Growth velocity before sudden infant death

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Abstract

Weight velocities of 136 infants who died from sudden infant death syndrome (SIDS) were compared with those of 136 controls matched for sex, birth weight, and type of feeding. It was found that the SIDS infants gained weight more slowly overall and that the differences were significantly different for infants who were not breast fed in the last two weeks in which it was possible to estimate their growth velocity. Breast fed infants had more periods of growth below the 25th centile than expected. These differences are unlikely to be useful in the prediction of which babies are likely to die from SIDS as there are frequent episodes of poor growth in infants who do not die.

A number of groups have addressed the issue of weight gain for infants who die from sudden infant death syndrome (SIDS).^{1 2} Some have concluded that such infants gain weight slowly or show signs of delayed physical development.³ Others believe, that while there may be some suggestion that SIDS infants grow more slowly than other children, the difference is so small and the normal individual variation so great that growth rate is unlikely to be useful as a predictor of SIDS.²

This study was part of a comprehensive case-control study which examined risk factors for SIDS in the South Island of New Zealand.⁴ This area has a particularly high incidence of SIDS (6.3/1000 live births) compared with the rest of New Zealand (4.2/1000 live births) and the rest of the Western world (on average 2/1000 live births). In this part of the study the growth characteristics of a group of infants dying of SIDS are compared with infants matched for sex, birth weight, and type of feeding.

Patients and methods

The infants in the study were born in the Christchurch, Invercargill, and Dunedin Health Districts between January 1979 and December 1984. Information about the SIDS deaths was supplied by the National Health Statistics Centre, Wellington, and was cross checked with regional coroner's records. All necropsy and historical data were reviewed and the SIDS label given independently by two of the authors (EASN and BJT).⁵ Of 377 infants who died of SIDS during that period, 297 (79%) attended clinics run by the Royal NZ Plunket Society. For the purposes of the risk factor study two controls were chosen for each infant.

For this part of the study the infants were

chosen from those who attended Plunket Society clinics. As part of their surveillance service the Plunket nurses weigh children in their homes until they are 8 weeks old and in clinics until they are 5 years old. They also advise on feeding and management. To be included in this part of the study the infants had to have survived for at least four weeks, have a weight recorded within four weeks of death, have inter-weight intervals of less than six weeks in the first three months of life, and less than three months in the next nine months of life. Each infant was matched with an infant from the control group, who was of the same sex, had a similar birth weight, and had been fed in the same way. Infants were described as breast fed if they were mainly breast fed without supplements at the age of 4 weeks. All infants born at less than 37 weeks' gestation, twins, and those with a congenital anomaly likely to disturb growth were excluded. Because the weight data was essentially 'field data', the intervals between measurements were irregular. To overcome this problem a smoothing spline technique was used to derive regular two weekly weights.⁶ This was done for as many infants as possible. Growth in terms of level, trend, and variability was compared between the two groups using paired *t* tests. The level of growth was defined as the average of the weights every two weeks up to the last one before death and was computed for each case. The same number of observations were used to compute a mean for the corresponding control. The second measurement was slope, trend, or average velocity and was calculated by method of least squares. Again, the death weight was excluded. This was measured in g/day. The square root of the residual variation was used as a measure of variation. This gives an indication of how closely the weight measurements fit the regression line (see figure).

We were also interested in the growth velocity within the last two complete two week periods before death of the SIDS infants and the corresponding period for their matched control. This was calculated by dividing the differences between successive spline measurement by 14, giving a velocity in g/day. The death weight of the SIDS infants, which was recorded by the pathologist at the time of the necropsy, was compared with the weight of the control infant for the equivalent day, calculated by linear interpolation.

Details of feeding and growth problems recognised by the Plunket nurses were extracted from the Plunket notes at the same time as the weight measurements.

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Example of pair of growth curves with regression line fitted. Death weight is shown for the case and estimated weight for the matched control at the same age.

The results are reported for breast fed infants and for those not breast fed separately because we had shown that growth rates for the first six months of life for the two groups were significantly different.

Of the 297 infants who had some contact with the Plunket Society, 33 were excluded because they were premature (gestational age 36 weeks or less) and 128 because their attendances at the clinic were too infrequent for reliable splines to be computed. Hence, this study was carried out on 136 infants (36% of the original sample and 46% of those seen by the Plunket Society). When the three groups were compared there were no significant differences for birth weight, length, and head circumference. There were, however, significant differences for mothers' age ($p < 0.01$). The mothers who did not take their babies to Plunket clinics were on average two years younger than those who did. The proportions of Maori and single mothers were similar.

Results

The figure shows the birth weights and the weights derived from the splines for a pair of infants. The last points are the death weight for

the SIDS infant and the weight, obtained by linear interpolation, of the matched control on the same day. The slope of the line shows the average weight gain from birth to the last weight measurements derived from the splines.

The results for the breast fed infants whose mean age at death SIDS was 88.8 days (range 29–322) are reported in table 1. The difference for birth weights was significant, but it should be noted that the mean difference was only 4 g. The difference in weight at the time of death was also significant, the mean difference being 237 g. The differences between the SIDS infants and their controls for the last two spline measurements were not significantly different. The differences in overall growth velocity as well as those in the two periods between the last three spline measurements were not significantly different, though the SIDS infants grew on average at a slower rate than their matched controls throughout. The growth velocity between the last measurements and death differed appreciably. Some of this difference can be attributed to weight loss at the time of death. The variability of weight velocity did not differ between the groups.

Infants who had not been breast fed died of SIDS at a mean age of 77 days (range 31–157). The comparisons with the controls show a rather different pattern than those for breast fed infants and are shown in table 2. Like the breast fed infants they showed significant differences in weight at the time of death, the mean difference being 371 g. The difference in growth velocities was also more noticeable, with the difference in overall velocity approaching significance ($p < 0.07$) and a lower growth velocity for the two weeks between the last two spline measurements ($p < 0.01$). Again the difference between the last measurement and the weight at the time of death was significant. Variability of growth velocity was not different between groups.

In order to examine the difference in velocity gradients more closely, the results for the last two two week periods are reported in terms of

Table 1 Breast fed infants: means, standard deviations, and differences for weights and weight velocities

	No of infants	Mean (SD)	Mean difference	t	p Value
Weight (kg):					
Birth	88				
SIDS		3.43 (0.433)			
Controls		3.43 (0.432)	0.00	-2.01	0.05
Death	66				
SIDS		5.48 (1.330)			
Controls		5.72 (1.335)	-0.24	-2.19	0.03
Velocity (g/day):					
Birth to last spline measurement	88				
SIDS		25.5 (9.15)			
Controls		26.4 (9.80)	-0.9	-0.62	0.54
Last two weeks	46				
SIDS		26.3 (10.69)			
Controls		27.4 (13.62)	-1.1	-0.50	0.62
Penultimate two weeks	88				
SIDS		25.0 (11.31)			
Controls		25.0 (10.89)	0.0	-0.01	1.00
Last spline to death	66				
SIDS		18.4 (24.18)			
Controls		24.7 (9.84)	-6.3	-2.60	0.03
Variability (kg):	88				
SIDS		0.9 (0.73)			
Controls		1.1 (0.97)	-0.2	-1.71	0.09

Table 2 Non-breast fed infants: means, standard deviations, and differences for weights and weight velocities

	No of infants	Mean (SD)	Mean difference	t	p Value
Weight (kg):					
Birth	48				
SIDS		3.35 (0.630)			
Controls		3.36 (0.550)	-0.01	-0.60	0.55
Death	33				
SIDS		5.25 (0.859)			
Controls		5.62 (0.910)	-0.37	-2.83	0.01
Velocity (g/day):					
Birth to last spline measurement	48				
SIDS		28.4 (10.42)			
Controls		31.4 (8.53)	-3.0	-1.86	0.07
Last two weeks	21				
SIDS		25.6 (14.24)			
Controls		36.5 (12.62)	-10.6	-3.15	0.00
Penultimate two weeks	48				
SIDS		28.4 (11.34)			
Controls		31.5 (12.59)	-3.1	-1.67	0.10
Last spline to death	33				
SIDS		18.9 (22.93)			
Controls		31.7 (14.58)	-12.8	-2.79	0.01
Variability (kg):	48				
SIDS		1.1 (0.77)			
Controls		0.9 (0.74)	-1.8	-1.22	0.23

Table 3 Frequencies and percentages for growth velocities in the last two two week periods standardised for sex and age. Results are number (%)

	Penultimate two weeks		Last two weeks	
	SIDS	Controls	SIDS	Controls
<i>Breast fed infants</i>				
Weight velocity quarters:				
First	34 (38.6)	22 (25.0)	19 (41.3)	12 (26.1)
Second	19 (21.5)	23 (26.1)	9 (19.6)	12 (26.1)
Third	16 (18.1)	25 (28.4)	6 (13.0)	11 (23.9)
Fourth	19 (21.5)	18 (20.5)	12 (26.1)	11 (23.9)
Total	88	88	46	46
<i>Non-breast fed infants</i>				
Weight velocity quarters:				
First	12 (25.0)	6 (12.5)	7 (33.3)	2 (9.5)
Second	9 (18.8)	9 (18.8)	4 (19.0)	0
Third	14 (29.2)	16 (33.3)	5 (23.8)	8 (38.1)
Fourth	13 (27.1)	17 (35.4)	5 (23.8)	11 (52.4)
Total	48	48	21	21

quartiles standardised by age and sex. From table 3 it can be seen that in the last month of life around 40% of the breast fed SIDS infants had a least one two weekly growth velocity below the 25th centile. The number of controls was much closer to the expected 25%. This excess was not so noticeable among the non-breast fed infants. The percentage of SIDS infants below the 10th centile was also more than expected, 17% compared with 12% of the controls for the breast fed infants; the rates for the non-breast fed infants were similar.

Information was obtained from the Plunket clinic notes about weight gain. Among the breast fed infants the nurses noted poor weight gain in five (6%) SIDS infants and five (6%) controls during the first four weeks of life and in nine (10%) SIDS infants and seven (8%) controls between five and 12 weeks. Only one of the SIDS infants and one control among the non-breast fed infants showed poor weight gain in the first four weeks and five SIDS infants in the next eight weeks.

Discussion

The findings of this study are consistent with those of other studies, which showed that the weight gain of SIDS infants was less than that of

normal infants.¹⁻³ This study suggests that the weight gain of breast fed infants who died of SIDS was not very different from that of infants who survived. There is some evidence, though, that in bottle fed infants the weight gain of the SIDS infants was considerably slower than the controls. The absolute level of weight gain of the SIDS infants was very similar to that of the breast fed infants, however, while the weight gain of the controls was greater. That fewer than expected non-breast fed control infants had growth velocities below the 25th centile is consistent with this finding as is the greater difference in death weight of bottle fed cases and controls compared with breast fed cases and controls. Despite there being more weight velocities below the 25th centile and the 10th centile, the number in the very low centiles was close to that expected, so it seems unlikely that the sort of weight velocity differences detected were clinically worthwhile.

It could be argued that fitting a linear trend to the data was inappropriate because weight gain, as can be seen from the figure, was not linear. But as we were interested in the differences in overall weight gain between each SIDS infant and his or her matched control, rather than differences in pattern of growth, comparing differences in slopes was a straight forward way of

doing this. The similarity in variability in the two groups suggests that the growth patterns were not different though the variability overall may have been reduced by the smoothing spline technique.

One of the limitations of this study was that sufficient data to analyse growth adequately was available for only 136 of 377 infants who died of SIDS. It should be recognised, however, that all these infants were full term (37 or more weeks' gestation) and regular attenders at infant health clinics. The babies studied would therefore be generally a rather low risk group for SIDS. A prospective study with less 'drop out' may well find a higher incidence of growth failure. As our data was from routine health surveillance, we can say with some confidence that this degree of routine weight monitoring is unable to alter substantially the high incidence of SIDS in our community (7/1000 live births).

This study, like others, found a significant difference between the death weight of the SIDS infants and the weight of the controls. The differences in this study were not of the same magnitude as those reported by Peterson who suggested that they were as high as 500 to 1000 g.⁷ He attributed some of the difference to agonal bowel and bladder evacuation and post-mortem dehydration but did not adjust for differences in birth weight. Matching for birth weight was intended to overcome this problem as well as making the comparisons between growth velocities more meaningful. These results suggest that the difference in weight was around 240 g for the breast fed infants and 340 g for the others. The slower weight gain of the SIDS infants from the time of their birth as well as in the period just before their death is consistent with this, though it is difficult to know how much of the difference can be attributed to slow growth and how much weight loss after death.

Other studies, however, offer more support for the idea that infants are compromised by poor weight gain.⁸ In examinations of thymus, rib, and liver in a series of 200 SIDS infants during necropsy it was found that more than 90% of them showed costochondral junction abnormalities. These were attributed to retardation in growth velocity and it was concluded that careful monitoring of these infants during life would have shown periods of slow growth in almost all. In another study in which apnoea monitors were compared with weighing scales in two groups of infants, who were siblings of SIDS infants, the weight fluctuations of 50 infants were described.⁹ Their progress was plotted on special charts constructed in such a way that an infant was not expected to move up or down more than one channel width in a two week period or two channel widths in an eight week period. It was found that there were 17 falls in weight and that 16 of these were associated with illness. After the conclusion of the

study one child, who had been in the apnoea monitor group, died of SIDS and it was found that his weight gain had been satisfactory until the 15th week but had remained virtually stable after that. It was suggested that his growth failure should have been detected before his death. On the basis of this study the authors have come to believe that daily weighing accompanied by weekly visits from the health visitor would be an acceptable way to monitor growth velocity and perhaps prevent SIDS. The less refined measurements obtained in this study suggest that many infants have experienced periods of slow growth, and that even though SIDS infants grow rather more slowly over long periods their gain in weight is in the main what is expected of infants at that stage of development. Thus monitoring their growth in this way is unlikely to identify potential SIDS victims. Monitoring their growth more closely may, despite the evidence of one study, lead to anxiety and is certainly more costly in terms of nurse time, but if it is thought to be worthwhile should be investigated in a large prospective study before being strongly recommended.

Our study suggests that weight monitoring would not appear to be useful in detecting babies likely to die of SIDS mainly because many infants who do not die of SIDS also have episodes of poor growth. Episodes of poor growth in our control group were often associated with the recording of symptoms that would explain the poor weight gain, however, and the detection of poor weight gain may lead to appropriate further investigation. The effectiveness of routine weekly weighing of babies with their further evaluation if the weight velocity falls below the 10th centile on two consecutive weekly periods needs to be evaluated in a large prospective study of infants at very high risk of SIDS.

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