

## PAPERS AND ORIGINALS

## Do fat babies stay fat?

E M E POSKITT, T J COLE

*British Medical Journal*, 1977, 1, 7-9

## Summary

A total of 203 children included in a study of feeding practices and weight in infancy were reviewed four to five years later. Although in infancy 28 (14%) of the children were obese and a further 52 (26%) overweight, in childhood most were of normal weight and fatness, with only 5 (2.5%) obese and 22 (11%) overweight. Three of the five obese children were also obese as infants, but only one in nine obese infants was obese at 5 years. Weight in infancy does not necessarily indicate later body size. Tall stature of the children was probably related to their socioeconomic environment.

## Introduction

The theory that overfeeding in infancy leads to adipose tissue hypercellularity and a lifelong risk of obesity is simple and attractive.<sup>1</sup> Yet not all work shows overweight in infancy to be associated with excessive feeding,<sup>2</sup> and weight in infancy may not be an important determinant of later body size.<sup>3,4</sup>

In 1969-70 Shukla *et al* studied 300 infants in Dudley.<sup>5</sup> The incidences of obesity and overweight (about 17% and 28% respectively) were attributed to high energy intakes related to the early age of weaning. We have reviewed these infants in early childhood to determine whether overweight in infancy resulted in obesity and overweight in childhood.

## Patients and methods

Children were traced by health visitors, and with parental consent were seen once between October 1974 and March 1976 either in an

infant welfare clinic or at home. All data were collected by EMEP. Review included a brief history and clinical examination with measurement of height, weight, and skinfold thicknesses. The children had all been seen as infants in the 1969-70 study, and weight, length, and triceps and subscapular skinfold thicknesses were available from that study.<sup>5</sup> Data from the first year used in this paper refer only to the children reviewed.

*Weight*—All children were weighed on the same set of bathroom-type Salter scales, which were checked against standard weights before each use. Weights were recorded to the nearest 100 g. Children were weighed in vest and pants, without shoes or socks.

*Height* was measured to the nearest millimetre on a Holtain portable Stadiometer with the child standing barefoot and the head supported so that the plane of the external auditory meatus to the lower margin of the orbit was horizontal.

*Skinfold thicknesses*—Triceps, biceps, subscapular, and suprailiac skinfold thicknesses were measured to the nearest 0.1 mm with Holtain skinfold callipers by standard techniques.<sup>6</sup>

## INTERPRETATION OF ANTHROPOMETRIC DATA

*Comparison with reference standards*—Distributions of weight and height for the group as infants and children were compared with the 1966 charts of Tanner *et al*,<sup>7</sup> and distribution of skinfold thicknesses with the 1962 standards of Tanner and Whitehouse.<sup>8</sup>

*Fat component of body weight*—Body density may be calculated from the sum of the triceps, biceps, subscapular, and suprailiac skinfold thicknesses by means of regression equations. Percentage body fat is derived from density by the Siri equation.<sup>9</sup> This estimate applies to our group in childhood only.

*Percentage expected weight in relation to actual weight and height* was assessed by two methods, the reference standards of Tanner *et al*<sup>7</sup> being used. (1) Percentage weight for height ratio (referred to here as the Shukla index). This was used in the study of the children as infants and was calculated as follows: (actual weight/actual height)  $\times$  (50th centile height for age/50th centile weight for age)  $\times$  100%. The index correlates with height for age, so that tall children tend to be classed as overweight, and short children as underweight. A 5-year-old with height and weight on the 90th centile of reference charts has a Shukla index of 109% if a boy and 111% if a girl. (2) Percentage weight at age when height is on 50th centile (referred to here as the Eid index). This index is similar to that used in Eid's<sup>10</sup> study, though we used different reference standards, and was calculated as follows: (actual weight/50th centile weight at age when child's height is on 50th centile)  $\times$  100%. With this index a 5-year-old boy or girl with height and weight on the 90th centile is 105% of the expected weight. The correlation of this index with height is less than for the Shukla

Institute of Child Health, Birmingham B16 8ET

E M E POSKITT, MB, MRCP, research fellow

MRC Dunn Nutrition Unit, Dunn Nutrition Laboratory, Cambridge CB4 1XJ

T J COLE, MA, BPHIL, member of scientific staff

index. With both the Shukla and Eid indices values of over 120% indicated obesity, over 110-120% overweight, 90-110% normal, and under 90% underweight.

## Results

Of the 300 children in the original survey, 203 (68%) (100 boys, 103 girls) were reviewed by us. Most of the remainder could not be traced, though a few parents were unwilling for their children to participate. Sixteen of the children (8%) were seen at home, and 187 (92%) in an infant welfare clinic. The table gives their mean ages when studied in infancy and childhood.

### Mean ages of children when seen in infancy and childhood

	Boys (n = 100*)	Girls (n = 103)	Total (n = 203)
Mean age in years ( $\pm$ SD) when seen in infancy (range)	0.42 $\pm$ 0.23 (0.04-0.98)	0.45 $\pm$ 0.25 (0.09-0.94)	0.44
Mean age in years ( $\pm$ SD) when seen in childhood (range)	5.1 $\pm$ 0.5 (4.3-6.2)	5.1 $\pm$ 0.5 (4.3-6.4)	5.1

\*A further boy, who was not clinically overweight, was excluded from the study because he refused to co-operate.

**Weight and height**—Fig 1 shows the cumulative distributions of weight and height in infancy and childhood compared with expected distributions from reference centiles. In infancy the children were significantly heavier ( $P < 0.001$ ) but not longer than expected. In childhood they were both heavier and longer than expected ( $P < 0.001$ ), the distributions being similar for both measurements. Altogether 132 (65%) of the children (70 boys, 62 girls) were above the 50th centile height, whereas 129 (63.5%) (72 boys, 57 girls) were above the 50th centile weight. The areas between the curves indicate the greater heaviness in relation to height in infancy.

**Skinfold thicknesses**—Fig 2 shows the cumulative distribution of skinfold thicknesses in infancy and childhood compared with the expected distribution from 1962 reference centiles. Both triceps and subscapular skinfolds were thicker than reference standards in infancy ( $P < 0.001$ ), but in childhood only the subscapular skinfold was thicker ( $0.01 > P > 0.001$ ).

**Fat component of body weight**—The mean ( $\pm$ SD) percentages of the children's weight made up by body fat were  $16.5 \pm 3.9$  (range 9.0-31.5) for the boys, and  $15.4 \pm 4.6$  (7.3-26.9) for the girls. The percentage of body fat correlated significantly with both indices of weight (for both indices  $r = 0.74$ ,  $P < 0.001$ ).

**Indices of percentage expected weight**—With use of the Shukla index 35 (17.2%) of the children were found to be obese and 51 (25.1%) overweight as infants. These findings were similar to those in the original survey, suggesting that the sample reviewed was representative of the original 300 infants. With the Eid index 28 (13.8%) of the infants were found to be obese and a further 52 (25.6%) overweight.

By the time of review, only 14 (6.9%) were obese and 24 (11.8%) overweight as assessed with the Shukla index, and 5 (2.5%) obese and 22 (10.8%) overweight as assessed with the Eid index. Few obese infants grew into obese children. Only six out of 35 and three out of 28 infants obese by the Shukla and Eid indices respectively were obese at 5 years, although a further 10 (Shukla) and seven (Eid) obese infants remained overweight. Of the five children obese at review as assessed with the Eid index, three were obese, one was of normal weight, and one was underweight in infancy. There were significant correlations for each weight index at the two ages (Shukla index:  $r = 0.40$ ,  $P < 0.001$ ; Eid index:  $r = 0.25$ ,  $P < 0.001$ ).

## Discussion

### FATNESS IN INFANCY AND CHILDHOOD

In infancy the children were overweight and fat compared with the 1966 height and weight and 1962 skinfold thickness standards. In childhood they were no longer heavy in relation to their height, and skinfolds were only slightly thicker than the 1962 standards. Whichever weight index was used, most of the overweight and obese infants were of normal weight in childhood. More obese infants remained obese in childhood as assessed with the Shukla index, but this was probably owing to the association of this index with height for age. Long infants are liable to have high values and are likely to become tall children with correspondingly high values. The height bias made the Shukla index unsuitable for use as an index of overweight in our group of tall children.

As assessed by the Eid index, 5 (2.5%) of the children were obese and 22 (10.8%) overweight. Of the children obese by this index in infancy, one in three was still at least overweight. The tendency to remain overweight may be important. Children are often at their thinnest in early school years, and classification of obesity as more than 120% of the expected weight may be too generous. Children obese in infancy and overweight in childhood may relapse into obvious obesity later. This cannot be determined without further follow-up. An optimistic interpretation of the data, however, is that only one in nine obese infants was obese at 5 years.

Not surprisingly some obese children were obese as infants. Asher<sup>11</sup> found that 44% of children attending an obesity clinic had been overweight since infancy. In Birmingham Children's Hospital during 1972-6 about half of all the children referred to the obesity clinic were stated by their parents to have been fat from infancy.<sup>12</sup> Our finding of three out of five obese children (Eid index) obese from infancy gives a similar proportion. This does not necessarily indicate that obesity in these children was due to overfeeding in infancy. Genetic determinants of obesity could act in the first year of life as well.

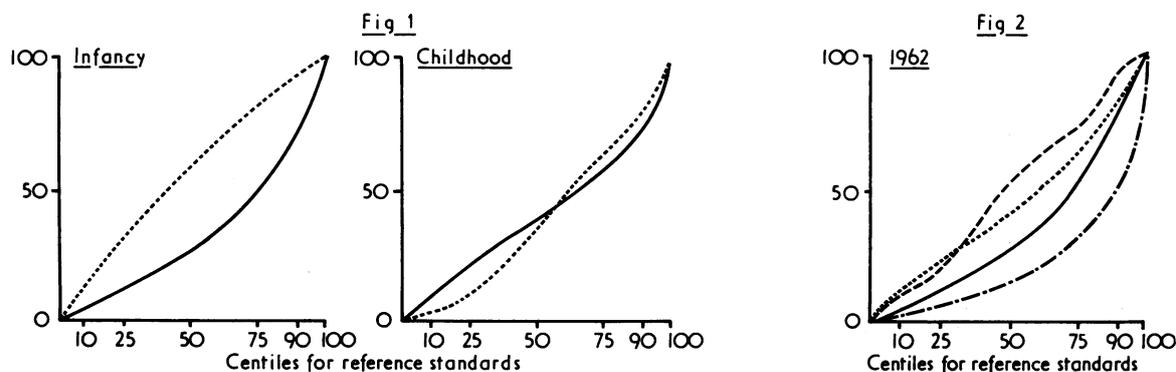


FIG 1—Cumulative distributions of weight (solid lines) and height (dotted lines) in infancy and childhood compared with standard percentile charts. FIG 2—Cumulative distribution of triceps and subscapular skinfold thicknesses compared with 1962 reference standards for infants and children. Triceps skinfold thickness: ——— infancy, — — — childhood. Subscapular skinfold thickness: — . . . — infancy, . . . . childhood.

## HEIGHT IN INFANCY AND CHILDHOOD

Why were these children taller than expected from reference standards? Improved nutrition has been used to explain the secular trends towards increased adult height in Britain. The increased height of these children over reference standards, however, seemed greater than can be explained by the secular trend since the standards were developed in 1965.<sup>13</sup> Fomon *et al*<sup>14</sup> showed increased linear growth velocity in infants receiving high energy intakes between 8 and 41 days of age, and when seen at 112 days of age the infants with early high intakes were still longer than those with lower intakes. If similar early overfeeding in our group was responsible for the tall stature in childhood, increased length should have been apparent in infancy as well as in childhood. This was not the case.

The most likely explanation of tall stature in our group was the unintentional selection of children from a good socioeconomic environment. The infants in the original survey were infants of normal birth and birth weight attending welfare clinics in Dudley. The children reviewed were those whose parents were sufficiently interested to allow their children to be examined again. This selection probably excluded many children from problem and poor homes, who might be expected to be below average height. The extent to which height and weight may vary with environment was shown in a recent study of primary school children at a private school in Hampshire and at a school on a housing estate in Sheffield. Only 1% of the Hampshire children had both height and weight below the 10th centile, whereas this was true for 45% of the children in Sheffield.<sup>15</sup> If nurture was responsible for the tall stature of our children, however, it is interesting that increased length was not apparent in the first year.

## ANTHROPOMETRIC STANDARDS

Throughout, the children's measurements were compared with anthropometric reference standards. These provide a basis for comparison but do not necessarily define the normal or even the average, except within their own group. There is no accepted distinction of normal from obese on British skinfold data. It would be ideal to define obesity from the percentage of body weight made up by fat, but estimates of this are imprecise, usually indirect, and again have no recognised normal range. Estimates of mean percentage body fat for our group were similar to those of clinically non-obese 4-year-olds studied by Griffiths and Payne<sup>16</sup> with the same formula, and slightly lower than those of white American 4-6-year-olds, in whom lean body mass was estimated with radioactive potassium.<sup>17</sup> Our values were much greater than those of Rauh and Schumsky<sup>18</sup> for boys aged 5, in whom lean body mass was determined by the multiple regression equations of Cheek and Mellits.<sup>19</sup> Thus except for this last comparison, rapid weight gain and fatness (from skinfold thicknesses) of our group in infancy do not seem to have resulted in a high mean percentage body fat in early childhood relative to other children of the same age.

Are rapid weight gain and fatness a disadvantage in infancy? It is normal for young infants to show an increase in body fat in the first few months of life. Fatness may protect against hypothermia and hypoglycaemia. The round, cuddly contours of a well-nourished infant may be important in mother-child

relationships. Predominantly breast-fed infants in rural Uganda,<sup>20</sup> in the poor areas of Ibadan,<sup>21</sup> and in areas of malnutrition in India<sup>22</sup> gain weight as rapidly as the 50th centile on British standards for the first three months of life, although their mothers may be producing milk inadequate in quality and quantity.<sup>23</sup> If young infants in these areas are growing as well as British standards, is it surprising that British infants grow better than this?

Even if early rapid weight gain is not a disadvantage, it must not continue long, if later obesity is to be averted. A slowing down in the rate of gain normally occurs. The infants in the original survey seen in the second six months of life were less overweight than those seen before the age of 6 months.<sup>5</sup> Our follow-up shows that obese infants usually return to normal weight in childhood. Thus while obesity in infancy does have some relation to obesity in childhood, presumably it is only one of many factors determining later weight. Further, if rapid weight gain in infancy is due to overfeeding, overfeeding in infancy seems to have little influence on childhood body size.

This study would have been impossible without the willing co-operation both of the families concerned and of the following members of the Dudley Area Health Authority: Dr P J C Walker, Miss A Lamb, and all the health visitors in Dudley. We are indebted to Dr A P Shukla and Mr H A Forsyth for use of the first-year data on the children. We also thank Dr P H W Rayner for support during the project, and Dr B A Wharton for helpful advice in preparing the paper. EMEP was in receipt of MRC grant G973/1001/C.

## References

- <sup>1</sup> *Lancet*, 1974, **1**, 17.
- <sup>2</sup> Rose, H E, and Mayer, J, *Pediatrics*, 1968, **41**, 18.
- <sup>3</sup> Mellbin, T, and Vuille, J C, *British Journal of Preventive and Social Medicine*, 1973, **27**, 225.
- <sup>4</sup> Fisch, R O, Bilek, M K, and Ulstrom, R, *Pediatrics*, 1975, **56**, 521.
- <sup>5</sup> Shukla, A, *et al*, *British Medical Journal*, 1972, **4**, 507.
- <sup>6</sup> Edwards, D A W, *et al*, *British Journal of Nutrition*, 1955, **9**, 133.
- <sup>7</sup> Tanner, J M, Whitehouse, R H, and Takaishi, M, *Archives of Disease in Childhood*, 1966, **41**, 613.
- <sup>8</sup> Tanner, J M, and Whitehouse, R H, *British Medical Journal*, 1962, **1**, 446.
- <sup>9</sup> Brook, C G D, *Archives of Disease in Childhood*, 1971, **46**, 182.
- <sup>10</sup> Eid, E E, *British Medical Journal*, 1970, **2**, 74.
- <sup>11</sup> Asher, P, *Archives of Disease in Childhood*, 1966, **41**, 672.
- <sup>12</sup> Poskitt, E M E. Unpublished data.
- <sup>13</sup> Tanner, J M, *Growth at Adolescence*, p 94. Oxford, Blackwell Scientific, 1962.
- <sup>14</sup> Fomon, S J, *et al*, *Journal of Nutrition*, 1969, **98**, 241.
- <sup>15</sup> Thomas, S, and Osner, R C, *Proceedings of the Nutrition Society*, 1976, **35**, 36A.
- <sup>16</sup> Griffiths, M, and Payne, P R, *Nature*, 1976, **260**, 698.
- <sup>17</sup> Flynn, M A, *et al*, *Archives of Environmental Health*, 1970, **20**, 604.
- <sup>18</sup> Rauh, J L, and Schumsky, D A, in *Human Growth: Body Composition, Cell Growth, Energy and Intelligence*, ed D B Cheek, p 242. Philadelphia, Lea and Febiger, 1968.
- <sup>19</sup> Cheek, D B, and Mellits, E D, in *Human Growth: Body Composition, Cell Growth, Energy and Intelligence*, ed D B Cheek, p 135. Philadelphia, Lea and Febiger, 1968.
- <sup>20</sup> Rutishauser, I H E, *East African Medical Journal*, 1974, **51**, 659.
- <sup>21</sup> Janes, M D, *Journal of Tropical Pediatrics and Environmental Child Health*, 1975, **21**, 26.
- <sup>22</sup> Gopalan, C, in *Protein-Calorie Malnutrition*, ed R E Olson, p 329. New York, Academic Press, 1975.
- <sup>23</sup> Morley, D, in *Paediatric Priorities in the Developing World*, p 113. London, Butterworths, 1973.

(Accepted 2 November 1976.)