Weaning Practices And Later Obesity

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In recent years many studies have correlated the nutrition of the first one thousand days of life to the development of non-communicable diseases and in particular to the development of obesity (1-4).

This hypothesis therefore radically shifts the goals of dietary recommendations for six months old infants from promoting growth in the short term within the limits of the reference curves and preventing any nutritional deficiency, to a state of optimal health in adult life. In this new spirit, the infant and early childhood nutrition would play a very important role as a factor of prevention at no cost in counteracting the epidemic of paediatric obesity.

When speaking of long term effects of early nutrition "programming" has to be differentiated from "tracking", even though both phenomena can be brought back to a common root of epigenetic changes.

Programming is a general process whereby a stimulus or insult at a critical period of development has a lasting or lifelong impact (5).

A high intake of protein during the first 2 years of age leading to an increased production of the insulin-like growth factor 1 (IGF-1) is an example of such programming in obesity development (6).
Tracking is a different phenomenon, in which the stimulus doesn't act during a specific critical period of risk, but consists of a dietary pattern starting in infancy, the negative effects of which on a specific disease may be due to repeated exposure. An example of tracking is the way a high salt intake starting during infancy and lasting beyond it may increase blood pressure and lead to hypertension.

Challenges of researches

Most studies have focused on the role of breastfeeding versus formula feeding (7,8) as well as of an early rapid weight gain in favouring obesity development (9).

Few studies, however, have focused on the role of complementary feeding (CF) in promoting long term health or favouring the development of obesity, even though CF represents the main source of calories and nutrients already by the end of the first year of life.

One of the commonest reasons given as an explanation for the lack of research on the long-term effects of CF is the huge difference among countries on the foods used during the CF period and the great importance of the cultural roots on weaning patterns.

However, if nutrients and calories are considered instead of foods, the differences among countries on the different CF patterns are much reduced.

Researches aiming at demonstrating the link between an unhealthy CF and the development of later obesity face several challenges such as the lack of randomized trials in human populations, the long latency period between exposure and health effects, the extrapolation of the effects of a single nutrient from the rest of the diet, the differences in food composition over time, and, last but not least, the retrospective studies' limitation of recall process (10). Ethical issues and the length of the duration of observation that may negatively influence the results are the major limits to such studies.

Randomized trials on infants are often non-ethical. As a consequence, most information derives from observational studies or has been extrapolated from data obtained either from older children or from experimental studies on animals.

The long interval between the time at which a specific factor starts influencing the nutritional status and its long-term effects in adulthood makes the assessment of its contribution a difficult task since many other confounding factors may intervene. In addition, the longer the period of time before the recall in a retrospective study, the bigger will be the bias.

The evolution in baby food composition is another but not less important bias: several changes were introduced slowly over time and patchily among different companies and across countries leading to very different compositions. These modifications obviously limits the correct analysis of long-term effects of baby foods on health issues.

Finally, extrapolating the effects of a nutrient from the rest of the diet is a hard and risky task. When comparing the effects of two isocaloric diets, reducing/increasing the amount of a specific nutrient in a sample will necessarily causes a compensatory change of at least another nutrient. This new balance makes it hard to differentiate or to isolate the role of that specific nutrient: its effects could be increased or reduced by the influence of other nutrients present in the diet, or the effects could be totally due to the new setup of nutrients.

However, these difficulties should not discourage scientists from leading further research studies, as other scientists have experienced the same difficulties 40 years ago when the challenge was to understand the relationship between early defective malnutrition and brain development (11). While obesity has become

a real epidemic all over the world, any ethical action that may counteract its further spreading has to be undertaken.

Complementary feeding is thought by many authors to influence later obesity development through several mechanisms, including the age when solid foods are offered, the excess of calories intake, the excessive or insufficient intake of specific nutrients, the quality of specific nutrients, the development of eating habits, and so on.

Early introduction of solid foods.

In the 80s AAP and ESPGHAN nutrition committees had already evidenced that the early introduction of solid foods (< 4 months) caused excessive weight gain (12,13). More recently, other observational studies have found that early solid foods introduction is positively associated with obesity in preschool children (14,15). This is especially true in formula-fed infants (16). However, other studies failed to confirm the association between early introduction of solid foods and development of obesity during childhood (17-19).
Studies have shown the effects of early solid foods introduction at different ages. A cohort study did not show a relation between early introduction of solid foods (<15 weeks) and children's weight at 2 years of age (20), but found a correlation at a later age, when children were 7 years old (21).

The study with the longest interval between solid foods introduction and obesity was published in 2010 and showed that children, born in the late 50s and who introduced solid foods late, showed a lower BMI at the age of 42 y. No effect related to the age of introduction of CF was seen earlier in life (22). These results, however, could have been strongly influenced by a very different baby food composition during the early 60s.

Two systematic reviews recently conclude that a clear association between the timing of the introduction of complementary foods and childhood overweight or obesity is lacking (23,24). However there is some evidence that the very early introduction of CF (at or before 4 months), rather than at 4-6 months or >6 months, may increase the risk of childhood overweight.

In conclusion, even though the evidence of an association between early introduction of solid foods and obesity in later ages is weak, keeping a prudent attitude and starting solid foods introduction around 6

months of age can only enhance potential short and long term general health benefits.

Role of nutrients from complementary feeding in promoting obesity development.

The role of nutrients in promoting obesity development in later ages has to be approached in terms of both quantity and quality.

The exact composition of human milk is difficult to assess since it varies over time in a given mother and among women. In all cases, it markedly differs from formula composition, hence the effects of complementary foods should be differentiated according to the milk source. Rephrasing it, lack of differentiation of CF patterns according to the milk source would assume that breastfeeding and formula-feeding are interchangeable, that, clearly, is not true. Official recommendations, however, do not advice, yet, to differentiate complementary foods introduction whether the infant is breastfed or formula fed. Nonetheless, the confounding factor represented by human milk vs. formula and their nutritional differences have to be taken into account when trying to analyze the role of nutrients in promoting obesity.

Proteins.

Generally speaking, infants living in developed countries face a notable increase in protein intake when starting a complementary feeding.

The first study showing a correlation between protein intake in infancy and obesity in later age was published 20 years ago. In this cohort study, a high protein intake at 24 months (>18% of total energy intake) was correlated to an early adiposity rebound. (25). Since then several longitudinal studies confirmed these results. Scaglioni and co-workers, using a 24 hours recall, showed a correlation between a high protein intake at one year (22% vs. 20%) and overweight status at 5 years of age (26). Gunther and co-workers, on the sample of children participating to the DONALD study, showed that a high protein intake at 12 months and between 18 and 24 months of age was correlated to a higher BMI Z-score and fat mass percentage at 7 years (27). Ohlund and co-workers found that protein intakes at 17-18 months and at 4 years were independent contributing factors to a higher BMI at 4 years of age, in a sample of 127 children (28). However, other studies did not confirm these findings. Dorosty and co-workers did not

find any correlation between protein intake at 8 and 18 months of age and BMI in a cohort of almost 900 children participating to the ALSPAC study (29). The total sample, however, showed a remarkable homogeneity in protein intake, which was below 17%, lower than the level (> 18%) at which an early adiposity rebound seemed to be facilitated, according to Rolland-Cachera (25).
No correlation was found either by Hoppe and co-workers in 143 children born in 1987-1988 the energy and protein intakes of which were accurately measured at nine months of life. BMI or body fat mass were checked at that same age and at ten years of age (30).
However, all mentioned studies evaluated the quantitative aspects of protein intake while the qualitative ones were seldom taken into account. The appropriateness of such an approach is at least questionable. Whereas the functional and qualitative specificities of human milk proteins are always mentioned in order to explain the protective effects of breastfeeding, the diverse properties, compositions, and functions of the proteins in formulas and baby foods are essentially ignored.

Therefore, the controversial results of these different studies may be explained by the use, in the daily diet of the infants, of foods with different protein compositions (milk / meat / vegetables / legumes), especially if given in different proportions, according to the actual eating habits in each country.

This criticisms makes especially sense, since the few studies published show that high intake of protein from milk and dairy products origin only are likely to be associated with an increased fat mass at different ages, whereas protein of meat and vegetables origin does not seem to play a significant role (31-33).
The correlation between protein intake and subsequent increase in BMI seems to be mediated by an increase in IGF-1 synthesis (34).

In summary, high protein intake in infancy, and particularly high dairy protein intake, seems to be associated with the risk of developing obesity later on, but further research is needed to better clarify the nature of this association (35).

Fats.

The relationship between fat during CF period and obesity development is even more controversial than that with proteins. According to several Scientific Institutions, fat intake should decrease from 40-60% of total energy intake at 6 months to about 35% at 24 months, and 25-30% after 4 years of age (36,37).

Data from the STRIP study, launched in 1989 in Finland, where the rate of coronary heart disease

mortality is one of the highest in the world (38), affirms that a strong reduction of fat intake (to 25-30% of the total daily energy intake with a correct unsaturated/saturated fat ratio) from 7 months of age onward is protective against cardiovascular diseases especially in boys, as compared with a control group with no reduction of fat intake (39,40). The two groups did not show any difference in BMI at any age up to 18 years (39). Although interesting, this data originate from a country with a specific epidemiological situation. Confirmation by studies performed in other countries facing different epidemiological backgrounds is therefore highly needed.

As a matter of fact, other studies, mainly produced by a French group bring different information. A cohort already studied to evaluate the role of a high protein intake in causing an early adiposity rebound, was followed up to 20 years of age. A low fat intake at two years of age was found to be associated with an increased fat mass, mostly located at the trunk level in adults (41). The authors acknowledge some weakness of the study such as the small sample size and the significantly high drop-out, both of which could have influenced the final results. In spite of these limitations, they underline that obesity is present in adults from both developed and developing countries. Whereas a high protein intake is reported only for young children from developed countries, a low fat intake is shown in both settings (42,43). The authors conclude that a significant fat restriction in the first two years of life could promote the susceptibility to obesity development when the child is exposed to a high-fat diet later in life (44).

This apparently conflicting information doesn't allow to draw a unique conclusion about the role of low or high fat intake in the first 2 years of age in promoting obesity at a later age. However, common sense would suggest to avoid both exceeding or reducing the fat content of the diet during the first 3 years of age. Following the route already built by nature and culture and reducing slowly the fat intake of children as advised by FAO is likely to be much safer (36).

Carbohydrates.

Little information is available on the role of carbohydrates during the first two years of life in relation to the development of obesity at a later age.

This scarcity of information is partly due to the wide variety of definitions used to describe the intake of carbohydrates (complex and simple sugars). Analyzing of foods carbohydrates content by using different techniques leads to the different values quoted in food composition databases. Last but not least, the number of studies performed in infants and toddlers is very limited. All these obstacles make the

comparison of the results from different researches difficult.

Unlike the studies about protein and fat intakes, the limited researches on total carbohydrates intake do not reveal any clear positive or negative association with the development of obesity in that age range. Given the very different metabolic behaviour of starch, oligosaccharides and simple sugars, the analysis has to address individually each one of these subgroups. Actually, most researches in this field are addressed to fibres and simple sugars (sucrose, glucose, fructose).

Fibres.

Fibre intake is thought to positively contribute to a healthy nutritional status. An adequate fibre intake during the first year of age has not been scientifically defined as the evidence to set recommendations for fibres intake is limited in children and almost lacking in infants. However, the EFSA (European Food Safety Agency) considers that a fibre intake of 2 g/MJ is adequate for children after one year of age (45).

The STRIP Study demonstrated that the average dietary fibre intake in 8 month-old infants was 3.9 g/day in boys and 3.4 g/day in girls. Dietary fibre intake between 8 months and 2 years of age was not associated with weight gain (46). The authors conclude that a relatively high fibre intake neither reduces energy intake in children aged from 13 months to 9 years, nor slows down growth rate between 8 months and 9 years of age (47).

Simple sugars

The association between simple sugar and obesity development has been extensively studied. Sugar-sweetened beverages (SSBs), which include fruit juices, sodas, sweet tea, sports and energy drinks, and so on are the main source of simple sugars.

Studies aiming at understand the association between SSBs intake and obesity have shown mixed results. Studies with a larger sample size and/or a longer follow up show a stronger association (48-51), whereas cross-sectional studies with a smaller sample size and/or longitudinal studies with a shorter follow-up do not find any association (52-54).

Among the studies that evaluated the association between SSBs intake in infancy and obesity

development later in life, a study performed in Germany on 216 children showed that BMI-Z-score at 7 years was associated to added sugar intake between 1 and 2 years of age (55). A more recent observational longitudinal study on a bigger sample (1189 children at the end of the survey) showed that the prevalence of obesity at 6 years in children who consumed SSBs during infancy was twice as high as that among those who did not consume SSBs (17% vs 8.6%) (56). High SSBs intake lack of compensation by a lower energy intake from other food sources is the most likely way through which obesity development is triggered (48). In addition, SSBs are often sweetened with fructose, which does not increase insulin levels as much as glucose does; high levels of plasma triglycerides are the consequence of unsuppressed lipolysis (57). In addition, fructose sweetened beverages can have an impact on satiety as fructose has been demonstrated to have a lower satiating power than glucose. Furthermore, fructose sweetened beverages decrease leptin levels and increase ghrelin levels. Since insulin and leptin, and possibly ghrelin, function as key signals to the central nervous system in the long-term regulation of energy balance, a decrease of circulating insulin and leptin and an increase of ghrelin concentrations, caused by high intake of fructose, may lead to increased caloric intakes and ultimately contribute to weight gain and obesity during chronic consumption of diets high in fructose (58).

SSBs intake during infancy significantly increases by more than two times the likelihood of consuming SSBs ≥ 1 time/day at six years of age (59). This link is a good example of the way a tracking behaviour can influence health later on.

In conclusion, SSBs intake in infancy can influence the development of obesity. As there is no reason to use SSBs in infants, SSBs shouldn't be offered at any age, and particularly avoided during infancy and early childhood (60).

Food variety and taste development.

The influence of the CF in favouring obesity development is not restricted to the effects of nutritional and metabolic factors. During the first year of life infants shift from consuming only breast milk or formula to the discovery of a wide range of foods with different flavours, textures, and taste. Infants tend to like sweet and salty tastes and to dislike sour and acid ones (61-63). These innate preferences can favour later in life unhealthy foods intake, since energy dense, palatable foods rich in fat, sugar or salt are abundant in our contemporary food environment (64).

Food preferences, however, can be modified through a "food learning" process (65, 66). This possibility

is very important since early food preferences of first two years of life, may track for long time, even in some cases until adulthood (67).

During the weaning time, a scarce variety of presented foods and a specific monotonous model of taste development can be responsible of eating pattern which can predispose to unhealthy foods preferences or a very selective eating pattern, which in turn could contribute to obesity development.

Repeated exposure to healthy foods since weaning is essential to acquire healthy food preferences. Exposure does not mean visual exposure only, but must include food tasting (68). At least eight repeated exposures have been demonstrated to be necessary for a new or disliked food to be accepted (69,70).

Conclusion.

Many studies confirm that weaning time is a key period to improve health on a short and long term basis. Even though no universal agreement has been reached, yet, some advices can be stated.
Timing: complementary foods offered at 4 months of age can increase the risk of obesity development, and there is no advantage in starting complementary foods' offer before 6 months of life.

Proteins: high protein intake in infancy, and particularly high dairy protein intake, seems to be associated with a higher risk of developing later obesity, but the nature of this relationship is not yet clear.

Fats: data are still very controversial so that a single conclusion cannot be drawn. Whether reducing fats' intake in the first 2 years of age may help or not to prevent obesity is still unclear. However, a slow reduction of fat intake from 50% at birth to around 30% at three years of age can be considered a safe behaviour.
Fibres: there is no evidence that fibres, during infancy, play a role in promoting/ preventing obesity development. From a general point of view, however, since fibres are mainly present in fruit and vegetables they should be present in the daily children's diet since infancy.

Simple sugars: SSBs intake during infancy can favour the development of obesity. Thus, since there are no positive effects on health in consuming SSBs, there is no reason to provide them, especially during infancy and early childhood.

Food variety and taste development: during weaning time, a strong "food learning" process has to take

place. Mothers need to learn that foods variety is important to develop healthy eating habits and that at least 8 repeated exposures to healthy foods since weaning may be necessary in order to accept novelties and acquire healthy food preferences.

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Margherita Caroli

Margherita Caroli graduated as medical doctor at the University of Naples in 1978 with the maximum, where she also got the title of specialist in paediatrics in 1981 with maximum et laude and specialist in Nutrition in 1986 with maximum et laude. In 2004 she got a PhD in Paediatric Nutrition with the publication of the thesis at University of Perugia.

She has been working at the Paediatric department in D Camberlingo Hospital since 1980 until 1998 when she was nominated Head of the Nutrition Unit at the Department of Prevention ASL Brindisi up to 31 December 2015 when she happily retired.

Dr. Caroli has been visiting doctor at the Paediatric Department of Luisiana State University in New Orleans, USA, in 1985 and 1987 working in the field of childhood obesity.

She has been the scientific coordinator of several projects at regional, national and European level in the field of promotion of health and prevention of obesity and chronic diseases mostly in children and during the last 15 years she got grant researches for her Nutrition Unit for almost 1million of euro. She is also member of numerous national committees and task forces at national and European level and expert for DG SANCO, DG RESEARCH, DG AGRI; and DG JOINT RESEARCH CENTRE. She is also frequently temporary advisor for WHO in the field of paediatric nutrition related to obesity. Dr. Caroli has been a founder member of the ECOG, then Board Member of the European Childhood Obesity Group, of the Italian Society of Obesity, of the EASO Task Force on Childhood Obesity, of the Italian Society of Paediatric Nutrition and President of the ECOG.

M Caroli has been invited speaker in more than 180 scientific meetings, conferences and workshop.

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