

Being big or growing fast: systematic review of size and growth in infancy and later obesity

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Abstract

Objectives To assess the association between infant size or growth and subsequent obesity and to determine if any association has been stable over time.

Design Systematic review.

Data sources Medline, Embase, bibliographies of included studies, contact with first authors of included studies and other experts.

Inclusion criteria Studies that assessed the relation between infant size or growth during the first two years of life and subsequent obesity.

Main outcome measure Obesity at any age after infancy.

Results 24 studies met the inclusion criteria (22 cohort and two case-control studies). Of these, 18 assessed the relation between infant size and subsequent obesity, most showing that infants who were defined as “obese” or who were at the highest end of the distribution for weight or body mass index were at increased risk of obesity. Compared with non-obese infants, in those who had been obese odds ratios or relative risks for subsequent obesity ranged from 1.35 to 9.38. Ten studies assessed the relation of infant growth with subsequent obesity and most showed that infants who grew more rapidly were at increased risk of obesity. Compared with other infants, in infants with rapid growth odds ratios and relative risks of later obesity ranged from 1.17 to 5.70. Associations were consistent for obesity at different ages and for people born over a period from 1927 to 1994.

Conclusions Infants who are at the highest end of the distribution for weight or body mass index or who grow rapidly during infancy are at increased risk of subsequent obesity.

Introduction

Levels of overweight and obesity have increased markedly during the past decade in all age groups.^{1,2} Observational evidence suggests that faster growth during childhood is associated with an increased risk of obesity in later life,^{3,4} suggesting that interventions aimed at modifying childhood growth could prevent adult obesity. It is not clear, however, how early in life prevention could begin. Recent studies in the US and Finland have shown that patterns of growth during infancy may be associated with both childhood and adult obesity.^{5,6}

suggesting the potential for intervention during infancy. The precise patterns of growth leading to obesity are unclear, and both infant size and infant growth have been implicated.^{5,6}

We carried out a systematic review to assess the association between infant growth and subsequent obesity and to establish whether groups of infants with particular patterns of growth are at greater risk. We considered both size and growth because each is important in understanding the growth status of an infant—for example, an infant may be small but be growing rapidly. Given secular trends in children’s growth,⁷ we also assessed whether any associations identified in the past are likely to apply to infants now.

Methods

We sought studies that described the relation between any aspect of infant growth or size and the development of overweight or obesity at any later age. The outcomes we considered were overweight or obesity. For details of search strategy and inclusion/exclusion criteria see bmj.com.

We assessed study quality to determine whether there was a low, medium, or high risk of bias for study results. The confounding factors we considered important in the relation between infant size or growth and obesity were socioeconomic status, parental size, and method of infant feeding.

Results

We identified 24 studies that met our inclusion criteria. All 24 studies were observational (22 cohort studies and two case-control). All but two studies were based in developed countries. We considered that 15 studies were at medium risk of bias, six at high risk, and three at low risk. Common sources of bias were insufficient description of participants, high rates of attrition, and inadequate consideration of confounding factors.

Studies of infant size

Eighteen studies assessed the relation between infant size and obesity at ages ranging from 3 to 35 years. Most focused on “infant obesity” defined in various

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BMJ 2005;331:929–31



This is the abridged version of an article that was posted on bmj.com on 14 October 2005: <http://bmj.com/cgi/doi/10.1136/bmj.38586.411273.E0>

ways or on infants at the highest end of the distribution of weight or body mass index. Year of birth of infants was 1927 to 1992. Sixteen were cohort studies, two were case-control studies, and all but one were set in developed countries.

All studies used centile points in body mass index, skinfolds, weight for height, or a clinical definition to define obesity as an outcome. Six studies focused on obesity in childhood up to the age of 10,^{5 8-12} five on obesity in adolescence (9-18 years),¹³⁻¹⁷ and seven described adult obesity, mostly in those aged 20-35 years.^{6 18-23}

There was considerable consistency in study findings. Eleven studies found that infants who were heavier during infancy or were defined as obese were more likely to develop obesity in childhood,^{5 8-10} adolescence,¹³⁻¹⁶ and adulthood.^{6 18 19}

Six studies related infant size to obesity in childhood. Four found that infants who had been obese^{8 9} or who were in the highest end of the distribution for weight^{5 10} were more likely to be obese at age 5-7 years than non-obese infants, with odds ratios ranging from 1.50 to 9.38. Of the two other studies in childhood, one study failed to show an association.¹¹ The other study failed to show an association in the overall sample, though did find an increased risk of obesity at 5 years in a subsample of infants who had been obese.¹²

Of the five studies of adolescence, four found that larger size in infancy was related to increased risk of obesity at 9-18 years.¹³⁻¹⁶ Effect sizes ranged between relative risk of 1.35 and odds ratio of 3.0 for adolescent obesity in infants at the highest end of the weight distribution¹⁴⁻¹⁶ or in obese compared with non-obese infants.¹³ The years of birth ranged from 1945 to 1982, suggesting that these relations have been consistent over time. In the remaining study the direction of the association, though not significant, was consistent with the findings of the other studies.¹⁷

Of the seven studies in adulthood, three reported significant associations between infant size and later obesity. Two studies showed that obese infants were more likely to be obese as young adults at ages 20-30 years than non-obese infants,^{18 19} and the third found that larger size at 6 months of age was associated with increased lifetime risk of obesity.⁶ The findings of three other studies of adults suggested a positive relation between infant size and later obesity but were not significant.²⁰⁻²² The final study, which had only 27 participants, failed to show an association.²³

Studies of infant growth

Ten studies assessed the relation between infant growth and subsequent obesity. Nine were cohort studies,^{5 10 14 24-29} and one was a case-control study.¹⁵ Definitions of infant growth varied. Eight studies used weight gain during the first year of life.^{5 10 15 25-29} Two studies used increase in weight for age²⁴ or weight for height z scores.¹⁴

Seven of the ten studies examining infant growth found that more rapid growth in infancy was associated with greater risk of obesity at ages ranging from 4.5 to 20 years. In four studies of childhood, odds ratios of obesity in children who grew more rapidly in infancy compared with those who grew less rapidly ranged between 1.06 and 5.70.^{5 10 27 29} The studies of

What is already known on this topic

Levels of overweight and obesity are increasing in all age groups

It is not clear how early in life prevention of obesity could begin nor what form it could take

Birth weight and childhood growth are related to risk of adult obesity, but the associations of infant size and growth with obesity have not been systematically assessed

What this study adds

Infants who are at the highest end of the distribution for weight or body mass index, or who grow rapidly during infancy, are at increased risk of subsequent obesity

Strategies for prevention of childhood and adult obesity may need to address factors during or before infancy that are related to infant growth

adolescents and young adults reported odds ratios of later obesity ranging from 1.41 to 5.22.^{14 24 28} Associations between infant growth and later obesity were consistent over time: year of birth ranged from 1945 to 1994. Three studies, two in children and one in adolescents, failed to show an association between infant growth and later obesity.^{15 25 26}

Discussion

This review suggests that both size and growth during infancy are related to risk of obesity in children and adults. Most studies of infant size found that infants who were defined as "obese" or who were at the highest end of the distribution for weight or body mass index were more likely to develop obesity in childhood, adolescence, or early adulthood than other infants. The evidence relating to infant growth was also consistent across most studies reviewed. Infants who grew more rapidly (usually measured as weight gain) were more likely to be obese in childhood, adolescence, and early adulthood than other infants. There was no evidence to suggest that exposure at a particular time during infancy was critical: larger size or a rapid phase of growth at a range of intervals during the first and second year of life predisposed to later obesity. Associations were also consistent across a range of settings in developed countries; for obesity measured in childhood, adolescence, and early adulthood; and over time for people born from 1927 to 1994.

Strengths and limitations of this review

There were several challenges in interpreting the evidence. Most studies had at least a medium risk of bias in relation to the review question. Less than half of the studies of infant size took adequate account of confounding factors, though seven of the ten studies of infant growth considered most important confounders. Definitions of exposure (infant size or growth) and outcome (obesity) varied between studies and made meta-analysis impossible. This limits our ability to

make precise conclusions about the size of the effect, though the consistency of the associations we observed between both infant size and growth and later obesity across a range of settings and time periods suggest that the association is robust.

As this review was part of a much larger review it was impractical to obtain original data from study authors to carry out secondary analyses.

Conclusions

Infants in the highest end of the distribution for weight or body mass index and those who grow rapidly are at increased risk of obesity in childhood and adulthood. This suggests that factors during infancy or before that are related to infant growth influence the risk of later obesity. The relation of infant growth with other health outcomes should be explored to assess whether interventions to alter infant growth to prevent obesity are likely to be associated with other benefits or harms. It will also be important to assess whether factors influencing infant growth are amenable to change, to establish which strategies might alter infant growth, and to find out whether these are acceptable to parents.

We thank our advisory group for their input to the project, especially Paul Dieppe for chairing it. We also thank Liz Payne for carrying out our searches and colleagues at Medical Research Council Epidemiology Resource Centre, Institute of Child Health, University College London, and the Centre for Reviews and Dissemination, University of York, for their assistance and support. We are grateful to those who have reviewed this project and thank the experts and first authors of papers that we contacted for their assistance.

Contributors: See bmj.com

Funding: Department of Health. JB is an MRC special training fellow in health services and health of the public research.

Competing interests: None declared.

Ethical approval: Not required.

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(Accepted 16 August 2005)

doi 10.1136/bmj.38586.411273.E0

Corrections and clarifications

BMA warns against unnecessary screening tests in private sector

In the fourth paragraph of this News article by Lynn Eaton the reported equivalent radiation dose of a whole body scan is underestimated (*BMJ* 2005;331:475, 3 Sep). A whole body scan involves the equivalent dose of hundreds of (not 100) chest radiographs.

Taking the final step: changing the law on euthanasia and physician assisted suicide. Time for change

The end of the final summary point went awry during last minute changes to this article by M A Branthwaite (*BMJ* 2005;331:681-3, 24 Sep). The statement should have read: "Terminally ill patients seeking assistance to die should be given the same respect for self determination as those who can end their lives by refusing life sustaining treatment."

Regulating the drugs industry transparently

The author's competing interest somehow "dropped off" this article during the editorial process (*BMJ*, 2005;331:528-9, 10 Sep). John Abraham had asked us to state that he is a specialist expert adviser to the Commons Health Committee.

Radiotherapy improves outcome in patients with locally advanced prostate cancer

In redrawing the graph that accompanied this Short Cut item, compiled by Christopher Martyn, we inadvertently got our labels the wrong way round and didn't notice (*BMJ* 2005;331:477, 3 Sep). The top (red) curve, reflecting better survival, represents the irradiation group, not the "wait and see" group.