Impact of complementary feeding on obesity risk

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Abstract

Purpose of review

To discuss recent evidence on the influence of complementary feeding (CF) timing, content and feeding methods on childhood obesity risk.

Recent findings

The evidence-base is limited by heterogeneity, risk of bias and the predominance of observational studies. The content of the diet and feeding practices are more influential than timing for obesity risk. There is limited evidence that CF introduction before 4 months may be associated with increased risk. Intake of animal protein, particularly dairy protein, may contribute to rapid weight gain; protein from infant/follow-on formula shows the most robust association with later obesity risk. Evidence linking sugar intake to obesity risk is limited, but intake should be as low as possible given there is no nutritional requirement. Responsive feeding (RF) practices may promote appropriate infant growth and reduce risk. The effect of baby-led weaning is inconclusive.

Summary

Recent evidence supports current recommendations to avoid high protein intakes, especially from infant/follow-on formula, for infants in HIC; and to promote responsive feeding practices for all infants. Studies in LMIC are required to define optimal CF practices given increasing rates of child obesity alongside double-burden malnutrition.

Key words (3-5): Complementary feeding, obesity, timing, content, feeding method

Key points:

- During the complementary feeding (CF) period infants are growing and developing rapidly, have high nutrient requirements and are exposed to new foods, flavours and feeding experiences which can influence infant growth trajectory and potentially influence later obesity risk
- The content of the CF diet and feeding practices are more influential than timing for obesity risk.
- Intake of animal protein, particularly dairy protein, may contribute to rapid weight gain; protein from infant/follow-on formula shows the most robust association with later obesity risk.
- Evidence linking sugar intake to obesity risk is limited, but intake should be as low as possible given there is no nutritional requirement.
- Responsive feeding (RF) practices may promote appropriate infant growth and reduce risk. The effect of baby-led weaning is inconclusive.

Introduction

Starting from the middle of the first year of life, breast milk alone can no longer meet infant nutritional requirements and additional 'complementary' foods are needed to support their rapid growth and development during complementary feeding (CF). CF practices, encompassing the timing, content and method of feeding, can influence infant growth trajectory and result in both under and overnutrition, depending on both infant and environmental factors. Child obesity has long been recognised as a problem in high income countries (HIC) but it is also increasing rapidly in low- and middle-income countries (LMIC), with many experiencing so-called double burden malnutrition. Alongside this, CF practices in many LMIC are transitioning from predominantly home-prepared foods to commercial products which may be high in energy, fat, salt or added sugar. These changes are considered as key factors contributing to child overweight/obesity [1]. Furthermore, the provision of ultra-processed foods in children may result in adverse metabolic outcomes according to a recent systematic review (SR) [2].Research on CF is challenging for several reasons, and study results can be difficult to interpret and compare. Different definitions of CF are used, and it is not always possible to distinguish effects of milk feeding from that of other foods. Parents often have strong preferences and may be reluctant to participate in trials requiring different practices. Hence, most research is observational with high potential for confounding by factors related both to CF and to the risk of later outcomes including obesity. Accurately recording CF practices is challenging, with some studies using retrospective maternal recall. Finally, the assessment of nutritional intake or dietary patterns is difficult, considering the need to maximise data quality whilst minimising parental burden.

In this review we provide an update on the evidence that CF practices may influence the risk of overweight/ obesity, considering timing, content and method of feeding and prioritising data from SR with or without meta-analysis (MA).

Timing of complementary feeding introduction

Two SR and MA [3, 4] concluded there is no evidence that introducing CF before 6 months of age (M) influences weight, BMI or the risk of overweight/obesity. The SR by English et al [5] reported limited evidence that introducing CF or beverages before 4M may be associated with higher risk; interestingly, these studies were considered to be at high risk of bias in the EFSA review [3].

Six recent observational studies (not included in the reviews above) examined associations between infant feeding practices and either weight or BMI at a single time point or BMI trajectories (see Table 1 for details). All adjusted for a range of potentially important confounders. Two reported no association between CF timing and later weight status [6, 7], whereas four reported greater adiposity outcomes with CF introduction before 4M [8, 9] (one significant only in non-breast-fed infants [9]) or 6M [10, 11]. In common with most previous studies, none adjusted for infant or child nutrient intake, physical activity, sedentary behavior, or sleep patterns – all factors known to influence weight trajectory and overweight/obesity risk.

Differding et al [12] examined the role of the gut microbiome as a potential mediator between infant feeding practices and later BMI using data from a Canadian cohort with BMI and stool microbiota assessed at age 5 years. Their findings suggested that the effect of early CF introduction on gut microbiota composition and BMI in childhood may depend on whether the infant is breast-fed or formula-fed at the time. The same authors also reported altered gut microbiota with significantly higher Shannon diversity and higher butyric acid concentrations in the stool at 3 and 12M in infants with early (≤ 3M) versus late (> 3M) CF introduction [13]. However, the significance of the findings is currently unclear in terms of future metabolic or immune outcomes. In a longitudinal analysis of infant stool samples, Galazzo et al [14] reported that from 13 weeks onward, diet became the most important determinant of microbiota composition; however changes were associated with cessation of breastfeeding rather than solid food introduction.

Complementary food content and dietary patterns

Energy and fat

SRs have concluded that there is no convincing evidence of a relationship between the intake of energy, fat (including different types of fat such as long-chain fatty acids) during CF and overweight/obesity risk [5, 15-16]. In contrast, a SR/MA using data from LMIC suggested that lipid-based nutrient supplements (LNS) provided with CF are effective in improving ponderal and linear growth of infants and young children (6-23M) compared to no intervention [17]. Although one cluster-randomised trial showed no difference in fatness among infants receiving LNS during the CF period versus controls, long-term follow-up is needed to ensure favourable outcomes at older ages [18].

Protein: Amount and Source

Evidence suggests that higher protein consumption in early life is an important risk factor for increased child overweight/obesity risk and body fatness [15,19]. The most recent review reported a probable positive association between total protein intake in early life (≤ 18M) and higher BMI later in childhood (BMI increase of 0.06 (95% CI 0.03, 0.1) kg/m^2 per 1% increment of energy from protein) [20]. Limited evidence also suggested an effect of protein intake on higher overweight/obesity risk [20]. Expert groups have recommended avoiding high protein intakes during CF, including limiting protein intake to ≤ 15% of total energy to reduce the risk of childhood overweight/obesity [21].

There is increasing focus on the influence of protein source. Currently, robust evidence only supports a causal effect of high protein intake from infant and follow-on formula on rapid weight gain and child overweight/obesity [15, 16]. Although the latest SR reported that protein from animal source foods (ASF) was more likely to be positively associated with higher weight and BMI/BMI z-score (BMIZ), it was unclear whether protein from dairy and non-dairy ASF had similar impact [20]. A previous SR concluded that there was moderate evidence that consuming different amounts of meat does not influence growth, body size or body composition in later life, with insufficient evidence to make a conclusion regarding child overweight/obesity [5].

A recent prospective cohort study in Thailand (a MIC) reported that protein from formula and cow's milk had greater impact on infant weight gain during the CF period than protein from non-dairy ASF, while growth parameters were not associated with plant-based protein intake [22]. A SR/ MA also reported no effect of plant-based diets during CF on weight gain or obesity risk, although these diets may increase the risk of micronutrient insufficiency/deficiency and growth faltering [23].

Current evidence suggests that animal protein may increase plasma amino acid concentrations, especially branch-chained amino acids (BCAA), which may enhance insulin and insulin-like growth hormone (IGF-1) secretion resulting in greater weight gain and potentially higher overweight/obesity risk [20]. The observed positive association between protein intake and insulin, IGF-1 and IGFBP-3 concentrations in the Thai cohort study was explained by protein from formula and cow's milk; consumption of protein from non-dairy ASF or plant-based foods had no significant effect on these hormones [22].

Sugar and sugar-sweetened beverages (SSB)

A SR [5] concluded there was limited evidence that SSB consumption during the CF period is associated with increased obesity risk in childhood but not with growth, size or adiposity. There was also limited evidence showing a positive association between juice intake and infant and child anthropometry. A more recent SR/MA concluded there was low certainty evidence that consumption of SSB and unhealthy foods in childhood (≤ 10.9 years) may increase BMI/BMIZ, body fatness, or odds of child overweight/obesity. However, firm conclusions could not be made regarding sugar intake during the CF period due to inconsistent findings, limited number of studies and serious risk of bias [24]. Nevertheless, one study suggested that frequent SSB consumption during the CF period (≥ 3 times a week) was associated with greater odds of obesity at 6 years compared to infants without SSB intake [24]. Notably, this SR/MA did not include studies from LIC and only 11.5% of studies were from MIC, whereas a previous survey reported high intake of SSB and sugary snacks among children (12-23M) in 18 LMIC [25].

Although sugar intake should be as low as possible during the CF period, in practice intakes are often high, and there is concern about the high sugar content of some commercial CFs, especially finger-foods. A survey conducted in 10 European countries reported that approximately one-third of the energy in commercial CF comes from sugar and, for most product categories, energy from sugar is higher than 10%, exceeding WHO recommendations [26].

Dietary patterns

Some studies have used 'dietary patterns' as an alternative way to reflect food consumption. Such methods typically identify patterns regarded as more 'health-conscious' (e.g., higher intake of fruits, vegetables, whole grains, and home-cooked meat/fish) and those including more refined carbohydrate foods, commercial or processed foods. A recent review concluded there was some evidence that more 'health-conscious' CF dietary patterns may contribute to more appropriate weight gain and favourable body composition in infants and young children which might prevent overweight/obesity in later life [27]. However, effects were modest, and few studies measured body composition. Previous reviews focusing specifically on fruit and vegetable intake during CF did not demonstrate a preventive effect on child overweight/obesity [15, 28-29]. Evidence on the impact of dietary patterns is thus limited and further well-designed research is needed.

Method of complementary feeding

Research has considered the role of responsive feeding and parenting practices, and the use of baby-led weaning (BLW) versus traditional spoon-feeding during CF.

Responsive feeding and parenting

Responsive practices – including educating parents to respond to infant hunger and satiety cues and avoiding the use of food to comfort or reward – were investigated in three previous RCTs with positive short-term effects on infant growth and lower BMI, although this was not maintained at 3-5 years

[30]. Recently Savage et al [31] reported data from the INSIGHT trial suggesting that intervention effects may spill-over to second-born infants, despite no reinforcement during the subsequent pregnancy. Firstborn and second-born children whose parents received the intervention with the first child had BMI that was 0.44 kg/m^2 (95% -0.82 to -0.06) and 0.36 kg/m^2 (95% CI -0.75 to 0.03) lower than controls. However, infants were only measured up to 12M and longer-term follow-up is important given the lack of persistence of intervention effects in the main trial.

A more recent RCT investigated the effects of repeated vegetable exposure, sensitive feeding or a combination of both in 246 healthy Dutch infants recruited at 4-6M and evaluated at 18 and 24M [29]. Interventions lasted until 16 months and had no impact on the primary outcomes – vegetable acceptance and energy intake. The proportion of children with overweight was significantly lower in the combined intervention group compared to the vegetable group at 18M (2% v 16%) and the control group at 24M (7% v 20%). However, the authors suggest this finding should be interpreted with caution due to the small number of infants with overweight and non-significant effects on continuous BMIZ measures.

Other studies have investigated associations between infant appetite, parenting styles and infant growth. In Mexican infants from a prospective birth cohort, 'pressuring to finish' and 'pressuring to eat cereal' constructs from the Infant Feeding Styles Questionnaire were associated with lower weight-for-length and BMIZ at 6M (n=263) with a similar although non-significant effect at 9M (n=234) [32]. However, the possibility of reverse causality cannot be excluded, where parents may have pressured the infant to eat because they were concerned about slow growth. Shriver et al [33] investigated interactions between infant appetite traits and restrictive and pressuring parental styles on infant weight gain in a longitudinal cohort of 159 mother-infant pairs studied at around 2M and between 6-11M. They concluded that, for infants with a large appetite, some level of restrictive feeding may be beneficial for preventing excessive weight gain while pressurising may exacerbate the positive association between faster eating and rapid weight gain.

Baby-led weaning

The BLW approach has been suggested to allow greater self-regulation by the infant and promote better appetite control which could result in lower overweight/obesity risk. However, the lack of a consistent definition of BLW makes it difficult to compare studies. Furthermore, most evidence comes from observational studies, which is problematic given that characteristics of parents using BLW differ from those favouring a more traditional spoon-feeding approach, and these same factors may also be associated with obesity risk**.** A randomised trial using a modified BLW intervention (BLISS) in New Zealand reported no effect on infant weight or adiposity at 24M [30].

Two recent SR investigated effects of BLW on infant growth and appetite outcomes. Boswell [34] included 29 studies (1 RCT) in a narrative review restricted to HIC and using a single database. The authors concluded that benefits of BLW included lower food fussiness, higher food enjoyment, lower food responsiveness and higher satiety responsiveness – a profile which might be expected to confer reduced obesity risk. However, few studies robustly examined the relationship between BLW and obesity risk. Martinon-Torres et al [35] searched 4 databases and 8 studies were included, including two RCTs. Results were inconclusive. All studies were considered to be at moderate to high risk of bias and only one RCT was pre-registered.

In a third SR/MA, Bergamini et al [30] investigated effects of a wider range of CF practices. There was no evidence that BLW approaches had any benefit for infant weight/length gain nor a preventive effect on future overweight/obesity. However, responsive feeding practices were found to result in adequate weight gain and lower incidence of overweight/obesity during the first two years of life. Conversely, non-responsive feeding styles, namely restrictive and coercive practices, had a negative effect, favouring excess weight and lower weight respectively.

Conclusions

Current evidence suggests that the content of the CF diet and the method of feeding are more influential than timing with respect to obesity risk. High protein intake from formula during the CF period can promote rapid weight gain and may increase the risk. Evidence for a specific effect of protein intake from other foods is less robust, but some data suggest that intake of animal protein, especially from dairy sources, has a greater effect on weight gain than that from non-dairy ASF or plant-based foods. BCAA may be a possible mechanism linking animal protein intake with increased secretion of growth-promoting hormones and faster weight gain. However, further research is required to assess longer-term effects of specific protein sources, as well as investigating underlying mechanisms.

Evidence linking sugar intake during CF with later weight or obesity risk remains limited in quantity and quality. However, considering there is no nutritional requirement for sugar, which provides empty calories and is bad for dental health, intake should be minimised and efforts made to lower the sugar content of commercial weaning foods as well as advising parents to limit sugar in home-prepared foods.

The evidence for a beneficial effect of responsive feeding or parenting practices on infant weight and overweight/obesity risk appears greater than that for BLW, although the latter may form part of responsive feeding by increasing infant control during feeding. This supports the inclusion of advice on responsive parenting in current infant feeding recommendations.

In general, recent studies suffer from the same methodological limitations as older studies, and some of these are difficult to address in practice. A further significant limitation of the current evidence-base is that most studies were conducted in high-income, western countries. Their findings may not be generalisable to other settings and high-quality research from LMIC where double burden of malnutrition is also prevalent are particularly required.

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Conflicts of interest

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