potently encourage a child to establish a preference for these foods.

The innate preference for a sweet taste is quickly modified by experience. Infants at birth prefer sweet solutions to water.[64] However, by 6 months, the preference was associated with dietary experience; only those children routinely fed sweetened water, compared with those who did not, showed a greater preference for sweetness. When preschool children were given sweetened, salty or plain tofu, they preferred the version with which they were familiar.[47] The sweetened tofu was preferred only when it came as a familiar food, clearly experience as well as taste was important.

During pregnancy, flavours from the mother's diet enter the amniotic fluid and are swallowed by the foetus. Similarly flavours enter breast milk. Mennella *et al*[65] considered the hypothesis that experience with a flavour, either in womb or via breast milk, would modify acceptance of flavoured foods at weaning. Mothers drank carrot juice during the last trimester of pregnancy and/or the first 2 months of lactation. Infants exposed to carrot juice were more likely than other

babies to enjoy carrots when they tasted them for the first time; they displayed fewer negative facial expressions.

The experience of early feeding has long-term consequences. Mennella and Beauchamp[66] compared the food preferences of 4- and 5-y olds who had consumed infant formulae of different types. Those who had consumed protein hydrolysate rather than milk-based formulae were more likely to prefer sour-flavoured apple juice. Those who had been offered a soy-based formula preferred a bitter-flavoured juice. Mothers reported that children who had consumed soy- or hydrolysate- rather than milk-based formulae had a preference for broccoli. Thus, a diet that had not been consumed for 3–4 y continued to direct taste preference. The authors suggested that there was a sensitive period, between 4 and 5 months, when a hydroysate-based formula would be accepted. By analogy with sensitive periods for other characteristics the effect would be expected to be persistent. In an evolutionary context, it may have been adaptive for taste preferences to be learned during a sensitive period. There may be an advantage for children to accept foods that are eaten by the mother and hence introduced via the amniotic fluid and breast milk. In this way the knowledge that the food is appropriate, nutritious and available can be passed on. It is easy to imagine that this type of early exposure lays the foundation for the acceptance of a culturally determined diet.

In suggesting a role for the experience of preweaning flavours, it should be remembered that it has been difficult to demonstrate the phenomenon, although the consumption of different types of formulae offers a novel means of considering the phenomenon. Babies who have been breast-fed have been found to consume significantly more of a novel solid food when it was presented at weaning.[67] An explanation for this finding is that breast-fed babies have been subjected to a wider range of flavours dissolved in the milk and hence are more accepting of a novel taste.

The ability to learn an association between a food and negative consequences is well described. In rats, taste rather than a light or sound can be readily associated with feeling sick; that is a food aversion can be created.[68] There appeared to a genetically determined relationship between taste and adverse intestinal reactions. Taste aversions can be acquired by a single trial when the illness occurs as much as 24 h after food consumption. It is ethically more difficult to run similar studies in humans and most data have come from retrospective questionnaires. However, humans appear to acquire taste aversions in the same way as rats.[69] Food aversions are common; a group of 517 students reported 415 taste aversions. They are strong and often last for decades, during which the food is not consumed.[69] It is an obvious suggestion that the frequency with which young children are ill may lead to the development of food aversions, as illness will be associated with recently consumed food. It has been reported that children undergoing chemotherapy formed aversions to foods presented after treatment.[70] As children's diets are more limited, learnt food aversions have the potential to play a more important role, particularly in children with a history of illness.

Parental style

Parents often have a policy of manipulating the availability of certain foods, either for a perceived health gain or alternatively as a reward or punishment. The question is whether such approaches achieve their intended consequences?

Food as a reward

The offering of one food as a reward for the eating of another is a common strategy; 'unless you eat up your vegetables you will not have any dessert'. The pattern is clear. The preference for the food used as the reward increases and there is a decrease in the preference for the distasteful food.[71] Birch *et al*[72] found that when children were rewarded for eating a disliked food this lead to a decline in the preference for that food. Rather than increasing the likelihood that a desirable food was consumed the approach had the opposite effect, it became more unlikely that the child ate the food. It is not helpful to use a food that is initially disliked, in a negative context, to gain access to something pleasurable.

Foods are sometimes paired with parental attention and rewards. When children were offered food items that were initially neither liked nor disliked, but were then used as rewards over a 6-week period or associated with parental attention, the liking for these foods increased.[73] It is easy to generalize this finding to real-life situations. High fat and sweet items such as chocolate are used repeatedly in positive contexts, for example they are given to those who we like, on special occasions or to say thank you. The consumption of already pleasurable items is in this way reinforced. If children are given foods as rewards for approved behaviour, the preference for those foods is enhanced.[73]

Emotional climate

The emotional atmosphere of a meal has been found to be influential. When real-life situations were observed, the making of negative statements about the child, by the parent, was associated with lower food consumption. Similarly, a more positive atmosphere led to greater food consumption.[74] More encouragement to eat has been correlated with the weight of the child.[75] The preference for food eaten in a positive atmosphere tends to increase, whereas the preference declines when the atmosphere is negative. Casey and Rozin[76] found that parents encouraged their child's eating by indicating that they liked the food and involving them in its preparation.

The message for parents is that if you wish to encourage your child to eat a particular item then it is counter-productive to complain if the food is not eaten, the

negativity will decrease rather than increase the probability of future consumption.

Parental rather than child-centred approach

Parents wishing to prevent their children becoming overweight may limit access to food.[77] Although well-intentioned behaviour, and intuitively sensible, the counterargument is that the behaviour may prevent the child from learning to regulate their own food intake. The evidence tends to support the latter argument.

In a laboratory study, preschool children were found to be less able to regulate their food intake, after a high calorie preload, if their parents reported greater control over food intake. In this study, those young girls who were allowed by their parents to regulate their own intake were lighter than those whose parents took that role.[60] The importance of allowing a child to control food intake was supported in a study of 5-y-old girls and their mothers.[78] The dietary restraint of the mother was related to the ability of the 5-y-old daughter to adjust her energy intake after an energy preload. The offspring of mothers with high dietary restraint also ate a greater number of palatable snacks after lunch, when they were not hungry. It appeared that the mothers attempt to restrain her own weight was being transmitted to the daughter, who in turn was failing to learn to control her own intake.

Lee *et al*[79] compared 5-y-old girls who consumed more or less than 30% of their energy as fat. Both the restriction of access to food by the mother, and a pressure to eat (eg finish food on plate), were associated with a higher intake of fat. Another unintended consequence of creating a pressure to eat, or restricting access to foods, is that it directs attention away from internal cues of hunger and fullness. Saelens *et al*[80] considered pairs of siblings where one was, and one was not, obese, predicting that there should be more parental control of the obese child. The study of 18 families failed to find a difference in parental behaviour towards the obese child. It is unclear to what extent the choice of an age range from 7 to 12 y may have influenced these findings.

Wardle *et al*[81] looked at the feeding styles of families in which parents either were, or were not, obese. Obese mothers were not more likely to offer food to deal with emotional stress, use food as a reward or encourage children to eat more than they wanted. The study failed to support the stereotype of an obese mother who gives food to her child for purposes other than nutrition and thus encourages childhood obesity. Obviously, cultural differences exist and it may not be possible to generalize such findings to other groups. When focus groups were used to explore the feeding practices of a sample of low-income American mothers, a different pattern resulted.[82] Mothers believed that heavy weight was the best marker of a healthy baby. They worried that the child was not getting enough to eat so they introduced solid foods earlier than recommended. Food was used to reward good behaviour and calm the child. Rather than physicians, the grandmother was the main source of information. It is likely that the behaviour of the mother, although well intentioned, was interfering with the development of the child's ability to regulate their own food intake.

Conclusion about parental behaviour

The many reported correlations between the behaviour of the mother and the adiposity of the child has lead to the view that we should be concentrating on styles of feeding the child, rather than on nutrition.[79] The correlation between parental behaviour and the child's adiposity does not, however, demonstrate a causal relationship. It is possible that the behaviour of the parent may be a response to the existing weight of the child. It should be remembered that any correlation between the child feeding practices of the parent, and the child's weight, might be in part at least a response by the parents to a pre-existing problem of obesity. There is an urgent need for a prospective study that relates the degree of parental control at an early age to the subsequent weight gain of the child.

The take home message from these studies is that we need to consider the impact made by parental child-feeding practices on the eating pattern of the child. There is a need to consider the degree of parental control. The message should not be to totally abandon any control but rather to avoid overcontrol. Children need guidance, for example the provision of a range of low-energy-dense foods, although if guidance reaches rigid prescription then it has gone too far.

Cultural influences

Probably the single best predictor of food preferences is knowledge of the cultural group to which you belong. Nicklas *et al*[83] suggested a range of cultural changes that were important in encouraging overeating. 'Grazing' rather than eating meals and the desire for convenience foods are increasingly common with an associated decrease in cooking skills. Fewer meals are eaten in the home and fewer meals are eaten as a family group, decreasing the opportunity for the parents to offer a model of healthy eating. In America, 46% of food expenditure is spent on food consumed outside the home, with 34% of the food expenditure on fast foods.[84] American adolescents consumed 27–30% of their meals away from home, with 18% as a comparable figure for preschoolers. Fast-food restaurants accounted for more than half of these meals.[85] In American adolescents, the frequency of using fast-food restaurants was positively associated with total energy intake and the per cent of energy coming from fat: it was also negatively associated with the consumption of fruit and vegetables.[86]

A related problem is that meals eaten outside the home tend to have a higher energy density and are served in large

portion sizes. The American experience is striking. Between 1957 and 1997, the portion size for a hamburger increased from one to 6 oz of meat; a soda increased from eight to 32 or 64 oz; a typical muffin increased from one and a half to 5–8 oz; a serving of popcorn increased from three to 16 cups.[84] When presented with larger portion sizes, 5- but not 3-y-old children have been found to eat more.[87]

Particularly with adolescents, eating dinner with the family is a less frequent phenomenon. Gillman *et al*[88] reported that those eating more often as a family consumed more fruit and vegetables and less fat. Systematic differences in the diets of American children are related to the frequency that they watch television while eating.[89] The frequent watching of television during a meal was associated with 5% more of their energy intake coming in the form of pizza, salty snacks and soda and 5% less from fruit, vegetables and juices. The watching of television was associated with a lower consumption of carbohydrate and a greater consumption of caffeine. Many factors may potentially lead to this association. Those watching television will be exposed to more advertising, but it may also encourage the eating of quickly prepared snack-foods rather than more elaborate meals. Parents whose children watch more television tended to choose foods that were easy to prepare because the children ate them without complaining. There was evidence that the watching of television was associated with the eating of some foods that were not normally advertised, suggesting that this activity is a marker for parental attitudes to the provision of their children's meals.

Clearly over recent decades, there have been marked cultural changes in the nature and patterning of meals, where and with whom they are eaten. Each change brings with it implications for the diet.

Concern with weight

More than 50% of British teenage girls want to lose weight as they feel too fat, although fewer boys have similar feelings.[90] The age at which such concerns begin has been getting younger. Hill *et al*[91] found 41% of 9-y-old girls would have preferred to be slimmer. It is not difficult to find girls of an even younger age that would make similar comments; this was true of 9% of a sample of 5-y-old American girls.[92]

A similar pattern of nutrient intake has been found in mothers and daughters.[79,93–95] Mothers may be acting as a model for their daughter and they may select their food from the same sources; alternatively, there may be a common genetic predisposition. The thin ideal body shape current in western societies is clearly an important factor. For example, a survey of the centre-fold models in Playboy magazine during the last 20 y found 70% to be clinically underweight, as judged by the BMI.[96] Dissatisfaction with your body has been associated with unhealthy weight loss, a strategy that may stunt growth, delay puberty, cause malnutrition, low self-esteem or eating disorders.

Obesity

Dietary preferences

Prentice and Jebb[97] concluded that epidemiological analysis suggested a modest, although inconclusive, association between obesity and the consumption of a high-fat/low-carbohydrate diet. A great many human studies have considered whether obese individuals prefer sweet-tasting foods or have a different threshold for sweetness. The majority of studies have failed to find differences between the obese and nonobese.[97–100] The optimally sweet taste varies between individuals: the preferred taste can either increase or decrease with increasing sweetness, in others the relationship is in the form of an inverted U.[101]

The preference for fatty foods in children aged 3–5 y has been found to predict skin-fold thickness, an index of adiposity.[102] In children of this age, food preference was associated with intake. Several studies have found an association between overweight children and a higher proportion of energy consumed in the form of fat.[102,103] Longitudinal studies are particularly informative, for example Klesges *et al*[104] reported that children consuming a higher intake of fat had a greater BMI 3 y later. Overall, there is growing evidence of an association between the percentage of energy consumed as fat and being overweight in children. In addition, several lines of evidence implicate protein intake and adiposity in young children. A study of the consumption of isoenergetic formulae, high or low in protein, found that the intake of low levels of protein resulted in rates of growth more similar to breast-fed babies.[105]

Discussion

Traditionally, educational strategies have almost inevitably involved the attempt to impart nutritional information, typically to eat less fat and more fruit and vegetables. For example, Weker *et al*,[106] in a paper entitled 'Models of feeding for healthy children', made a series of points such as children should avoid products rich in fat, sugar, salt and cholesterol. Although it is an approach that is typical of much of health education, and may be viewed as being valid in its own terms, for many non-scientists it misses the point. These types of data are important to a physiologist, but irrelevant to life as most people live it. The objective of health education is to change behaviour, however, the giving of bald information often has little if any impact on what people do. The vast majority of those who smoke are well aware that it is bad for your health but this does not lead to abstinence. It is a basic psychological finding that there is no necessary relationship between knowledge, attitudes and behaviour. It can be argued that any attempt to improve the diet of at least young children needs to acknowledge the psychological predispositions of the child and to use the family to inculcate food preferences and eating patterns. To a large extent, the suggested approach acknowledges

biological predispositions and emotional reactions rather than knowledge and rational choice. We should be aiming to establish in the first place healthy attitudes, rather than simply giving information to try change inappropriate behaviour that has been formed previously. In the early stages a key role is played by the parents, who need to understand the implication of their behaviour for the development of the eating pattern of their child.

If a strategy of instructing the parent how to teach healthy eating patterns is to work in the longer term, then there must be a consistency of food preferences from childhood to adulthood. Does childhood food intake predict later diet? Data relating eating patterns in childhood to disease in later life are very limited. The Bogalusa Heart Study offers some data. At 10 y of age, more fruit, fruit juices, desserts, bread, candy and milk were consumed than in young adulthood. On the other hand, young adults rather than children were more likely to consume cheese, seafood, snacks, beef and more sweetened drinks. At the individual level, over time there was evidence of a consistency of food preference, in particular, for the intake of bread/grains, vegetables, seafoods, eggs and sweetened drinks.[107] The evidence of consistency over time suggests the need to promote a healthy diet in young children in the hope that these dietary preferences continue into adulthood. There is a general preference for sweetness that persists from childhood to old age, although there is consistent evidence that children prefer higher sucrose concentrations than adults.

When a cohort of American children was monitored from third to eight grade, systematic changes in dietary behaviour were observed.[108] With age the consumption of breakfast, fruit and vegetables declined. Over the period, the consumption of soft drinks increased three-fold with a corresponding decline in the drinking of fruit juice and milk. The transition from being a child to being an adult is associated with a reduced preference for sweet items, lower sugar consumption and a diet of a lower energy density. With age bitter tastes are more accepted and there tends to be a greater preference for vegetables and fruit. The energy density of the diet peaks at 5 kJ (1.2 kCal)/g in adolescence with a low of 3.1 kJ (0.75 kcal)/g in older adult women.[109] Older women eat less fat and more fibre suggesting a greater fruit and vegetable consumption. Drewnowski[109] suggested that it was plausible that with age sensory factors mediate changes in food preference. However, although food preferences change gradually with age, there is consistency. Although not all overweight adults were overweight children, there is a higher risk that children who were overweight will become obese adults.[110] Children obese at ages 1–6 were twice as likely to be obese at 35 y, whereas those obese at ages 10–14 had a five- to 10-fold increase in the risk of obesity.[111]

Thus, it is proposed that an alternative strategy to trying to give children nutritional knowledge would be to convey psychological knowledge to parents so that they can teach appropriate dietary skills. Although it is natural to see the parent as a key figure, from the above description of the literature it is apparent that many of the obvious and commonly used parental strategies, which aim to encourage healthy eating, have an effect opposite to that intended. With younger children, strategies based on the principles listed in Table 1 offer the means of encouraging the growth of a slimmer and healthier child. Information about weaning could be added to prenatal classes, although if made available at the time of weaning it is likely to have a greater impact.

Table 1 Advice for parents wishing to encourage healthy eating

- The emotional atmosphere of the meal is important. Do not use meal times as the opportunity to chastise and do not let a child's failure to eat cause unpleasantness.
- Siblings, peers and parents can act as role models to encourage the tasting of novel foods.
- The child should be exposed to a range of foods, tastes and textures.
- Repeated exposure to initially disliked foods can breakdown resistance.
- The offering of a range of low-energy-dense foods allows the child to balance energy intake.
- Restricting access to particular foods increases rather than decreases preference for and consumption of that food.
- Forcing a child to eat a food will decrease the liking of that food. Neophobia is to be expected and should not be allowed to generate negativity.
- Encourage the child to be aware of satiety cues and allow these to define how much is eaten. If you wish a plate to be cleared, then allow the child to dictate the quantity placed on it or give a series of small servings until no more is needed.
- Parents should be careful that high-energy-density foods are not used as rewards and treats.

There is, however, a risk that the teaching of healthy eating patterns becomes another cause of worry and guilt in an already pressurized parent. Important although parents are, particularly with younger children, it should be expected and accepted that their importance declines with time. In considering the development of food preferences, it should be recalled that liking a food is only one factor that influences nutrient intake. Although of considerable importance in childhood, the opportunity to eat the preferred food is critical and with advancing age a multitude of other factors, external to the home, become important. While the family is undoubtedly important, it should be kept in mind that there is a larger societal context. Parents have their own time demands, dining out is increasingly common, the media systematically generate messages for their own purposes. In older girls, in particular, the drive to be thin is pervasive with the associated tendency to diet. The understanding of the origins of food choice requires the consideration of at least four factors; individual, interpersonal, psychosocial and biological influences. The physical environmental also plays a part; for example the nature of schools and provision of fast-food outlets.

Much of the above description of the impact of parental behaviour reflects a limited literature. We await systematic data that consider the role of parents as the child grows older and is increasingly influenced by external events. Although

the data with younger children have been collected in a systematic manner, typically the studies have been small scale, carried out almost exclusively on white Americans and sometimes with a highly selected sample. It is unclear to what extent the findings generalize to other populations. Robinson *et al*[112] studied 792 8–9-y-old children from a diversity of backgrounds. A complex association between the behaviour of parents and children's weight was found. In fact in girls, but not boys, increased parental control was associated with a lower and not as previously reported a higher BMI. A possible reason for the failure to replicate the findings is the age of the children. In general, children 3–5 y are likely to be under the influence of the parents. As children get older, parental controls tend to relax in many although not all cases. Thus at an older age where parents are still exerting considerable control over eating, this might be expected to decrease food consumption and influence weight.

In conclusion, it is clear that learning plays the major role in the development of a child's eating behaviour—it follows that the parent inevitably plays an important role. It is reasonable to suggest that the role can either lay the foundations of obesity or alternatively develop a healthier pattern of eating with enormous implications for health. The data on the topic increasingly suggest that some common-sense parental strategies are counterproductive in that they tend to produce an effect on healthy eating opposite to that intended. To date, there has been no systematic attempt to use the suggested approach of changing parental behaviour as an intervention to discourage the development of childhood obesity.

The major conclusion is that there is a need for further studies that experimentally consider whether teaching the parent how to feed their child might discourage obesity. Lessons on how to feed a child could be added to prenatal classes. However, until the impact of such lessons has been systematically evaluated, such an approach remains only a novel and unevaluated suggestion, albeit one that is rationally based and plausible.

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