



Figure 2 Increase in crown-heel length (A) and ulnar length (B) compared with age.

observed between the sexes, or between feed groups, and the data have therefore been combined.

As crown-heel length, ulnar length, and occipitofrontal circumference were not measured at the time of birth, the graphs for these measurements do not intersect the y axis. Their incremental changes are shown relative to the first measurement, made at a group mean age of 16 hours after delivery.

It can be clearly seen that despite losing weight, and with an initial decrease in head circumference (possibly due to moulding), both crown-heel and ulnar length increased from the first day after birth.

### Discussion

We have shown that the linear growth of a single bone and of length overall continues from the first day after birth. The percentage increase in crown-heel length was 2.5%, and in ulnar length 3.0%. The close degree of agreement between these values makes it unlikely that other factors, such as variation in muscular tone, or alterations in soft tissue water content contributed significantly to the observed increase in body length.

The actual rate of growth of 11.5 mm in one week is the most rapid seen ex utero, and is essentially a direct continuation of that observed

in the latter part of the third trimester.<sup>3</sup> By contrast, weight falls immediately after birth by an average of 6%, and is not usually regained by the age of 1 week. This implies that skeletal growth is to some extent 'preprogrammed' to continue despite the abrupt alteration in nutrient supply. It is possible that the consequent demand for mineral substrate contributes to the hypocalcaemia commonly observed in the neonatal period.<sup>4</sup>

Total energy requirements increase post-natally,<sup>5</sup> yet until enteral food intake is established there is negative energy balance. It is interesting that rapid early bone growth is given priority at this stage and is presumably fuelled at the expense of other tissues. Our observations also have important implications for the interpretation and collation of growth and mineral balance data in neonates.

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## Neonatal cilia: ultrastructure

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### Abstract

The number of inner and outer dynein arms and gross ciliary abnormalities of well newborn children and adults were similar. Inability to

see all nine outer dynein arms in healthy adults may be due to technique and not recent infection or congenital ciliary malformation.

*Inner and outer dynein arm counts and percentage of multiple or disorganised cilia and cilia with missing doublets in adults and neonatal patients*

Subject No	No of cilia counted	Outer dynein arms	Inner dynein arms	Multiple (%)	Disorganised (%)	Missing doublet (%)
<i>Adults</i>						
1	35	6.3	2.3	—	—	—
2	30	7.3	3.7	—	—	0.1
3	26	7.6	3.5	—	2.7	2.2
4	35	8.1	3.6	2.1	—	6.3
5	46	7.2	2.9	2.5	2.5	10.6
6	61	6.6	3.4	—	—	—
7	42	6.5	3.0	—	—	—
8	36	6.5	3.2	0.7	1.5	—
9	29	7.2	4.3	—	—	0.6
10	46	7.5	3.3	—	—	10.6
<i>Neonates</i>						
11	38	6.8	3.3	1.6	1.7	0.0
12	15	6.7	3.8	2.6	3.7	1.1
13	38	7.9	3.4	—	0.3	2.7
14	26	6.9	4.2	2.8	1.0	4.0
15	29	6.8	3.7	—	0.3	—
16	36	7.1	3.2	—	—	—
17	30	5.8	3.3	—	—	1.3
18	18	6.9	3.3	—	2.3	0.8
19	33	6.0	3.6	—	—	—
20	41	5.1	3.2	—	0.6	—
21	48	7.8	4.2	1.8	—	—
22	32	7.1	3.7	—	—	1.9
23	28	6.2	4.2	—	2.6	—
24	38	7.2	2.8	1.0	1.8	1.2
25	37	7.8	3.2	1.8	—	0.6
26	40	6.0	2.4	—	4.2	8.0
27	25	6.7	2.1	1.0	4.1	12.3
28	36	6.8	3.7	—	—	—
29	35	6.8	3.8	2.7	5.3	10.0
30	32	5.5	3.4	—	0.0	0.0

Respiratory tract infections are common in patients with abnormal nasal cilia structure.<sup>1</sup> The presence of genetically abnormal cilia has prognostic implications and the study of ciliary structure is a useful investigation in children with recurrent respiratory tract infections.

Cilial ultrastructure is assessed by determining the mean number of inner and outer dynein arms in a large sample of cilia. In addition, abnormalities such as multiple, disorganised cilia or cilia lacking microtubules are noted.

It is rarely possible to see all inner and outer dynein arms in a cilial sample probably because of recent infection or fixation technique. We compared cilial ultrastructure in a group of adults with well newborn children before any respiratory illness to determine the effect of fixation on electronmicroscopical appearance.

#### Patients and methods

Twenty well neonatal patients from the postnatal ward were studied; their mean (SD) age was 1.8 (0.5) days. Ten adults with mean age of 21 (5) years, and who had been free from an upper respiratory tract infection for at least six weeks, were studied.

Cilia were obtained by nasal brushing. In adults this was done by direct vision of the inferior nasal turbinate bone. In the neonatal patients the brush was inserted 1.5 cm, rotated, and withdrawn in a blind fashion from the nose.

Immediately after brushing the cilia were dislodged by brisk agitation directly into sodium cacodylate buffer at pH 7.4 and fixed in buffered glutaraldehyde. Ultra thin sections were prepared and stained with uranyl acetate and lead citrate. The grids were examined by

transmission electron microscopy ( $\times 75\ 000$ ) and gross structural abnormalities recorded. These included the percentage of cilia with missing doublets and percentage of multiple or disorganised cilia. Magnification was raised ( $\times 130\ 000$ ) and the number of dynein arms counted ( $>150$  individual cilia from each patient). A tilting and rotating grid holder allowed optimal cross sectional cilial views.

An unpaired *t* test was used for statistical analysis. Ethical approval was given by the Nottingham University Hospital Committee and parental consent was obtained.

#### Results

There was no significant difference in the number of gross abnormalities (percentage of multiple or disorganised cilia or percentage of cilia missing doublets) or numbers of inner and outer dynein arms between the neonatal or adult groups (table). No neonatal patient appeared to be distressed by the nasal brushing. Several sneezed but none had a nose bleed.

#### Discussion

It is rare to see all of the inner and outer dynein arms of a cilial. It has been difficult therefore to say whether the reduced number of dynein arms seen is due to fixation, infection, or congenital absence. Older children and adults are frequently exposed to upper respiratory tract pathogens that may induce changes in nasal cilia.<sup>2,3</sup> Some of these changes last for short periods of time, but others may take several months to disappear after treatment of the precipitating cause.

The neonatal patients we studied were well and most less than 3 days old, thus we assumed their cilia were normal. There was no difference in ciliary ultrastructure between adult controls and the neonatal group. Thus with our technique for measuring dynein arms we can assume the mean (SD) value of 6·81 (0·7) for outer arms and 3·38 (0·54) for inner arms in the adult group is due to fixation and technique and not loss of dynein arms with age or insult. It is important that electronmicroscopists define the

normal values as this may vary from unit to unit. In addition, full ciliary analysis includes functional studies as ultrastructure may be normal but function abnormal.<sup>1</sup>

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