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EARLY POSTNATAL GROWTH OF PRETERM LOW BIRTH WEIGHT, APPROPRIATELY-SIZED INFANTS

*** O.F Njokanma , ** M.T.C Egri-Okwaji , *** J.O Babalola**
*Department of Paediatrics, *Havana Specialist Hospital, Suru-Lere, Lagos, **College of Medicine, University of Lagos, Idi-Araba, Lagos, . ***Olabisi Onabanjo University Teaching Hospital, Sagamu, Ogun State, Nigeria.*

SUMMARY

Background: Postnatal growth monitoring is useful in assessing the health of preterm babies but their growth patterns have not been sufficiently studied in Africans.

Aim: To describe the growth achievements of preterm, low birth weight, appropriately-sized, Nigerian infants.

Study design: The subjects were prospectively recruited from two centers Olabisi Onabanjo University Teaching Hospital (January 1994 to June 1995) and Havana Specialist Hospital (June 1995 to June 1997). The weight, length and occipito-frontal circumference of 89 preterm, low birth weight, appropriate-for-dates infants were monitored from birth until 53 post-conceptual weeks. Growth velocities were compared with 46 term infants.

Results: Initial weight loss, age at regaining birth weight and growth rate in the early postnatal weeks were inversely related to gestational age. Subsequent weight gain was directly related to gestational age. Between birth and 40 weeks post conception, growth rates for different gestational age groups were 129 to 207g/week (weight), 0.78 to 0.93cm/week (length) and 0.62 to 0.65cm/week (head circumference). After 40 weeks, the corresponding rates were 188 to 238g/week, 0.86 to 0.96 cm week and 0.48 to 0.50cm/week, respectively. Head growth demonstrated a faster catch-up than weight and body length in that order. The observed growth rates were slower in some respects than Caucasian figures but faster than reported for the Japanese.

Conclusion: Study subjects had growth patterns within previously defined ranges. The better profile of western babies is probably related to better infrastructure while the advantage over Asian babies is probably racial.

Key Words: Postnatal Growth, Preterm, Low Birth Weight, Infants. (*Accepted 30 April 2007*)

INTRODUCTION

Gestational age at delivery is a strong determinant of birth weight and postnatal survival. [1] In the second half of intra-uterine life, there is a rapid weight gain especially in the last trimester when the weight triples and the length doubles as body stores of protein, fat, iron, and calcium increase. About 75% of the birthweight is gained during this period at a rate of about 700gms per month. The rapid weight increase is accounted for by an increase in size and maturation of the organs formed earlier on. During the last months, the fetus becomes well rounded due to the deposition of subcutaneous fat and by the time of birth, the weight of the fetus is 3000-3200gms and crown heel length about 50cm. [2]

If however, gestation is terminated before term, birth weight is likely to be low and the growth pattern of the preterm, low birth weight infant differs significantly from what might have been expected had the baby remained in utero. [3,4] The quality of postnatal growth of born preterm or with low birth weight babies depends on many factors. One of the most important of these factors is the quality of intrauterine growth. Babies who have suffered significant intrauterine growth restriction are less likely to grow as well as those in whom intrauterine growth had progressed normally. [5,6] Extrauterine factors like nutritional intake, duration and severity of postnatal illness are also important determinants of postnatal growth.[7] Thus, postnatal growth monitoring not only gives an indication of continued well being but is a useful adjunct to the care of the low birth weight infant.[8,9] Studies on postnatal growth of preterm of low birth weight babies have been extensively conducted in

Correspondence: Dr OF Njokanma
E-mail: faconj@yahoo.com

Caucasians[3,8,10,11] black Americans[12] , Japanese[13] and Chinese[14] but not sufficiently in African babies. The diversity in findings from earlier studies suggests that there may be infrastructural, environmental or racial influences[15] on the quality of postnatal growth of preterm babies.

In this study, we present the growth achievements of a series of Nigerian, preterm, low birth weight, appropriately-sized infants.

SUBJECTS AND METHODS

The study was conducted at the Olabisi Onabanjo University Teaching Hospital (OOUTH), Sagamu and the Havana Specialist Hospital, Lagos both in Nigeria. Neither centre has facilities for parenteral nutrition or automated assisted ventilation. The primary subjects were preterm, low birth weight, appropriate for gestational age neonates born between January 1994 and June 1995 for the Sagamu babies and July 1995 to June 1997 for the Lagos babies. The choice of appropriately-sized infants was influenced by the need to exclude infants whose poor intrauterine growth might confound postnatal growth. Informed consent was obtained from all the mothers.

The babies were weighed within one hour of birth on a standard infant scale graduated in 50g units. Preterm babies were grouped into five sets (Groups I, II, III, IV and V) corresponding to gestational aged 26 28 weeks, 29/30 weeks, 31/32 weeks, 33/34 weeks and 35/36 weeks, respectively. The crown heel-length (CHL) and occipitofrontal circumference (OFC) were measured within 24 hours of birth using a non-elastic tape. Gestational age was determined from the mother's last menstrual period corroborated by early antenatal ultrasonography and the clinical methods of Dubowitz et al.[16] The intrauterine growth chart developed by Lubchenco et al[17] was used to select preterm, low birth weight infants whose weights were appropriate for gestational age (AGA). Weight was recorded daily while CHL and OFC were measured weekly until discharge. After discharge, growth was monitored weekly until a weight of 2500g was achieved, every two weeks until a weight of 3500g and monthly afterwards. Growth achievements at birth, 36, 40, 46 and 53 weeks post conception and the velocity of growth during the intervening periods are reported. When the patient's visit did not coincide with desired postnatal age, a graphical estimate of body size was made from the prior and subsequent visits (assuming uniform growth).

Concurrently, controls were randomly selected from well, appropriately sized, term neonates. Their growth achievements and growth velocities were recorded at birth, 46 and 53 post conceptual weeks. The birth weights were taken by midwives in the labour ward and confirmed in the neonatal unit by authors JOB and OFN: daily weighing was done by authors JOB and OFN: weekly measurements (length and OFC) and all post-discharge measurements were done by author OFN.

RESULTS

Eighty-nine preterm, low birth weight, AGA babies (41 boys and 48 girls) and 46 term, AGA subjects (22 boys and 24 girls) were studied. All neonates were fed with mother's own breast milk during the study period. The major morbidities encountered among study subjects were moderate/severe asphyxia in nine babies, hypothermia (8), recurrent apnoea (7), respiratory distress syndrome (6) and recurrent anaemia (6). Four babies had severe jaundice requiring exchange transfusion, three patients each had documented hypoglycaemia and culture proven sepsis and two had symptomatic persistent ductus arteriosus.

The characteristics of weight change are shown in Table 1. The degree of initial weight loss, age at nadir weight and age of regaining birth weight were all inversely related to gestational age.

The weight achievements at different post-conceptual ages are shown in Table II. There was a paradoxical reversal of weight achievements at 36 weeks post-conceptual age with Group I babies having a higher mean weight than babies in Groups II to IV. By 40 weeks post-conceptual age however, more mature babies had achieved higher mean weights. Also, Group V babies had become comparable to the birth weight of controls ($t = 0.58$, $p = 0.56$). The mean weights of Groups I and II babies were almost identical and so were those of Groups III and IV babies. Further, the mean weight of babies born at $\leq$ 30 weeks gestation (Groups I and II combined) was significantly smaller than for Group V babies born at 35/36 weeks (2767g $\pm$ 596 Vs 3137g $\pm$ 401: $t = 2.21$, $p = 0.034$). Similarly, the mean weight of babies born between 31 and 34 weeks (Groups III and IV combined) were smaller than for Group V (2853g $\pm$ 449 Vs 3137g $\pm$ 401: $t = 2.47$, $p = 0.017$). These observations became more distinct at the 46 weeks and 53 weeks assessments.Figure 1 shows the weight achievements of Group I and Group V babies superimposed on the Fenton[18] standards. The Group I babies had a mean birth weight above the 50th centile, dropped and remained below the 10th centile, before rising above the 10th centile at 46 weeks. The Group V babies on the other hand, started with a mean birth weight slightly above the 10th centile but the mean weight achievement climbed steadily until it rose above the 50^{th} centile at about 50 weeks.

Table I: **Features of weight changes in preterm, low birthweight infants**

Group	No	Weight loss %	Nadir day	Regain day
1	7	13.9	13.5	23.3
II	12	8.1	10.5	16.4
III	19	7.9	7.1	15.9
IV	34	7.9	6.5	14.2
V	17	3.0	3.5	5.9

Group I: 26 to 28 weeks gestation
Group II: 29/30 weeks gestation
Group III: 31/32 weeks gestation
Group IV: 33/34 weeks gestation
Group V: 35/36 weeks gestation

The findings with respect to CHL and OFC are shown in Table III. The same pattern of bunching up of groups I and II babies and of groups III and IV babies was observed. Also, by 53 weeks post-conception, there were more distinct gestational age related differences between the various groups of babies. Similar to the observations with weight, at 40 weeks, the CHL of babies born at $\leq$ 30 weeks gestation was significantly smaller than for Group V babies (47.4cm $\pm$ 1.88 Vs 49.3 $\pm$ 1.86: $t = 3.06$, $p = 0.004$). Also, the mean CHL of babies born between 31 and 34 weeks were smaller than for Group V (47.5 $\pm$ 1.49 Vs 49.3 $\pm$ 1.86: $t = 3.54$, $p = 0.001$).The figures for Group V babies at 40 weeks and controls at birth were comparable ($t = 1.22$, $p = 0.227$). Head growth demonstrated earlier and closer catch-up than weight and length. By 40 weeks, all the preterm groups had caught u with controls. However, at subsequent assessments, the mean OFC for Groups I and II were smaller than controls by0.9cm and 0.8cm,

Table II: **Mean weights at various post-conceptual ages**

Gestational Age (weeks)	At birth	36 weeks	40 weeks	46weeks	53 weeks
		Post-conceptual ages			
26-28	1121 (118)	1953 (447)	2757 (669)	4084 (893)	5300 (906)
29/30	1311 (191)	1948 (407)	2773 (554)	4100 (930)	5428 (1272)
31/32	1587 (101)	1929 (316)	2823 (493)	4203 (707)	5530 (948)
33/34	1865 (280)	1921 (280)	2870 (424)	4276 (491)	5771 (577)
35/36	2153 (168)	2125* (209)	3137 (401)	4618 (587)	6147 (645)
Control	3199 (311)			4759 (558)	6283 (686)

Figures in brackets are one standard deviation of the mean
* The figure is lower than 2153 because the babies born at 35 weeks lost some weight in the first week of life.

Table III: **Achievements in crown-heel length (cm) and head circumference (cm)**

Gestational Age (weeks)		Birth	40 weeks	46 weeks	53 weeks
		Post-conceptual age			
26-28	CHL	37.7 (1.21)	47.5 (2.23)	52.6 (2.51)	58.4 (2.65)
	OFC	25.8 (0.98)	34.1 (1.35)	37.1 (1.78)	40.3 (1.64)
29/30	CHL	38.8 (1.60)	47.3 (1.68)	52.7 (1.73)	58.6 (1.31)
	OFC	27.1 (1.35)	34.0 (1.12)	37.1 (0.97)	40.4 (1.07)
31/32	CHL	40.4 (1.16)	47.4 (1.05)	53.2 (1.55)	59.0 (2.84)
	OFC	29.0 (0.72)	34.3 (1.07)	37.4 (0.63)	40.8 (0.47)
33/34	CHL	41.6 (2.05)	47.8 (1.73)	53.8 (1.40)	59.3 (1.73)
	OFC	30.4 (1.10)	34.7 (0.99)	37.8 (0.96)	41.0 (0.74)
35/36	CHL	44.6 (1.24)	49.3 (1.86)	55.3 (2.27)	62.0 (1.85)
	OFC	31.6 (0.56)	34.1 (0.70)	37.8 (0.77)	41.2 (1.00)
Control	CHL	49.9 (1.30)		55.3 (1.41)	61.8 (1.84)
	OFC	34.7 (1.92)		38.0 (0.86)	41.2 (0.93

CHL = crown-heel length
OFC = occipito-frontal circumference
Figures in brackets are one standard deviation of the mean

Table IV: **Weekly rates of growth in weight, length and head circumference**

	Gestational age at birth (weeks)				
	26-28	**29/30**	**31/32**	**33/34**	**35/36**
Weight (g/wk)					
To 36 weeks	97 (52)	102 (45)	80 (44)	18 (55)	-25 (90)
36-40 weeks	203 (78)	202 (66)	224 (67)	228 (52)	265 (72)
40-46 weeks	204 (59)	232 (66)	244 (61)	261 (61)	278 (41)
46-53 weeks	174 (28)	189 (67)	204 (48)	212 (43)	204 (37)
Crown-heel Length cm/wk					
To 40 weeks	0.78 (0.26)	0.83 (1.11)	0.86 (0.01)	0.82 (0.24)	0.93 (0.23)
40-46 weeks	0.93 (0.23)	0.91 (0.13)	0.98 (0.16)	1.00 (0.18)	1.00 (0.15)
46-53 weeks	0.82 (0.07)	0.85 (0.10)	0.83 (0.19)	0.79 (0.12)	0.95 (0.09)
Occipito-frontal circumference cm/wk					
To 40 weeks	0.65 (0.10)	0.65 (0.09)	0.65 (0.08)	0.64 (0.13)	0.62 (0.07)
40-46 weeks	0.51 (0.06)	0.52 (0.07)	0.52 (0.10)	0.51 (0.04)	0.52 (0.07)
46-53 weeks	0.46 (0.04)	0.47 (0.06)	0.49 (0.04)	0.48 (0.05)	0.48 (0.05)

Figures in brackets are one standard deviation of the mean

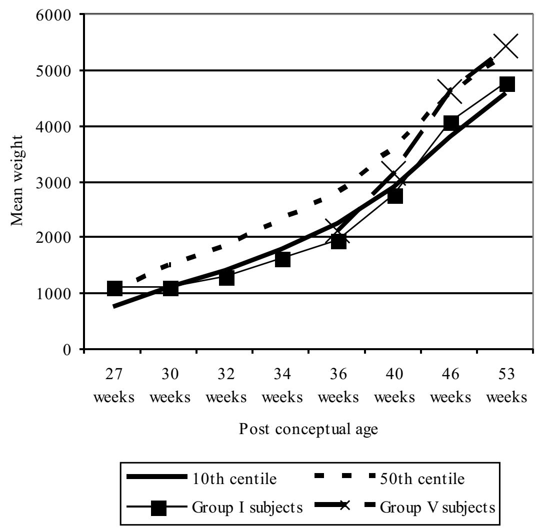
Table V: **Comparison of growth rates in selected studies**

		Weight g/day			Length cm/week		OFC cm/week	
		A	**B**	**C**	**X**	**C**	**X**	**C**
Group I	Babson[3]	14.5	19.2	27.7	0.88	0.69	0.84	0.43
	Wright[11]	20	-	-	0.85**	-	0.71**	-
	Cooke [12]	-	25.0	-	1.12**	-	1.12**	-
	Itabishi [13]	-	14.5^{+}	-	0.75	-	0.65	-
	Ehrenkranz[22]		24.7		1.0		0.95	
	Index	13.9	21.8	26.9	0.78	0.87	0.65	0.48
Group II	Wright [11]	19.7	-	-	0.94**	-	0.71**	-
	Cooke [12]	-	25	-	0.91**	-	1.12**	-
	Itabishi [13]		-	15.9^{+}	-	0.74	-	0.66 -
	Musoke[19]	-	22*	-	0.70	-	0.80	-
	Ehrenkranz[23]		26.3		0.99		1.00	
	Index	14.6	22.7	29.9	0 .83	0.86	0.65	0.49
Group III	Babson[3]	10	19.6	29.7	0.85	0.72	0.75	0.44
	Schaffer[8]	-	20.3	-	-	-	-	-
	Ehrenkranz[23]		27.8		0.86		0.74	
	Index	11.4	23.1	32.0	0.86	0.91	0.69	0.50
Group IV	Schaffer[8]	-	20.9	-	-	-	-	-
	Index	2.6	25.5	33.0	0.82	0.88	0.64	0.50

OFC= Occipitofrontal circumference
Column A = birth to 36 weeks, B = nadir to 40 weeks, C = 40 to 53 weeks, X = birth to 40 weeks

+: Calculation was from birth to 40 weeks, *: Calculation was from nadir to 36 weeks
**: Calculation was from birth to 36 weeks.

Figure 1: Postnatal weight changes in Groups I and V babies superimposed on the 10th and 50th centiles of the Fenton chart[18]



Respectively. The rates of growth in weight, length and head size during designated intervals are shown in Table IV. Before 36 weeks post-conception, preterm babies had relatively slow rates of change in weight inversely related to gestational age. Subsequently, three phases of weight gain were observed: fairly rapid (36 to 40 weeks) peak (40 to 46 weeks) and modest decline (46 to 53 weeks). The weekly rates of weight gain were similar between 36 weeks and 40 weeks post-conception for groups I and II babies and also for groups III and IV babies. The peak rates of increase in body length occurred between 40 and 46 weeks while for OFC, it was observed between delivery and 40 weeks post-conception in all the gestational age groups.

DISCUSSION

Our findings agree with earlier series in which babies of lower gestational age and birth weight tended to lose more weight and to grow more slowly than more mature ones.[3,8,10,11,13] Nigerian babies in groups I and II lost an average of 13.9% and 8.1% of their birth weights, respectively. These conform to a range of 9.5% to 13.7% for group I and 8% to 11.6% for Group II infants found among Caucasians,[8,10,11] black Americans[12] and East Africans[19] but are definitely lower than 18.6% and 16.1% reported for Japanese infants[13]. The rather narrow range found in most studies is in keeping with the theory that initial weight loss is physiological rather than a pathologic process or fluid management.[20] The Group I babies in our series regained their birth weights at an average of 23 days which was faster than 26 days in Japanese babies[13] but slower than 12 to 19 days in Caucasians[8,11,21] and black Americans[12] The corresponding figure for recovering birth weight in our group II babies (16 days) also fell within the range observed in Caucasians[8,11,13,17,22] (12 days to 18 days) black Americans[12] (15 days) East Africans[19] (15 days) and Japanese[13] (18 days). A more recent study in the United States[23] involving babies of mixed ethnicity also reported average age at regaining birth weights between 11.5 and 13.2 days for subsets of babies corresponding to groups I to III babies in our series In order to facilitate comparisons, growth rates from selected studies are shown in Table V. For groups I and II babies before 36 weeks of gestation, the growth rate of babies in our series was similar to that reported by Babson[3] in an older Caucasian study, slower than those of more recent reports involving white infants,[11] but faster than Japanese babies[13]. At 36 weeks, the groups I to III babies in our series had achieved weights between 1929g and 1953g (Table II). This was somewhat lower than the 2000g achieved by babies of comparable weight and gestation in the study by Ehrenkranz.[23]

_Itabishi et al[13] postulated that the greater availability of parenteral nutrition was responsible for the better performance of very low birth weight babies from western nations. However, in the light of nutritional and infrastructural factors, the better growth profile of our subjects in comparison with Japanese babies would appear paradoxical. Access to quality parenteral nutrition and automated ventilation was certainly better in the Japanese study[13] than in ours. It may be argued that the availability of these facilities selectively included very ill babies with poor growth potentials in the Japanese series who might otherwise have died. However, this argument is not valid for two reasons. Firstly, the absence of automated ventilatory support did not lead to uniform mortality in Nigerian babies. More than 25% of surviving groups I and II babies experienced recurrent apnea and might have fared better with automated rather than manually assisted ventilation. Secondly, if the argument were valid, Nigerian and Japanese babies would also have had an advantage over their western counterparts.

Another study in the United Kingdom[15] involving babies of white, black and Asian ancestry provides evidence that given the same quality of care, black preterm, low birth weight babies grow as well as their white counterparts. Indeed, black infants born before 32 weeks gestation had a better growth profile in terms of weight and head circumference. We, therefore, conclude that sophisticated neonatal intensive care was responsible for the better growth conclusion is supported by the fact that growth rates profile in western than in Nigerian babies. This conclusion is supported by the fact that growth rates of our very low birth weight infants after the turbulent early postnatal weeks and that of the bigger preterm babies are comparable to those of their Caucasian counterparts. We also conclude that other factors, possibly environmental or racial may explain the seemingly paradoxical advantage of Nigerians over the Japanese. It is instructive that in a study done in the United Kingdom, Asian infants demonstrated poorer growth characteristics than black and white infants.

The overall growth pattern of preterm babies in the study conformed to earlier developed reference standards. [3,11,21] There was confirmation of the observation by Fenton et al[21] that catch-up in head growth occurs before 40 weeks post conception week, after 40 weeks for length, while that of weight may occur before or after 40 weeks. Also, the empirical time subdivisions birth to 36 weeks, 36 to 40 weeks, 40 to 46 weeks, 46 to 53 weeks corresponded to the four phases of growth earlier described by Babson[3] namely: initial weight loss, slow weight gain, rapid weight gain and then a modest reduction in growth rate. At 36 weeks, the mean weights of babies in Groups I to IV varied within a narrow range of 32g, in reverse order of gestational age at birth. This was obviously because the more immature ones had more time for postnatal adjustments and subsequent growth. Between 36 and 40 weeks however, all babies were in the growing phase. During this phase, the more mature babies in Groups 3 to 5 had a weight accretion of 46% to 49%, compared to 41% and 42% in Groups 1 and 2. The result was twofold. First, there was restoration of a direct relationship between gestational age at birth and achieved weight. This was evident in Table II which shows that more mature babies consistently had higher weight achievements from 40 corrected weeks onwards. Secondly, the stage was set for progressive widening of the differences in achieved weight of successive subgroups.

Overall, we note that Nigerian preterm babies conformed to the expected general pattern of growth but differed in the following specific details. In the early post-conceptual weeks, our preterm babies born at ≤ 30 weeks gestation exhibited slower growth than their western counterparts. Subsequently, their growth rates and those of babies born after 31 weeks gestation were comparable to western figures. Also, the growth rates of Nigerian preterm babies were faster than reported for Japanese babies. We conclude that the better growth profile reported for Western babies is a reflection of better facilities for care of the high-risk newborn. Also, the growth advantage over the Japanese babies despite the infrastructural advantage of the latter reflects racial or environmental factors.

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