The role of early life nutrition in obesity prevention

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Keywords:

Obesity

Prevention

Nutrition

Infancy

Abstract:

Obesity rates have increased rapidly throughout the world with more than 900 million adults having a body mass index of greater than 25. As the increase in obesity is beginning in infants and pre-school age children there has been increasing emphasis on risk factors for obesity in early life, reinforced by increasing interest in the Developmental Origins of Health and Disease (DOHAD) hypothesis. Prenatal nutrition is important with weight gain and birthweight related to subsequent obesity. The promotion of exclusive breastfeeding, reducing prelacteal feeds and the appropriate use of complementary foods remain the best public health strategies for controlling future obesity.

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(Paper presented at the 45th APACPH Conference hosted by the School of Public Health at Wuhan University, October, 2013.)

Introduction

A recent report from the Overseas Development Institute summarises the increase in obesity and overweight as a world-wide public health problem[1]. A total of 904 million people in developing countries are now classed as overweight or above, with a BMI of more than 25, up from 250 million in 1980. This compares to 557 million in high-income countries, while during the same period, the global population nearly doubled. In the Asian region childhood nutrition problems have traditionally been related to under nutrition and specific micronutrient deficiencies. But around three decades ago the situation began to change and there are now substantial numbers of obese children. In Asia (excluding Japan), nearly 5% of preschool aged children were estimated to be overweight or obese in 2010, a 50% increase in prevalence since 1990 [2]. In 2010, preschooler obesity rates were higher in Western Asia (which includes the Middle East) than in Eastern, South-eastern, or South Central Asia (15, 5, 5, and 4% respectively). But because of the large populations in India and China, the actual number of overweight and obese infants is very large [2]. However the collection of statistics is hampered in many countries by the varying definitions in use[3]. Different studies report using different definitions of obesity and different techniques and standards of measurement. The International Obesity Taskforce provides more details of the distribution of obesity in Asia in its databases [4]. Despite difficulties in measurement it is estimated that the obesity rate in children in China has increased above its historical levels, from1-2% obesity in the 1980s to a situation where currently 20% is not unusual in the cities[5].

The Developmental Origins of Health and Disease (DOHAD) hypothesis has become an important theme in paediatrics and highlights the relationships between early life growth (and other developmental factors) and lifetime health [6]. The idea that nutrition and other factors early in life can influence growth and health in later life is not new, but the hypothesis has become widely accepted only in the past few decades. The term 'programming' originated Germany and the concept was subsequently developed by Barker [7]. The original studies on which Barker based his hypothesis involved a cohort of men and women born in Hertfordshire between 1911 and 1920. Follow-up of the cohort about 50 years later showed that those who had a low birthweight were more likely to die of coronary heart disease or to develop metabolic syndrome [8]. Originally, the hypothesis related early life nutrition (prenatal), as reflected in weight at birth, to subsequent disease patterns. The hypothesis has been further developed and refined to include not only birthweight but also body leanness at birth and growth during

childhood [9]. The relationship between early life nutrition and growth is U-shaped, with underweight and obesity having lasting effects on health. Understanding of early influences on later diseases has expanded to encompass the concepts of metabolic programming, developmental plasticity and the new science of epigenetics [10-12]. They provide a theoretical basis for understanding for patterns of chronic disease. Public health nutrition interventions should emphasis the health of mothers and prenatal care to minimise the number of low-birthweight babies and thin babies (ponderal index <26) and also the number of high birthweight infants (>4000G). In early childhood programs to avoid under-nutrition or the development of overweight or obesity during childhood would minimise rates of chronic disease.

The importance of definitions in assessing obesity.

Ideally obesity would be defined on the basis of short and long term predisposition to morbidity and mortality. For adults in Western countries there are numerous studies over many decades that have been used to define the current classification using body mass index. In non-Caucasian societies the evidence suggests that limits for obesity should be lower to reflect the differences in body fat composition. For children it is a different matter and many different definitions are in use throughout Asia [5]. One approach has been to extrapolate from the adult values of BMI, an approach endorsed by the International Obesity Task Force [13,14]. However it is not known if adjustment should be applied to this classification to reflect non-Caucasian children. The alternative approach used is to select a percentile or Z score value on a specific growth reference to determine the proportion of children suffering from obesity. One of the problems with this approach has been the change in the growth references in use in different countries. In 2006 the WHO introduced its new growth standard. The rate of growth of the children included in the standard was higher in the first six months of life and then slightly lower after 12 months of age. This has the effect of decreasing the proportion of children classified as suffering from malnutrition, but increasing the proportion suffering from obesity over the age of 12 months [15,16]. Before comparing rates of obesity across time or geographical location it is important to examine the definitions used, sample selection, response rate and measurement protocols.

Overweight (excluding obesity) and obesity prevalence has now stabilised in somedeveloped countries. In Australia in school age children the rate has reached 21%, but has plateaued for the past decade[17]. In the Netherlands children of Dutch, Moroccan and Surinamese and South Asian ethnicity have stable or declining rates of overweight or obesity, but not children of Turkish origin [18]. In this study they used the revised IOTF cutoff levels for BMI for children[14]. However for most of Asia obesity rates are still rising in all socio-economic strata. Since it is far easier to prevent obesity

than it is to treat it and the public health emphasis should be on prevention. In this brief review some of the major issues in early life nutrition and the development of obesity will be considered.

Monasta and Cattaneo reviewed the early life factors associated with obesity several years ago[19]. Factors associated with later overweight and obesity include maternal diabetes and smoking, rapid infant growth, no or short breastfeeding, obesity in infancy, short sleep duration, low levels of physical activity and consumption of sugar-sweetened beverages [19].

Perinatal Factors

Birthweight

Low birth weight is defined as a birth weight of a liveborn infant of less than 2500g and high birth weight more than 4000g regardless of gestational age[20]. Monitoring the incidence of low birth weight is important for the development of perinatal medicine. Low birth weight and high birth weight not only directly affect the incidence of neonatal morbidity and mortality, but also have strong relations to long-term health outcomes in childhood and as adults. In the history of China low birth weight rates and neonatal mortality were very high but with increasing economic development and improved education and health services these rates have declined[21]. The low birth weight rate in China is now reported to be one of the lowest in the world at 3 per 1000 live births, and even as long ago as 1976 it was as low as 4.7% in Shanghai[22]. However recent reports suggest that it is likely to be more similar to other developed countries at around 6% [23]. Low birth weight if followed by rapid growth during infancy is associated with obesity and chronic disease [24]. In recent decades there has been a trend towards an increasing number of births greater than 4000 grams that has corresponded to the secular trend in increasing birth weight in China and the current rate is 6.9% of births[25,26]. Higher birth weights are associated with obesity later in life with all of the problems associated with being overweight [27,28]. A meta-analysis of birth weight and hypertension in adult life shows an inverse relationship, particularly with systolic blood pressure[29]. Recent data from the UK provides the strongest evidence by far that paternal diabetes is associated with lower birthweights, whereas maternal diabetes is associated with increased birthweight.[30]. Either outcome is not optimal for lifetime health.

The incidence of Caesarean section has increased rapidly in Asia, and has reached rates as high as 80% in some Chinese cities. Being born by caesarean section is associated

with obesity. A large Chinese birth cohort study (n=181000) found a modest association between caesarean section and obesity. Possible explanations for this may be related to increased use infant formula in these infants or to changes in the human microbiome[31]. Several studies have reported associations between parental smoking during and after pregnancy and later obesity[32,33]. There may be a direct effect of smoking or the effect could be moderated by the link between maternal and paternal smoking and lower rates of breastfeeding[34,35].

Infant feeding

Infant feeding is potentially modifiable by health promotion interventions and maternal support. There have been many recent reviews of the value of breastfeeding to infant and adult health and its role in the prevention of obesity [36,37]. The US Surgeon General tabulated the excess health risks associated with not breastfeeding in Table 1 and estimated the excess risk of obesity in non-breastfed infants to be 30%.

Table 1: Excess health risks associated with not breastfeeding

Among full-term infants	***Excess Risk (%)***
Acute ear infection (otitis media)	100
Eczema (atopic dermatitis)	47
Diarrhoea and vomiting (gastrointestinal infection)	178
Hospitalisation for lower respiratory tract diseases in the first year	257
Asthma, with family history	67
Asthma, no family history	35
Childhood obesity	32
Type 2 diabetes mellitus	64
Acute lymphocytic leukaemia	23
Acute myelogenous leukaemia	18
SIDS	56
Among preterm infants	
Necrotising enterocolitis	138
Among mothers	
Breast cancer	4
Ovarian cancer	27

* The excess risk is approximated using odds ratios. Source:[36]

The National Health and Medical Research Council gave a Grade A rating to the evidence that breastfeeding, especially prolonged breastfeeding are associated with the lowest risk of later obesity [37]. However causality will never be proven, because it is unethical to randomize women to a formula-feeding arm and so there is still some debate on the role of breastfeeding in the prevention of obesity. Casazza and colleagues suggest that existing data indicate that breastfeeding does not have important antiobesity effects in children, it has other important potential benefits for the infant and mother and should therefore be encouraged[38]. However an editorial in JAMA Pediatrics made the case for the public health perspective that there is enough evidence that breastfeeding does prevent obesity and anyway it should be strongly promoted because of its many benefits including for higher cognitive development scores[39,40]

Infant Formula

In the very rare occasions that a mother is unable to breastfeed and other sources of human breastmilk are not available, then infant formula remains the best alternative[41]. The amino acid content infant formula differs from human breastmilk and a higher protein level is required to meet minimum amounts of specified amino acids, especially tryptophan. A major well-conducted, randomised, controlled trial of lower protein formula undertaken in Europe concluded that a 'higher protein content of infant formula is associated with higher weight in the first two years of life but has no effect on length. Lower protein intake in infancy might diminish the later risk of overweight

and obesity'[7,42]. Since the publication of this study, the quality of the protein in many brands of infant formula in Europe has been improved, enabling the overall protein levels to be reduced. A review of links between protein levels of infant formula and cow's milk and obesity and chronic disease in adulthood is now available[43]. This evidence suggests that the preferable levels of protein in formula to promote appropriate growth rates should be similar to the levels in human milk, subject to a minimum content of specific amino acids[44]. Human breast milk contains 1–1.1 g protein per 100 mL and infant formulas with levels as close to this as possible should be preferred in order to reduce the risk of obesity.

The introduction of solid foods

The World Health Organisation and almost all governments and pediatric societies recommend 'exclusive breastfeeding' until six months of age, with no liquids or solids aside from breastmilk and medications. Unfortunately this is not often achieved in China or other countries in the region[45,46]. Infancy is the period of most rapid growth in weight, height and all of the developmental parameters. Appropriate growth during infancy protects against stunting at one extreme and obesity at the other[47]. There is increasing evidence of the importance of growth and nutrition in relation to obesity rates and cognitive development[47]. By around 6 months of age breastmilk (or infant formula) no longer provides sufficient nutrients and energy for growth and development, but continues to be a major source of bioavailable nutrients. At around six months the introduction nutrient dense complementary foods that are culturally acceptable is important. Introduction of complementary feeds earlier than this may reduce breastmilk production and predispose to obesity. For infants over 6 months of age, drinking water is preferable to fruit juices and other caloric drinks.[48]. Excess consumption of fruit juice by young children has also been associated with gastrointestinal symptoms, failure to thrive, decreased appetite, loose stools, failure to gain weight, and at the other end of the growth spectrum increased rates of obesity.[49]. Breastmilk and water have been the only traditional fluids given to infants and the body does not allow for calories ingested in a liquid form (Popkin 2010). The promotion of potentially unhealthy food and drinks is now recognised in Europe as a significant risk for child obesity and for developing diet-related non-communicable diseases [1].

Energy expenditure

It is important to encourage exercise and reduced sitting time from an early age to reduce obesity. There is now research that shows the importance of reduceing the amount of time sitting, such as watching television, as well as increasing exercise [50,51]

Conclusion

The first step in an obesity prevention program is to ensure that all mothers have the opportunity to breastfeed their infants, exclusively for six months and then continuing while complementary feeds are introduced. Infants who are not breastfed are one third more likely to become obese children. Preventing obesity in children requires regular monitoring of growth and introducing appropriate complementary foods after six months of age. The avoidance of infant formula, prelacteal feeds and early complementary feeds (before six months) are important public health strategies for the prevention of obesity. As a part of health promotion programs health workers and parents need to be educated on the importance of appropriate growth and a healthy diet as the basis of a healthy life. Programs designed to achieve the goals of improved maternal and child nutrition can be justified on many grounds, have no downside, and should therefore be promoted without waiting for further evidence.

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