

Does the early introduction of solids promote obesity?

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ABSTRACT Childhood obesity is a major public health challenge across the developed world, and it is vital to understand the modifiable factors that contribute to it. The influence of early-life nutrition on predisposition to later obesity and metabolic disease is now well established. Much research has concentrated on the preventative effects of breastfeeding in relation to childhood obesity risk, but the optimal timing of introducing solid foods has received far less attention. This remains a much-debated and contentious issue, and differing guidelines from international bodies have caused confusion among parents. There is no conclusive evidence from current research that introducing solids before six months of age is associated with an increased risk of obesity in infancy or childhood. Current studies suggest that the most clearly established risk factor for childhood obesity is maternal body mass index. There is a need for continued research in this area.

Keywords: childhood obesity, infant solids, review

INTRODUCTION

Childhood obesity is one of the greatest public health issues globally, with an estimated 42 million children under the age of five years being overweight.⁽¹⁾ Approximately one in four Australian children is overweight or obese.⁽²⁾ Most of these children remain overweight or obese into adulthood,⁽³⁾ and are therefore at increased risk for adverse health consequences, such as cardiovascular diseases and diabetes mellitus.⁽⁴⁾

Both animal and human epidemiological and clinical studies have provided compelling evidence that the nutritional environment before birth and in early infancy is an important determinant of metabolic health later in life.^(5,6) In particular, individuals who are exposed to an inappropriately high or inappropriately low nutrient supply during fetal or early postnatal life have an increased risk of later obesity and diabetes mellitus as children and adults.⁽⁵⁾ In this context, there has been considerable interest in establishing nutritional practices for the early infant period that can promote optimal metabolic health in later life.

As the timing of introducing solids is arguably one of the most readily modifiable aspects of infant nutrition, establishing evidence-based guidelines on the optimal timing of introducing solids to achieve later metabolic health has the potential to significantly impact the health of future generations. The World Health Organization (WHO) currently recommends exclusive breastfeeding for six months, followed by the gradual introduction of “*nutritionally-adequate and safe complementary foods*” in conjunction with the maintenance of breastfeeding for up to two years or beyond.⁽⁷⁾ However, the WHO recommendations have been challenged by more recent studies that suggest that the optimal timing of introducing solids is likely to be earlier, at least in relation to the avoidance of allergy. The new data has led to the introduction of recommendations by a number of international health agencies that the optimal timing of introducing solids is between four and six months of age. Indeed, population-based surveys in the United States, Australia and

Denmark have consistently indicated that the large majority of parents are introducing solids before six months,⁽⁸⁻¹¹⁾ with some Australian data suggesting that up to 93% of infants have been given solids before six months.⁽¹¹⁾

One of the concerns that have been raised in relation to the early (i.e. before six months) introduction of solids is that this practice increases the risk of the infant going on to become overweight or obese in childhood and adult life. This review will discuss some of the current (published) evidence surrounding the relationship between the timing of introducing solids and later obesity risk, and the research gaps that still exist in this area. We also include a commentary based on the clinical experience of the lead author, including preliminary data from a survey of children in whom solids were introduced well before the current recommended time (many before four months of age).

CURRENT RECOMMENDATIONS

The optimal timing for introducing solid foods to an infant's diet remains controversial and a topic of considerable interest among health professionals, researchers and the community. The WHO guidelines continue to recommend exclusive breastfeeding for the first six months of life to “*achieve optimal growth, development and health*”.⁽⁷⁾ These guidelines clearly define ‘exclusive’ as meaning that they are fed no other food or drink. The infant feeding guidelines released by the National Health and Medical Research Council of Australia in 2012 recommended that solids be introduced at “*around six months of age*”.⁽¹²⁾

The debate around the optimal time to introduce complementary foods has centred largely on the impact that this would have on later allergy risk. It was initially believed that delaying the introduction of specific food types (e.g. nuts, egg and wheat) could reduce the risk of allergic disease later in life.⁽¹³⁾ A number of prominent studies have now shown that delaying the introduction of allergenic foods increases the incidence of allergies.⁽¹⁴⁻¹⁶⁾ The Learning Early about Peanut

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Allergy trial conducted in the United Kingdom demonstrated that early introduction (4–11 months) and sustained intake (until 60 months) of peanut protein significantly decreased the risk of peanut allergy in children who were medically defined as being at a high risk of peanut allergy.⁽¹⁷⁾ Peanut avoidance in infancy was also associated with a higher frequency of clinical allergy.

Other infant feeding guidelines from international organisations in the United States and Europe differ from those of the WHO, recommending the introduction of solid foods from the age of four to six months.^(18,19) For instance, the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) Committee on Nutrition recommends that *“complementary feeding (i.e. solid foods and liquids other than breast milk or infant formula and follow-on formula) should not be introduced before 17 weeks and not later than 26 weeks”*.⁽¹⁸⁾ Recommendations from the Australasian Society of Clinical Immunology and Allergy and ESPGHAN state that there is no convincing scientific evidence to support previous advice to avoid or delay the introduction of potentially allergenic foods, such as eggs, peanuts and fish, to prevent allergies.^(18,20) The American Academy of Pediatrics recommends no introduction of foods other than breast milk or formula before four months of age, and no introduction of sweetened beverages before six months of age.^(21,22) We were unable to find evidence in the published literature of the risks involved if solids are introduced before four months, although this practice is commonly discouraged.

EARLY INTRODUCTION OF SOLIDS AND OBESITY RISK: CURRENT EVIDENCE

One argument raised by health professionals is that earlier introduction of solids (i.e. before six months) is associated with an increased risk of the child becoming overweight or obese. This argument is based on a number of epidemiological studies, which suggest that infants who are started on solids before the recommended six months have a higher risk of obesity compared to those who commence solids at or after six months of age.^(23–26) However, these results are far from universal, with other studies finding no association between the timing of introducing solids and measures of overweight or obesity later in childhood.^(27–31) These studies (Table I) represent a small part of this literature.

Three more comprehensive reviews that examined the timing of the introduction of solids and obesity risk were recently conducted.^(32–34) Moorcroft et al,⁽³⁴⁾ who included 24 studies and data from over 34,000 infants/children, concluded that there was no clear association between the age of introduction of solids and obesity. The other two reviews also concluded that there is no clear evidence showing an association between the introduction of complementary feeding between four and six months of age and childhood obesity, although they noted that introducing solids prior to four months may result in an increased risk of children becoming overweight.^(32,33) However, this conclusion in the latter two reviews was based on a very small number of studies. There are a number of factors that may contribute to the disparate findings. These include the lack

of control for potentially important confounders, small sample sizes resulting in a lack of power, and reliance on retrospective recall for outcome measures, which affects internal validity. Potentially important confounders are not always identified and included in analyses, including method of milk feeding, child's birth weight, sociodemographic factors and important maternal factors such as body mass index (BMI), as well as which foods were introduced (and at what volumes). Also, overweight and obese women are less likely to initiate breastfeeding and, if initiated, will breastfeed for shorter durations than normal-weight women.^(35,36) Many studies on infant and child weight have failed to control for maternal BMI in studies that examine the duration of breastfeeding^(37–39) or timing of introducing solids.^(25,26) Thus, there is currently a lack of robust evidence that the introduction of solids before six months of age increases an individual's subsequent risk of overweight or obesity.

CLINICAL PERSPECTIVE: SOLIDS BEFORE FOUR MONTHS OF AGE

The lead author of this article encourages the introduction of solid foods into the infant diet (in conjunction with continued breastfeeding, where possible) well before the recommended six months of age, usually by 10–12 weeks. This practice is part of an integrated care plan that has been demonstrated, in a randomised controlled trial, to improve sleep duration in infants and breastfeeding duration in mothers.⁽⁴⁰⁾ Despite these positive outcomes, however, there is reluctance on the part of other health professionals to adopt the practice of introducing solids ahead of current recommendations. While the reason for this is unclear, it appears to centre largely on the perceived negative effects on infant health, in particular the risk of early excess nutrition promoting fat deposition and increasing later obesity risk. While this is a legitimate concern in the context of the current obesity epidemic, as outlined above, there is currently limited evidence that this concern is warranted.

In order to investigate this further, we undertook a review of a group of 61 children who had attended the principal author's clinic between 2002 and 2008, and who had commenced solids before four months of age, to examine any association between the timing of solids being introduced and BMI in childhood. We focused specifically on infants with a body weight greater than the 90th percentile at the time of their final clinic appointment (at approximately three months of age), determined using the infant growth charts provided by the United States Centers for Disease Control and Prevention.⁽⁴¹⁾ If excess infant weight gain is associated with heightened risk of obesity later in life, this group of infants may be expected to represent those at the greatest risk of obesity in childhood. The study was approved by the Human Research Ethics Committee of the University of Adelaide, Australia.

Our preliminary findings suggest that the age of introduction of solids (age range 4–28 weeks) was unrelated to the child's BMI percentile or BMI z-score at follow-up (age range 3–11 years). The only factors that emerged as significant predictors of BMI percentile at follow-up were parental anthropometrics, with

Table 1. Summary of studies that examined the introduction of solids and infant or child obesity outcomes.

Author, yr, country	Study design	Age at follow-up	No. of children	Findings	Mean age at starting solids	Confounders	Secondary findings
Zive et al, ⁽³¹⁾ 1992, US	Study of children's activity and nutrition	4 yr	331	No association between introduction of solids and adiposity measures (BMI, sum of skinfold thickness)	4.7 mth (girls) and 5.0 mth (boys) for Anglo-American infants	Demographic and child characteristics, maternal physical measures, infant-feeding variables	Maternal BMI and sum of skinfold thickness explained the largest proportion of variance in childhood adiposity measures
Forsyth et al, ⁽⁴⁵⁾ 1993, UK	Dundee Infant Feeding Study	2 yr	671	Infants who started solids at ≤ 12 wk were heavier than those introduced to solids at > 12 wk at 6 mth of age, but not at 1 yr or 2 yr of age	≤ 12 wk for 49% of infants	Mother's parity, parental smoking, father's social class, maternal height, birth weight	Early introduction of solids was not related to gastrointestinal illness, wheeze, dermatitis
Wilson et al, ⁽²⁶⁾ 1998, UK	Dundee Infant Feeding Study	7.2 yr	545	Infants who started solids at < 15 wk had higher percentage body fat and weight than those who started at ≥ 15 wk; no difference in BMI	< 15 wk for 74% of infants	Gender, birth weight, weight at first solid feed (for percentage body fat)	Exclusive BF for 15 wk was associated with significant reduction in respiratory illness
Mehta et al, ⁽²⁸⁾ 1998, US	Randomised controlled trial (RCT)	3 mth; 6 mth; 12 mth	165	DXA showed no difference in body composition at age 1 yr between those who started solids at 3–4 mth and those at 6 mth	NA: RCT	NA: RCT	Total energy intake was not different among infants in early group compared with late group at any age
Baker et al, ⁽²³⁾ 2004, Denmark	Danish National Birth Cohort	18 mth	3,768	<ul style="list-style-type: none"> Introduction of solids at < 16 wk was associated with greater infant weight gain Timing of introduction of solids did not increase weight gain at longer durations of BF (≥ 20 wk) 	17.7 ± 2.8 wk	Primiparity, gestational weight gain, duration of gestation, maternal smoking, gender, birth weight, maternal pre-pregnancy BMI	Higher maternal pre-pregnancy BMI was associated with increased infant weight gain
Reilly et al, ⁽²⁹⁾ 2005, UK	Avon Longitudinal Study	7 yr	8,234	No relationship between age of introduction of complementary feeding (in 2-mth increments) and obesity	Not provided	Gender, maternal education, energy intake, birth weight, maternal smoking, parental obesity, hours of sleep and TV viewing time at age 30 mth, dietary patterns	<ul style="list-style-type: none"> With one obese parent, risk of obesity at age 7 yr increased and risk was higher when both parents were obese 8 risk factors associated with obesity risk, including parental obesity, > 8 hr/wk TV viewing at age 3 yr, weight gain in first yr, birth weight, short sleep duration (< 10.5 hr) at age 3 yr

(Contd...)

Author, yr, country	Study design	Age at follow-up	No. of children	Findings	Mean age at starting solids	Confounders	Secondary findings
Burdette et al. ⁽²⁷⁾ 2006, US	Prospective cohort study	5 yr	313	DXA showed solids (introduced before or after 4 mth) was not associated with adiposity at age 5 yr	> 4 mth for 50% of infants; > 6 mth for 8% of infants	Lean body mass, gender, birth weight, maternal obesity, sociodemographics, ethnicity	Duration of exclusive/any BF was not associated with fat mass
Kim et al. ⁽⁴³⁾ 2008, US	Cross-sectional, Early Childhood Longitudinal Study	9 mth	8,150	Early introduction of solids (< 4 mth) was a risk factor for weight gain	Not provided	Age, gender, ethnicity, poverty level, maternal education, employment, marital status, BMI, age of initiation of child care	Child care factors were associated with more weight gain during first year of life
Schack-Nielsen et al. ⁽²⁴⁾ 2010, Denmark	Copenhagen Perinatal Cohort	42 yr	1,305	Introduction of solids from 2–6 mth increased BMI and risk of overweight in adulthood	3.8 ± 1.5 mth (spoon-feeding); < 3 mth for 17% of infants; ≥ 4 mth for 46% of infants	Gender, maternal age at birth, pre-pregnancy BMI, gestational weight gain, smoking, social class, education, single-mother status, prematurity birth weight	Longer duration of BF was associated with lower BMI at age 1 yr, but no effect was observed in later childhood or adulthood
Seach et al. ⁽²⁵⁾ 2010, Australia	Melbourne Atopy Cohort Study	10 yr	307	<ul style="list-style-type: none"> Delayed introduction of solids was associated with reduced odds of being overweight/obese Started solids ≤ 20 wk: 35% overweight/obese Started solids ≥ 24 wk: 19% overweight/obese 	20.0 ± 4.3 wk	Socioeconomic status, parental smoking, childcare attendance, birth weight, BF	<ul style="list-style-type: none"> Duration of exclusive/any BF was not associated with weight status Antenatal parental smoking was associated with overweight/obesity
Huh et al. ⁽⁴²⁾ 2011, US	Project Viva	3 yr	847	<ul style="list-style-type: none"> BF infants: timing of introduction of solids was not associated with odds of obesity Formula-fed infants: solids before 4 mth was associated with a six-fold increase in odds of obesity 	< 4 mth for 8% of BF infants and for 33% of formula-fed infants	Maternal education, income, pre-pregnancy BMI, paternal BMI, child age, gender, ethnicity, early child growth	Introduction of solids after 6 mth was not associated with obesity among BF or formula-fed infants at age 3 yr
Vehapoglu et al. ⁽³⁰⁾ 2014, Turkey	Cross-sectional study	2–14 yr	4,990	No significant differences in prevalence of overweight and obesity between the groups of children who were introduced to solids early (< 4 mth) and late (≥ 6 mth)	49.1% had exclusive BF for 6 mth	Not listed	<ul style="list-style-type: none"> Strongest predictor of BMI of child was maternal BMI No association between duration of BF and childhood obesity

BF: breastfeeding; BMI: body mass index; DXA: dual-energy X-ray absorptiometry; NA: not applicable; TV: television; UK: United Kingdom; US: United States

significant positive relationships between both maternal BMI ($r = 0.34$; $p = 0.009$) and paternal BMI ($r = 0.44$; $p < 0.001$). These predictors remained highly significant in the multivariate model (statistically adjusted for gender, age, birth weight, maternal education, parental smoking and breastfeeding duration; $p < 0.0001$ for both maternal and paternal BMI).

TYPES OF SOLIDS INTRODUCED AS FIRST FOODS

The content of early solids undoubtedly varies in people from different countries, cultures and socioeconomic status. For example, the first foods given in the United States and Australia are usually infant cereal, and pureed fruit and vegetables. The Chinese prefer to give gruel boiled with pork bones, and in Singapore, many parents give rice gruel with powdered anchovy. Unfortunately, very few of the reviewed studies specifically measured or described the type of solid foods that were given as first foods. The exception to this was a study by Schack-Nielsen et al,⁽²⁴⁾ who reported the risk of overweight at age 42 years according to the age of introduction of spoon-feeding (infant cereal), vegetables, egg, meat and firm food (considered to be soaked bread and biscuits). Other studies stated the types of foods that were considered as 'complementary or solid foods' but did not relate these foods directly to the outcome measure.^(27,42,43) While examining the type of foods first introduced, as well as their relative energy values, was not an aim of this review, it must certainly be acknowledged as a relevant factor that is of importance for future research.

CONCLUSION

The interplay between rate of growth, feeding methods, parental weight status and socioeconomics in determining an individual's risk of becoming overweight or obese is undoubtedly complex. However, there is currently no robust evidence that introducing solids before six months of age has any appreciable impact on the risk of overweight and obesity in childhood. Research now indicates that the early introduction of solids should be promoted for health reasons and not simply to 'feed a hungry baby'. The most compelling evidence for this would appear to be related to allergy prevention. As the prevalence of early introduction of solids is likely to increase as awareness of the allergen protection that it provides grows, it is important to better understand whether there are any potential negative long-term consequences to such a practice.

This review highlights the limited data currently available in this area, and the need for well-designed randomised controlled trials to establish the effects of early introduction of solids on child and adult health, and in particular, metabolic health and future allergy risk. In addition, as noted by recent reviews in the field,⁽⁴⁴⁾ there is a need to consider the quality and quantity of foods that are introduced. Clinical studies that prospectively follow up with individuals through infancy and childhood are needed to more fully evaluate the effects of early introduction of solid foods on weight gain and other health outcomes later in life.

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