CATCH-UP GROWTH OF SUPINE LENGTH/HEIGHT OF VERY LOW BIRTH WEIGHT, SMALL FOR GESTATIONAL AGE PRETERM INFANTS TO ADULTHOOD

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Objective To analyze linear growth of very low birth weight (VLBW), small for gestational age (SGA; < 10th percentile) preterm infants from birth as to catch-up or no catch-up growth.

Study design VLBW SGA preterm infants (n = 46) with primarily symmetric intrauterine growth restriction from the Bonn Longitudinal Study were compared with 62 appropriate for gestational age (AGA) VLBW preterm and 73 term infants and with their parents.

Results Forty-six percent of VLBW SGA (21 of 46) had complete height catch-up by adult age, and most became taller than target height (TH) (15 of 21; 71%). The others did not catch up; most of them remained shorter than TH (18 of 25; 72%) after initial catch-up followed by catch-down growth. Mean adult height z-score was lower than that for birth length. Mean body mass index was similar in the catch-up and no catch-up groups (21.8 and 21.3, respectively) and lower than in the controls (23.2). Approximately 1/2 of the head circumference (HC) catch-up children achieved height catch-up as well.

Conclusions Height catch-up extended beyond age 6 years, independent of HC growth. We could not predict height catch-down or successful catch-up. *(J Pediatr 2005;147:662-8)*

Little is known about the long-term catch-up growth of very low birth weight (VLBW), small for gestational age (SGA) preterm infants to adulthood. Apart from the study of Hack et al,[1] there have been no reports on adult growth attainment of VLBW women. The usual norms for the growth of preterm SGA of higher birth weight (ie, > 1500 g) or term infants do not seem to apply to VLBW infants, and the reports on short children of "low birth weight" born in 1958 or earlier do not apply to the present generation of VLBW SGA preterm infants. We are not considering the extensive literature on SGA term infants for this report.

The definition of catch-up is not uniform; it ranges from reaching a height > - 2 standard deviations (SDs),[1-3] ≥ P3,[4] or a *z*-score of −1.28 (10th percentile).[5] As to the time period for height catch-up, reports in the literature vary from age 20 months to 20 years.[1-8] In contrast to head circumference (HC) catch-up, the likelihood of which declined with rapidly decreasing growth velocity up to 12 months,[9,10] height catch-up was theoretically possible as long as growth velocity was sufficiently high.

As part of our Bonn Longitudinal Study,[11] we analyzed linear growth patterns from birth to adulthood for a group of VLBW SGA preterm infants with primarily symmetric intrauterine growth restriction (ie, weight, length, and HC ≤ 10th percentile). We compared these with the German growth standards based on the AGA preterm and term control children of the Bonn study and at adult age with the results of the AGA preterm and term controls[9] and with their parents.

AGA	Appropriate for gestational age	MPH	Midparental height
AH	Adult height	PI	Ponderal index
BMI	Body mass index	SD	Standard deviation
EQ	Energy quotient	SDS	Standard deviation score
HC	Head circumference	SGA	Small for gestational age
MH	Maximum height before the catch-down	TH	Target height
MIT	Mannheimer Intelligence Test	VLBW	Very low birth weight

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Table I. Amount of height catch-up of the SGA preterm infants, group 1, n = 21

	Mean	SD	Range	< −2 SD
Birth length (BL), z score	−1.66	0.83	−3.5 to −0.6	5 (24%)
Adult height (AH), z score	0.03	0.99	−1.3 to +2.0	0
AH-BL, z score	1.69	1.19	+0.2 to +4.8	
Height of the mother, z score	−0.89	1.14	−2.7 to +1.2	4 (19%)
Height of the father, z score	−0.03	1.06	−1.6 to +2.0	0
Midparental height, z score	−0.46	0.86	−1.6 to +1.5	0
Target height (TH), z score	−0.40	0.90	−1.4 to +1.8	0
AH-TH, z-score	0.43	0.88	−1.09 to+2.23	0

METHODS

Between 1967 and 1975, all VLBW preterm infants admitted consecutively to the University Children's Hospital and some infants of higher birth weight were included in the Bonn Longitudinal Study. We defined SGA as birth weight < 10th percentile.[12] To increase the number of VLBW SGA infants, we enrolled such infants until 1978. At that time (eg, 1973), the neonatal survival rate for VLBW infants was low, 6.8% for babies of birth weight < 1000 g and 39.3% for those between 1000 and 1500 g. The 116 preterm infants included 65 AGA infants (birth weight ≥ 10th percentile) with a mean birth weight (SD) of 1350 (150) g (range, 920 to 1900 g) at a mean gestational age of 30.5 (2) weeks, and 51 SGA infants with a mean birth weight of 1200 (220) g (range, 780 to 1860 g) at a mean gestational age of 33 (2) weeks. Eighty-five full term controls were chosen at random from an obstetric outpatient clinic in Bonn or enrolled as siblings of the preterm infants. Infants with major malformations or chromosomal abnormalities were excluded.

All infants were examined at birth, twice weekly until term, monthly in the first year, every 3 months up to age 2 years, every 6 months up to age 6-1/2 years, and in adulthood (mean, 22.8 years; range, 17 to 28 years).

From birth to age 2.5 years, supine length was measured using a Harpenden infantometer, and from age 3 to 6 years and at adulthood standing barefoot height was measured with a Martin anthropometer. The parents' height was measured when they entered the study, the fathers at the mean age of 31.6 (7.6) (range, 19.5 to 47.8) and the mothers at 28.1 years (6.9) (range, 17.5 to 43.2). The first author (I.B.) performed all of the anthropometric measurements.

We calculated *z*-scores (ie, standard deviation scores [SDSs]), because these provide a more sensitive assessment of growth than percentile cutoffs. We computed the *z*-scores for weight and length from birth to 40 weeks gestational age according to the current, gender-specific German intrauterine growth standards of Voigt et al,[13] for height up to 6 years according to the German growth standards based on the AGA preterm and full-term control children of the Bonn Longitudinal Study,[9] and in adulthood according to the results of the AGA preterm and term controls (Brandt, unpublished results). For body mass index (BMI), we used the German standards given by Kromeyer-Hauschild et al.[14] Birth weight alone does not provide sufficient information on an infant's nutritional status. Therefore, the ponderal index (PI) ($g/cm^3 \times 100$),[15] evaluated according to the percentile distribution of Miller and Hassanein,[16] was used for distinguishing malnourished SGA preterm infants (PI ≤ 3rd percentile) from well-nourished SGA preterm infants (PI > 3rd percentile). BMI was calculated as the relation of body weight to height squared (in kg/m^2).

To compare adult height, we used midparental height (MPH) SDS, (ie, height *z*-score of the father + height *z*-score of the mother, divided by 2) and, as an indicator of genetic growth potential, target height (TH), which is MPH corrected for sex (ie, + 6.5 cm for boys and −6.5 cm for girls).[17] In the 1970s, few VLBW SGA infants survived, especially very few males because of their greater vulnerability. However, this small group yielded interesting results for length/height growth.

We assessed mental development at adult age using the Mannheimer Intelligence Test (MIT),[18] a German paper-and-pencil test with 10 subtests, for measuring general intelligence, with an emphasis on reasoning and language. Age was corrected for prematurity during the first 5 years of life.

We calculated correlations between *z*-scores of height and MIT IQ using Pearson's *r*; correlations between adult height and age at menarche, using Kendall's tau. Significance was tested using a 2-tailed χ^2 test, the Mantel-Haenszel procedure, or the Mann-Whitney U test and Student *t*-test. SPSS 10.0 was used for statistical analysis. Further details on the methods of the Bonn Longitudinal Study are given elsewhere.[10,19]

RESULTS

The dropout rate was 7.6% (15, excluding the 5 deaths) for the 196 children in our study. The final sample comprised 108 preterm infants (62 AGA, 46 SGA) and 73 full-term controls. Length at birth of the SGA infants was ≤ 10th percentile[20] in all but 10 subjects (22%). Symmetric growth restriction occurred in most of the SGA infants (33/46; 72%). Weight alone was ≤ 10th percentile in 3 SGA infants. The optimality score, consisting of 50 items, was used to evaluate conditions during pregnancy, birth, and the neonatal