

Symposium on 'Dietary management of disease'

Session 3 (Joint with the British Dietetic Association): Management of obesity Prevention of obesity in preschool children

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Obesity is a serious problem that affects children from diverse ethnic backgrounds in both industrialised and developing countries. Worldwide, an estimated twenty-two million children <5 years of age were overweight in 2007. In the UK if current trends continue an estimated one-quarter of all children <16 years of age will be obese by 2050. Recent evidence suggests that most obesity is established during the preschool years, and because one in five obese 4 year olds will become obese adults this situation has major implications for public health. The causes of obesity in preschool children are complex and multifactorial. Although 30–50% of the predisposition towards obesity in preschool children can be explained by genetic factors, environmental influences also play a crucial role. The preschool period in particular is a pivotal time during which long-term dietary and physical activity habits are established, with potential lifelong effects on health. However, research in this age-group is limited. Previous studies have aimed to improve diet, increase physical activity and achieve behavioural change. However, few of these studies have been successful and there is an urgent need, therefore, for the development of evidence-based interventions aimed at the prevention of preschool obesity.

Obesity: Preschool children: Interventions

Obesity is a serious problem that affects children from both industrialised and developing countries. In recent years its prevalence has reached epidemic proportions and it is estimated that 10% of the world's children are currently overweight or obese⁽¹⁾. The problem is not confined to school-age children; twenty-two million children <5 years of age are now estimated to be overweight or obese⁽²⁾.

Recent evidence suggests that in obese children most of their excess weight is gained before the age of 5 years⁽³⁾ and that adiposity tracks into later childhood^(3,4). This situation is a major concern for public health because weight gained before puberty has a strong association with risk factors for CVD, which are typically seen in adulthood but are becoming apparent in children as young as 4 years of age⁽⁵⁾. These risk factors are also known to track to adulthood⁽⁶⁾ with major implications for long-term health. Early childhood is therefore a key period for the development of obesity and an important target for intervention⁽⁷⁾.

The present review considers factors that influence the development of obesity during the preschool period, summarises the evidence to inform preventative strategies and considers the effectiveness of interventions aimed at its prevention.

Determinants of obesity

Evolution has favoured hunger over satiety signals, resulting in a preference towards energy-dense foods. Previously, this predisposition would be advantageous because energy can be stored during periods of abundant food availability and accessed during famine. Human subjects are therefore genetically predisposed to adiposity and in the current environment approximately half to one-third of an individual's risk of overweight can be explained by genetic factors⁽⁸⁾. However, the human gene pool has

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remained relatively static despite a massive increase in obesity prevalence, suggesting that environmental factors are the most influential for the current obesity epidemic. Human subjects are particularly susceptible to the 'obesogenic' environment in which energy-dense foods are freely available and sedentary behaviours are common.

At the individual level excessive weight gain results when energy intake exceeds energy expenditure over a prolonged period. Environmental factors, both within individuals and within societies, have a major role in producing this positive energy balance. Societal changes that predispose to excess energy consumption include increased availability of food and use of technology⁽⁹⁾. Within individuals factors predisposing to obesity in young children include intrauterine exposures, size at birth and early growth patterns, parental obesity and sleep duration⁽¹⁰⁾. However, the two lifestyle factors that have the greatest impact on the risk of obesity are likely to be diet and physical activity^(11–13).

Role of diet

Surprisingly, the relationship between diet and obesity in preschool children is poorly researched but is likely to involve interaction between appetite, dietary composition, feeding or meal patterns and parental feeding influences⁽¹⁴⁾. Research into the dietary determinants of preschool obesity has focused either on the role of total energy intake or the contribution of individual macronutrients^(15–18).

Reports from studies investigating associations between energy intake and obesity in preschool children are conflicting. Two studies have found that high energy intake is associated with increased obesity risk^(19,20), whilst surprisingly a randomised controlled trial has found that a lower energy intake during the preschool years is associated with increased risk of later obesity^(21,22). This discrepancy may be a consequence of difficulties in assessing energy intake, which can be confounded by factors such as body weight, metabolism and physical activity level. For example, when assessing energy intake studies do not always adjust for body size and physical activity level and few measure metabolisable energy intake using the 'gold standard' doubly-labelled-water method. Evidence from the USA suggests that increased energy intake rather than reduced energy expenditure is the major driver of obesity⁽²³⁾. A meta-analysis of data from seven studies including 963 children aged 4–18 years has found that total energy intake is the greatest contributor to increases in body weight⁽²⁴⁾. More data from preschool children using the doubly-labelled-water technique to assess energy expenditure are needed before firm conclusions can be made.

Several studies have investigated the influence of macronutrient intake and the development of obesity in preschool children. The evidence is most consistent for an association between higher protein intake and increased obesity risk^(15–17,19,25,26). For instance, one study has shown that higher protein intake in the preschool years (14–15% total energy intake *v.* 11–12% total energy intake) more than doubles the risk of being overweight (OR 2.34 (95% CI

1.1, 5.0))⁽¹⁶⁾. Higher protein intake (16.6% energy intake *v.* 14.9% energy intake) is also associated with earlier age at adiposity rebound (<4 years of age, $P < 0.01$), the point at which BMI begins to increase after reaching its childhood nadir (usually between 4 and 8 years of age)⁽¹⁷⁾, which itself is associated with an increased risk of later obesity^(27,28).

Evidence for an influence of fat and carbohydrate intake on obesity risk is less convincing. Two studies suggest that higher fat intake increases the risk of obesity^(22,29) whilst another study has found no such association⁽¹⁹⁾. Most studies investigating carbohydrate intake have focused on sweetened beverages as the source of carbohydrate and have reported conflicting results. For instance, in a recent study of >10 000 US preschool children consumption of more than one sweetened drink daily has been shown to double the risk of becoming overweight⁽¹⁸⁾. In contrast, other studies have not found an association between sweetened beverage consumption and risk of overweight^(26,29–31). Thus, although approximately half 18-month-old children consume sweetened drinks daily in the UK, it is not known whether this factor increases the risk of obesity⁽³²⁾.

Overall, there is limited evidence to support the role of diet alone in the development of preschool obesity, although there are data to support the hypothesis that a high protein intake during infancy and early childhood increases the tendency to obesity.

Role of physical activity

Evidence suggests that increased physical activity reduces the risk of obesity in preschool children^(33–37). One cross-sectional study has shown that children with lower physical activity are approximately four times (3.8 (95% CI 1.4, 10.6) times) more likely to have increased body fat⁽³⁸⁾. The effect size of physical activity on obesity may be considerable. For example, in Thailand preschool children reported to have low exercise levels have been shown to have >2-fold risk of obesity compared with children with a normal exercise level⁽³⁹⁾.

The intensity of physical activity may be particularly important in influencing obesity risk. For example, one study has shown that overweight children spend approximately 9 min less time (22.9 min *v.* 32.1 min, $P < 0.05$) in vigorous physical activity daily compared with normal-weight children⁽³⁴⁾. Another study has found that children in the highest quartile for vigorous activity at 4–6 years of age are in the lowest quartile for body fat percentage at 3 year follow-up. No differences in body fat percentage were seen in association with low or moderate physical activity⁽⁴⁰⁾. Thus, even small differences in vigorous physical activity could contribute to the development of obesity.

There are only two studies of physical activity interventions in preschool children, neither of which report a positive effect. An intervention to increase physical activity and reduce BMI in Scottish nursery school children was unsuccessful⁽¹²⁾, whilst an intervention in Thailand has shown a trend ($P = 0.06$) towards reduced obesity prevalence in the intervention group⁽³³⁾.

Although the extent of the contribution of physical activity to preschool obesity is unclear, adopting a physically-active lifestyle is crucial for long-term health promotion. However, despite increasing awareness, most preschool children do not achieve the recommended 60 min moderate–vigorous physical activity daily^(41–43).

Developmental factors

Recently, developmental factors in early life such as nutrition and the pattern of early growth have been shown to influence the later risk of obesity. For instance, rapid growth during infancy is strongly related to obesity risk^(44–46), an effect largely attributed to nutrition. Indeed, four systematic reviews now provide strong evidence for a protective effect of breast-feeding on risk of obesity^(47–50), possibly as a result of differences in nutritional composition between human and formula milk. For example, early protein intake has been reported to be 70% greater in formula-fed infants than in breast-fed infants, which could increase the rate of infant growth and hence the risk of later obesity. Evidence to support this notion has emerged from a large trial of >1000 infants in which infants randomised to a higher protein diet during the first year of life were found to have greater weight gain in infancy and greater BMI at 2 years of age⁽⁵¹⁾. Overfeeding in early postnatal life may therefore programme obesity development later in life.

The mechanisms for the effect of nutrition and growth in infancy on the development of obesity are poorly understood. Evidence suggests that programming of energy balance is central to energy regulation and hence the development of obesity, although there are few data in human subjects to support this hypothesis. However, animal studies suggest that neuro-endocrine systems controlling energy balance develop during the perinatal period, probably controlled by the action of hormones such as insulin and leptin on the central nervous system. Environmental factors in perinatal life, including nutrition, could therefore affect the development of appetite and hence obesity risk. For example, in mice growth restriction as a result of undernutrition *in utero* followed by postnatal overfeeding leads to increased body weight and adiposity in adult life^(52,53).

The role of developmental nutritional factors beyond infancy, when diet is no longer predominantly milk based, is largely unexplored⁽¹¹⁾. However, the preschool period is a pivotal time during which long-term dietary habits are established, with potential lifelong effects on obesity⁽⁵⁴⁾. For instance, appetite in preschool children strongly influences later adiposity⁽⁵⁵⁾. Development of particular food preferences and consumption of a greater diversity of energy-dense foods could therefore influence the development of obesity⁽⁵⁶⁾.

Food preference is a strong determinant of dietary diversity. Both food preference and diversity track from the first year of life⁽⁵⁷⁾ and therefore dietary behaviours adopted in early childhood are likely to persist throughout life⁽⁵⁶⁾. A greater variety of food choice is associated with increased energy intake and a greater risk of obesity in several^(58,59) but not all studies⁽⁶⁰⁾, possibly as a

consequence of more energy-dense foods being consumed in individuals who have a diverse diet.

Secular changes affecting diet and physical activity

Societal changes

Whilst individual behaviours are influential in the development of obesity, these behaviours are strongly influenced by societal factors. The recent dramatic increase in obesity is partly attributable to societal changes that encompass educational, financial and recreational aspects⁽⁹⁾. For example, improvements in food manufacturing and marketing have resulted in increased availability of energy-dense foods⁽⁶¹⁾. Eating habits have also changed markedly. More food is now eaten outside the home, with energy-dense ‘convenience foods’ more commonly consumed⁽⁶²⁾. At the same time, increased use of technology such as lifts, moving walkways and cars has reduced the time spent in physical activity. Schoolchildren are less likely to walk to school⁽⁶³⁾, while televisions and personal computers may encourage sedentary behaviours⁽⁶⁴⁾. However, the role of these behaviours is controversial and despite the obesity epidemic it has been suggested that there has been no increase in television viewing in the USA⁽⁶⁴⁾.

Changes in diet

Dietary patterns among children have changed considerably over the past 30 years⁽⁶¹⁾. National surveys from the USA and UK suggest that preschool children’s diets do not comply with recommendations for fruit and vegetable intake but exceed the recommended intake for fat and refined carbohydrate^(65–67). Reports on energy intake of preschool children from national surveys are conflicting. In the UK energy intake has remained static or declined during the course of the obesity epidemic⁽⁶⁸⁾. For instance, the energy intake of 4-year-old children in the UK has been reported to have declined from 6046 kJ (1445 kcal)/d in 1950 to 5138 kJ (1228 kcal)/d in 1992⁽⁶⁸⁾. However, in the USA energy intakes of preschool children appear to have significantly increased from 5812 kJ (1389 kcal)/d in 1977 to 6519 kJ (1558 kcal)/d in 1994, possibly because of increases in portion size and increased consumption of food outside the home⁽⁶⁹⁾. This discrepancy may be a result of difficulties in assessing dietary intake in this age-group, which is particularly problematic for foods consumed outside the home. In the USA, for instance, a decrease has been reported in food consumed at home, from 76% total energy during the 1970s to 69% total energy in the 1990s, together with large increases in the consumption of energy-dense foods including salty snacks, pizza and soft drinks⁽⁷⁰⁾.

Changes in physical activity

Societal changes mean that many children spend more time in childcare facilities, where structured activities have displaced time spent in free play. For example, American preschool children spend less time playing, approximately 8.5 h per week less in 1997 compared with 1981⁽⁶⁴⁾.

American preschool children also spend insufficient time in recreational activity⁽⁷¹⁾. One survey (in 1998) has reported that only 16% of children take part in daily physical education sessions, with 13% participating less than once per week, often for <30 min each day⁽⁶³⁾.

Increased time spent in sedentary activities may contribute to positive energy balance and the development of obesity. In the USA many children exceed recommendations for a maximum of 2 h television viewing per d^(72,73). Recent increases in the use of media sources such as videos and computer games are likely to have increased the time spent in sedentary activity and $\leq 30\text{--}40\%$ of American children aged <6 years watch videos and play computer games daily⁽⁷³⁾. Time spent reading or being read to has also doubled in preschool children between 1981 and 1997, probably as a result of increased pressure to excel academically⁽⁶⁴⁾.

In summary, secular trends at the societal and individual level have led to changes in dietary and physical activity behaviours in preschool children that have increased the risk of obesity. Interventions to redress these changes are therefore urgently sought.

Planning an intervention for preschool obesity prevention

The main causes of the current obesity epidemic are large changes in diet and physical activity as a result of individual behaviours and societal changes. Whilst it is difficult for healthcare professionals to intervene at a societal level, there is a critical need for interventions that can help individuals to modify their behaviours.

In its recently-issued guidelines for prevention, management and treatment of obesity in the UK the National Institute for Health and Clinical Excellence recommends that interventions for childhood obesity should include advice on achieving a healthy diet, address lifestyle risk factors within the family and social settings and incorporate strategies for behavioural change⁽⁷⁴⁾. Importantly, interventions should include at least one other family member. Specific guidance for preschool children suggests that nurseries and childcare facilities should minimise sedentary activities and provide regular opportunities for active play and structured physical activity. However, despite these recommendations there are currently no published data from successful interventions for the prevention of preschool obesity in the UK.

Previous interventions for the prevention of obesity in children have reported limited success, especially in the critical preschool years. A Cochrane systematic review has found little evidence that interventions prevent weight gain or obesity⁽⁷⁵⁾ and a further review has reported that only nine of 150 childhood obesity interventions have targeted the 0–5 years age-group⁽⁷⁾. Data from controlled trials of interventions to prevent obesity in preschool children are available for only five trials (all of which were of <12 months duration). Two of these five trials intervened to increase physical activity only^(12,33) and three had interventions combining diet and physical activity^(76–78). The following is a review of the results.

Physical activity interventions

A study from Thailand in 292 preschool children randomised to either an exercise or control group has found a trend towards lower obesity prevalence in the intervention group (8.8% v. 9.4% in controls, $P = 0.06$)⁽³³⁾. The second study of 545 Scottish nursery-school children has reported no significant effect on BMI at either 6 or 12 months after the intervention⁽¹²⁾.

Combined dietary and physical activity interventions

Three controlled trials of interventions in preschool children have combined dietary advice and physical activity^(76–78). Only one of these trials has reported success, with lower BMI z-score 2 years after intervention (difference -0.54 (95% CI $-0.98, -0.10$) kg/m^2 , $P = 0.02$)⁽⁷⁸⁾.

Behavioural therapy

Previous interventions have all highlighted the importance of behavioural therapies that include theoretical frameworks to address eating behaviours and the factors that influence them^(79–81). Assessment of carers' and children's motivation to change adverse behaviours in general⁽⁸²⁾ (and eating behaviours in particular⁽⁸³⁾) is important. Although family involvement is critical to the success and sustainability of obesity prevention programmes in children, only 3% of such programmes have included a family or home-based component⁽⁷⁾.

Overall, only one intervention to prevent obesity in early childhood (age 1–5 years) has shown long-term benefits⁽⁷⁸⁾. This US-based programme combined dietary and physical activity intervention and included a behavioural theoretical framework. However, the validity and generalisability of this study to a UK population is unknown, and there appear to be no interventions in the UK designed to prevent obesity in preschool children that meet all the National Institute for Health and Clinical Excellence recommendations⁽⁷⁴⁾.

Recently, a new method has been described for building and evaluating internet-based health interventions⁽⁸⁴⁾ that could equally be applied to the development of obesity interventions. This strategy employs a multiphase optimisation design that requires: a screening phase in which candidate components for inclusion in an intervention are identified; a refining phase in which selected components are developed and their optimal proportion within the intervention is assessed; a confirming phase in which the optimised intervention is evaluated in a randomised controlled trial. This strategy may help in the design of successful interventions for childhood obesity and has been used in the Trim Tots obesity intervention.

Trim Tots preschool obesity prevention programme

As a consequence of the lack of effective interventions a programme for the prevention of obesity specifically in preschool children has been developed and piloted. The Trim Tots healthy lifestyle programme (designed by a multidisciplinary team of health professionals including

dietitians, paediatricians, exercise instructors and clinical psychologists) from the Institute of Child Health, University College, London, UK aims to educate parents and carers of preschool children in nutrition and physical activity. Behavioural change strategies are used to encourage the adoption of healthier dietary and physical activity habits. Importantly, the programme meets all current National Institute for Health and Clinical Excellence recommendations for interventions to help prevent childhood obesity⁽⁷⁴⁾.

Trim Tots is currently being piloted within a Sure Start Children's Centre. Such centres are central to the UK Government's strategy to deliver better outcomes for children and families⁽⁸⁵⁾ and have the advantage of being placed within easy access for families living in areas of medium to high social deprivation. This programme is a community- and home-based intervention that aims to help parents or carers of young children develop the knowledge and skills needed to establish healthy dietary and activity patterns. It aims to increase children's understanding of foods and nutrients using nutrition workshops incorporating music, art and craft.

The active intervention period spans 6 months during which adults and children attend twice weekly sessions in the first 12 weeks. A 2 h nutrition and activity session teaches the basics of nutrition and physical activity through interactive teaching and workshops and a 1 h physical activity session gives parents a chance to exercise while their children take part in play-based activity. Each week a 'themed' approach based on a specific nutritional topic, e.g. dairy foods and the importance of Ca in the diet, is used and included in each aspect of the intervention. Adults are encouraged to take part in interactive nutrition education that develops their understanding of how to make the best food choices, to shop for a family, plan menus and prepare healthy meals. After the intensive period the intervention continues for a further 12 weeks in which education from the initial 12-week intensive period is consolidated through a weekly session that includes music and movement, practical nutrition workshops and physical activity classes for both adults and children.

Feasibility of the Trim Tots intervention is currently being tested in a randomised controlled trial with BMI z-score as the primary outcome. Secondary outcomes include measures of body composition, dietary exposures, physical activity and cardiovascular health and fitness. If successful, it is hoped that the study will be extended to a large-scale randomised controlled trial to test the feasibility of the intervention in a national setting and evaluate cost effectiveness.

Conclusions

Clearly, the prevention of obesity in young children is a major public health priority both for societal benefit and long-term health consequences in individuals. The UK Government's strategy is to reduce numbers of obese children by 2020 to levels reported in 2000⁽⁸⁶⁾. However, the Foresight Report argues that a paradigm shift at societal and government will be required to achieve this

outcome⁽⁸⁷⁾. Substantial societal changes, e.g. large increases in food or fuel prices, might be the only scenario in which a reversal of obesity would occur. In the absence of such change it is predicted that by 2050 the prevalence of obesity in individuals <20 years of age will be 25% in the UK. It is unlikely that social change of this magnitude can be achieved. Thus, because of the serious long-term consequences of obesity there is now an urgent need for interventions to modify behaviour at the individual level, particular in young children.

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