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Influence of elective preterm delivery on birthweight and head circumference standards

P L YUDKIN, M ABOUALFA, J A EYRE, C W G REDMAN, AND A R WILKINSON

Departments of Obstetrics and Paediatrics, John Radcliffe Hospital, Oxford

SUMMARY We calculated new birthweight and head circumference centiles for boys and girls between 24 and 42 weeks' gestation from 20 713 singleton live births at our hospital between 1978 and 1984. Among the 803 babies born at or before 34 weeks' gestation, 28% were delivered electively for fetal problems; they were considerably lighter than babies born after spontaneous preterm labour. In contrast, they showed only a small deficit in head circumference, possibly due to a brain sparing effect in growth retarded infants. Electively delivered preterm infants cause a bias in birthweight and head circumference centiles and we recommend that these babies should be excluded when these centiles are calculated.

Commonly used tables of birthweight and head circumference centiles[1–5] differ from one another, varying both in the mean and spread of values at different gestational ages. These differences are likely to reflect differing degrees of accuracy in determining gestational age but also genuine differences in the populations from which the data were derived. A further problem is the lack of data relating to very early gestational ages, yet elective delivery of infants before 30 weeks' gestation is increasingly common.

Thus there is an incentive to construct new standards based on local data, and such data will become more widely available as more hospitals develop computerised obstetric data banks. In constructing centiles based on deliveries at our hospital between 1978 and 1984 we noticed that the birth weights of our preterm babies were lower than those reported in other series based on births occurring 10 or 20 years earlier. We surmised that this might be due to the fairly large number of preterm infants in our series delivered electively for fetal problems. We therefore decided to examine separately the birth weights and head circumferences of electively delivered preterm babies and those born after spontaneous onset of labour.

Patients and methods

Detailed and complete information about all deliveries at the John Radcliffe Hospital, Oxford, has been recorded on the Oxford Obstetric Data System since 1978. Coding is from the case notes taken by trained staff, with supervision throughout by one of us (CWGR). The data are double keyed and subjected to rigorous error checks (full details on request).

The system provided the birth weights and gestational ages of 20 713 singleton infants, comprising all those births in 1978–81 and births at 34 weeks' gestation or less in 1982–84. Of these infants, 19 107 (92%) also had a recorded occipitofrontal head circumference. Nearly all (96%) were white. Study infants were selected after excluding stillbirths and babies with major congenital malformations—that is, defects of the skull, brain, spinal cord, musculoskeletal system, and chromosomes and renal agenesis.

Healthy babies were weighed in the delivery suite and those needing special care on admission to the special care nursery. From 1978 to 1981 we used scales (Avery) accurate to within 5g, which were subjected to weekly validation. During 1981 these were replaced by electronic scales (K-Tron) accurate to within 1g, which were also regularly validated. Head circumference was measured by a paediatrician within 24 hours of birth, using a disposable tape.

Gestational age was defined as the number of completed weeks from the last menstrual period. This result was compared with gestational age predicted by an early—that is, before 20 weeks—ultrasound scan. As the approximate 95% confidence limits for this prediction are ±10 days,[6] the

scan assessment was preferred only if it estimated a gestational age differing by more than 14 days from the estimate based on dates. Assessment of gestational age by paediatric examination[7] was made for low birthweight (<2000 g) babies. If the assessment by paediatric examination differed by more than 21 days from the previously estimated gestational age the former was preferred.

Ultrasound scanning before 20 weeks' gestation was carried out on an estimated quarter of all women in 1978, the proportion rising steadily to half of all women in 1984. For the remaining women, gestational age was estimated from dates and paediatric assessment alone. Where gestation estimated by dates was clearly incompatible with the size of the baby, or where the date of the last menstrual period was unknown, the baby was excluded from our series; 169 babies (0·8% of the total) were excluded for this reason.

Birthweight and head circumference means and standard deviations were calculated separately for boys and girls for each week of gestational age.

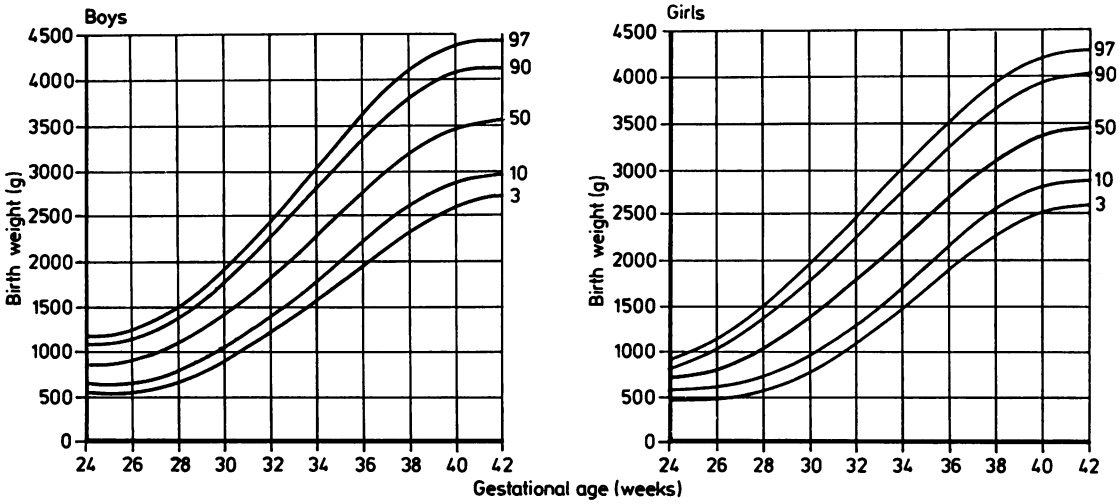

Fig. 1 *Birthweight centiles for all the babies studied.*

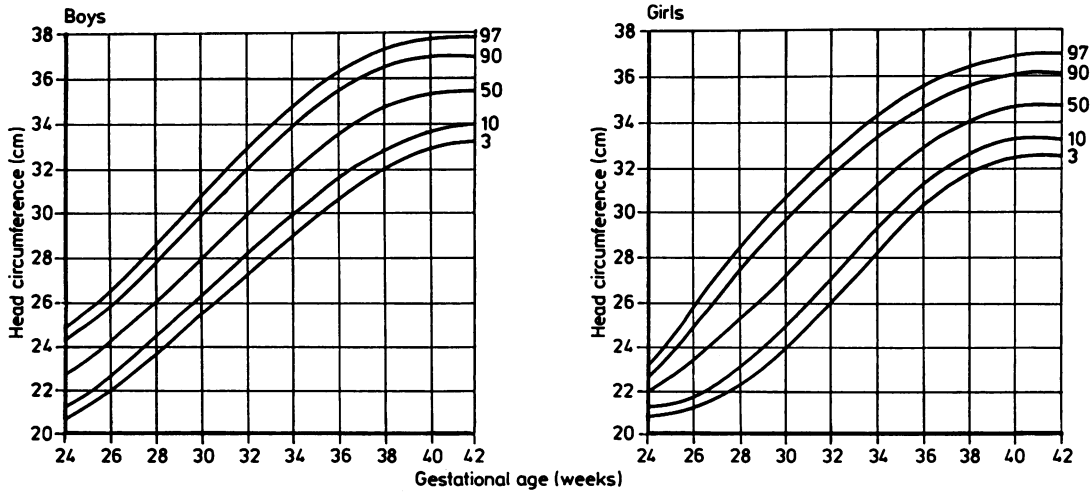

Fig. 2 *Head circumference centiles for all the babies studied.*

Curves were fitted to the mean values, using polynomial regression, the best fit (r=0·99) being obtained with a third degree polynomial.

The 803 babies of gestational age 34 weeks or less were separated into two groups, 'elective' and 'spontaneous'. The 'elective' group (n=226) included all babies born after induction of labour or by caesarean section before labour for pre-eclampsia, intrauterine growth retardation, fetal distress, or rhesus incompatibility. The 'spontaneous' group (n=577) consisted of babies born after spontaneous premature labour, premature rupture of the membranes, or antepartum haemorrhage. Birthweight and head circumference means and standard deviations were calculated between 24 and 34 weeks' gestation for the spontaneous group and between 27 and 34 weeks' gestation for the elective group. Only four babies were delivered electively before 27 weeks and they were excluded.

To examine the influence of the electively delivered preterm babies on the birthweight and head circumference standards, a second set of curves was constructed excluding these babies. These curves were fitted, using polynomial regression, to the mean values for the spontaneous group between 24 and 34 weeks' gestation and the mean values for all babies at later gestations.

Comparisons between means were made using the *t* test; correction for unequal variances followed the method of Cochran.[8]

Results

Preliminary analysis. The distributions of birth weight and head circumference at each gestational age were examined. Before 32 weeks' gestation there were too few observations to give a clear picture. At 32 and 33 weeks' gestation both distributions showed a negative skew, which was reduced by removing data from the electively delivered babies. At later gestational ages the distributions were very close to normal. Based on these observations and supported by data from other studies,[3 4 9] the centiles at all gestational ages were estimated assuming a normal distribution. The 3rd and 97th centiles were placed 1·88 SD from the raw mean and the 10th and 90th centiles 1·28 SD from the mean. The resulting centiles were smoothed using polynomial regression.

Birthweight and head circumference values. Smoothed means and centiles of birth weight and head circumference for all babies of gestational age 24 to 42 weeks are illustrated in Figures 1 and 2. Smoothed mean values for boys were higher than for girls at each week of gestational age. Head circumference values were more closely clustered around the mean than were birthweight values.

Raw birthweight means for the spontaneous and elective groups between 27 and 34 weeks' gestation are shown in Table 1 and raw head circumference means in Table 2. At each gestational age, babies in the spontaneous group were heavier and had larger heads than those in the elective group. The differences in mean birth weight ranged from 163 to 569 g and were significant except at 28 weeks' gestation in boys. The differences in head circumference were proportionately smaller (ranging from 0·8 to 4·1 cm)

Table 1 *Birthweight raw means for the spontaneous and elective groups by gestational age*

Gestational age (wks)	*Spontaneous*		*Elective*		*p Value*
	n	*Mean (SD) (g)*	*n*	*Mean (SD) (g)*	
Boys					
27	17	1085 (167)	3	690 (50)	<0·001
28	14	1122 (133)	5	903 (269)	NS
29	23	1310 (201)	13	968 (228)	<0·001
30	18	1467 (247)	13	1168 (253)	<0·01
31	23	1751 (290)	7	1304 (338)	<0·05
32	48	1965 (249)	9	1541 (361)	<0·01
33	66	2078 (279)	30	1915 (390)	<0·05
34	94	2363 (345)	28	1935 (445)	<0·001
Girls					
27	12	1009 (221)	3	605 (151)	<0·05
28	20	1101 (167)	6	789 (108)	<0·01
29	17	1410 (151)	6	841 (269)	<0·01
30	6	1566 (270)	13	1078 (308)	<0·05
31	17	1653 (337)	15	1211 (315)	<0·01
32	20	1722 (270)	14	1469 (380)	<0·05
33	33	2071 (306)	31	1818 (365)	<0·01
34	98	2330 (336)	26	1828 (315)	<0·001

NS=Not significant.

Table 2 *Head circumference raw means for the spontaneous and elective groups by gestational age*

Gestational age (wks)	*Spontaneous*		*Elective*		*p Value*
	n	*Mean (SD) (cm)*	*n*	*Mean (SD) (cm)*	
Boys					
27	16	25·6 (1·23)	3	23·2 (0·64)	<0·01
28	12	26·3 (1·12)	5	24·8 (1·46)	<0·05
29	21	27·5 (1·72)	10	25·9 (1·47)	<0·05
30	16	28·1 (1·39)	12	27·3 (1·59)	NS
31	22	29·1 (1·65)	7	28·3 (1·53)	NS
32	43	30·6 (1·39)	9	28·8 (1·60)	<0·001
33	64	31·5 (1·48)	26	30·7 (1·94)	<0·05
34	89	32·2 (1·40)	26	31·1 (1·59)	<0·001
Girls					
27	11	25·8 (1·27)	3	22·3 (1·70)	NS
28	17	25·8 (1·65)	6	24·6 (1·56)	NS
29	13	28·2 (1·37)	5	24·1 (1·87)	<0·01
30	6	28·6 (1·63)	13	26·0 (1·42)	<0·01
31	17	28·9 (1·79)	14	27·6 (1·65)	<0·05
32	15	29·3 (1·77)	13	28·5 (1·35)	NS
33	31	31·2 (1·51)	30	30·5 (1·45)	<0·05
34	96	32·0 (1·33)	23	31·0 (1·49)	<0·01

NS=Not significant.

and not all were significant. Smoothed mean values of birth weight and head circumference for the spontaneous and elective groups are illustrated in Figures 3 and 4.

The effect of the electively delivered preterm babies on the birthweight and head circumference mean curves is shown in Table 3. Between 26 and 34 weeks' gestation smoothed mean birth weight excluding these babies was higher than the smoothed mean based on all the babies. The difference was most pronounced between 28 and 32 weeks' gestation, being 80 to 100 g for boys and 140 to 160 g for girls. There was little difference, however, between the head circumference mean curve based on the spontaneous group and that based on all the babies. The maximum differences (0·3 to 0·4 cm for boys and 0·8 to 1·0 cm for girls) were observed between 27 and 32 weeks' gestation. The spread of birth weights (assessed by variance) was smaller among the spontaneous group alone than among all the

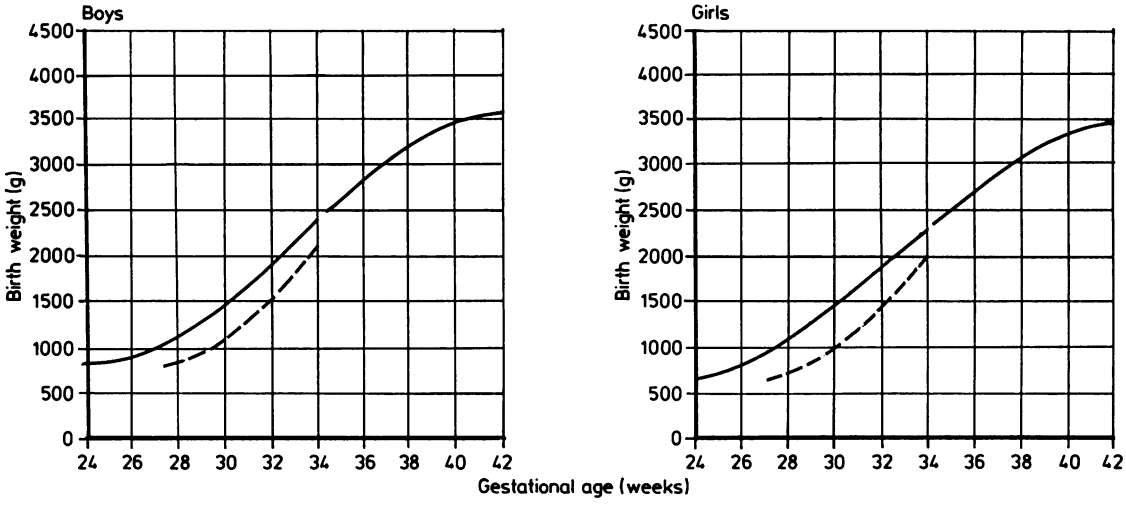

Fig. 3 *Smoothed mean values for birth weight in the spontaneous (——) and elective (– – –) groups up to 34 weeks' gestation and in all the babies at 35 weeks' gestation and later.*

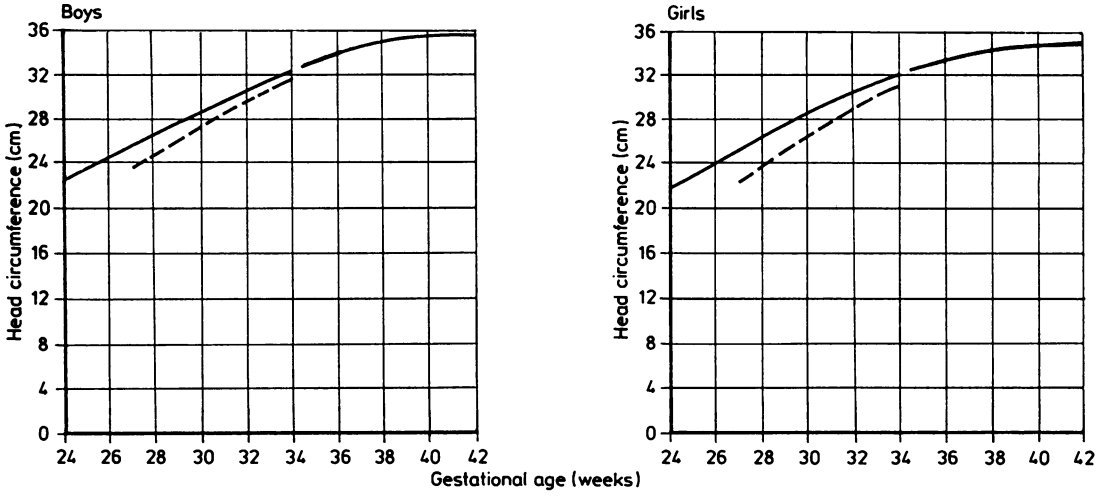

Fig. 4 *Smoothed mean values for head circumference in the spontaneous (——) and elective (– – –) groups up to 34 weeks' gestation and in all the babies at 35 weeks' gestation and later.*

Table 3 *Birthweight and head circumference smoothed means for all babies and for the spontaneous group only*

Gestational age (wks)	*Birthweight (g)*		*Head circumference (cm)*	
	All babies	*Spontaneous group*	*All babies*	*Spontaneous group*
Boys				
24	820	820	22·7	22·6
25	840	840	23·5	23·6
26	850	900	24·3	24·5
27	930	1000	25·2	25·5
28	1050	1140	26·2	26·5
29	1210	1310	27·1	27·5
30	1400	1500	28·1	28·5
31	1620	1710	29·1	29·5
32	1850	1930	30·1	30·4
33	2090	2160	31·0	31·3
34	2330	2390	31·9	32·1
Girls				
24	670	670	22·0	21·6
25	710	740	22·7	22·8
26	780	840	23·5	24·0
27	860	970	24·4	25·2
28	980	1120	25·3	26·2
29	1130	1290	26·3	27·3
30	1320	1480	27·4	28·3
31	1530	1690	28·4	29·3
32	1760	1910	29·4	30·2
33	1990	2110	30·4	31·0
34	2230	2330	31·3	31·7

babies, although the differences in variances did not in general reach significance. The same tendency was observed for head circumference (variances not shown in Table 3).

Discussion

Among babies born at a gestational age of 34 weeks or less we have observed that those born after spontaneous onset of labour are considerably heavier and have slightly larger head circumferences than those delivered electively. This is not surprising as most elective deliveries are because of severe pre-eclampsia, suspected intrauterine growth retardation, or fetal distress, all of which are known to be associated with unusually small fetal size. Between 27 and 34 weeks' gestation, nearly 30% of babies in our series were delivered electively. Inclusion of these babies in our calculations resulted both in lower mean birth weight and in greater variation of birth weight than would otherwise have been obtained. Their effect on head circumference values was, however, slight, perhaps due to a brain sparing effect in growth retarded babies.

It is generally supposed that birthweight and head circumference standards should reflect the ideal values for sex and gestational age. For this reason, published standards usually exclude stillbirths[1 3–5 10] and babies with serious congenital abnormalities,[1 2 4 5 9] with hydrops, or born to diabetic mothers.[1 4 5 9] It therefore seems logical to exclude babies born after other complications known to affect fetal size, such as pre-eclampsia or placental insufficiency. Exclusion of abnormal babies from the calculation of birthweight and head circumference standards results, however, in a paradox. The standards represent the population of normal babies, and yet a baby whose measurement is found to fall outside the cut off centile will be defined as abnormally grown. Furthermore, the exclusion of abnormal babies from the standards will narrow the spread of values observed at any gestational age, so that the measurement of any individual baby will be more likely to fall outside a given centile.

There is a case, though, for excluding particular abnormalities from the standards, while including others. The infants to be included should match the population to which the standards will be applied. For instance, if there is no intention of estimating the birthweight or head circumference centiles for macerated stillbirths or for grossly malformed infants these infants should not contribute to the standards. This argument could leave other abnormal infants, such as those born to diabetic or pre-eclamptic mothers, in the calculation of the standards.

Conceptual arguments about the inclusion or exclusion of particular abnormalities from birthweight and head circumference centiles will not matter in practice if the abnormality is rare enough not to affect the means or standard deviations observed at any particular gestation. We have shown, however, that the growth retardation associated with elective preterm delivery occurs often enough to affect both the mean and spread of birth weight and, to a lesser extent, of head circumference at a gestational age 34 weeks and earlier.

The proportion of electively delivered preterm babies in the birthweight and head circumference series of the 1960s and earlier is not recorded. It is certain, though, that elective preterm delivery has increased in the last 10 or 15 years. Obstetricians are now better able to diagnose impending intrauterine death and, because of the improved survival of preterm babies, are more willing than before to deliver them electively for problems such as pre-eclampsia. Many of these pregnancies would previously have resulted in stillbirth, though there would have been some live births at a later gestation. This change in obstetric management will have produced an 'artificial' excess of small preterm live births and would account for the negative skew we observed in the birthweight and head circumference distributions at 32 and 33 weeks's gestation. This skewing is reduced by the removal of electively

delivered infants, leaving roughly normal distributions similar to those observed at later gestational ages.

As it is illogical that changes in obstetric practice should alter the definition of an abnormally grown baby and as we cannot determine the 'correct' frequency of the electively delivered preterm infants at each gestation, we suggest that they should be excluded from birthweight and head circumference standards. The proposed standards would be based on the spontaneous group of births between 24 and 34 weeks' gestation and on all births at later gestations. The separation of elective and spontaneous births only up to 34 weeks' gestation is to some extent artificial and we recognise that our recommendation is a compromise. The distorting effect of elective deliveries is likely to occur at later gestations also, but the effect would be expected to decrease sharply towards term as the proportion of elective deliveries in the population declines. Whether or not birthweight standards should be adjusted for elective deliveries beyond 34 weeks' gestation is a subject for further study.

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Correspondence to Dr A R Wilkinson, Neonatal Unit, John Radcliffe Hospital, Headington, Oxford OX3 9DU, England.

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