Growth monitoring of small for gestational age in a Algerian cohort

F. BOUFEROUA

Abstract-Objectives. The aim of the study was to describe post-natal growth during a 2-year follow-up in a cohort of infants born at term but small for gestational age (SGA). **Methods**. This was a prospective study in infants with gestational age between 37 and 42 weeks amenorrhea with a birth weight below the 10th percentile. Height, weight and head perimeter were measured from birth to two years. **Results**: The prevalence of term SGA infants was 3.9% during the enrollment period (from 1 December 2012 to 31 March 2014). Of these 457 infants, 446 (97.6%) were followed up to 2 years of age. Children with height, weight and head perimeter measurements at 24 months ≥ -2 standard deviation score (SDS) were 87.9%, 96.4% and 97.1%, respectively. (i.e., 12.1% had persistent growth retardation for at least one parameter). In a multivariate analysis, the independent predictors of catch-up growth at 24 months were associated with maternal height, target height and its difference with birth height, history of SGA, breast feeding duration, ponderal index and height gain at 6 months. **Conclusion**: This study provides data concerning the epidemiology of SGA births in Algeria and the factors associated with post-natal growth. These results are in favor of setting up a national program, integrating obstetricians and pediatricians for a joint action for the ante- and postnatal follow-up of SGA infants.

Index terms: Small for gestational age; Intra-uterine growth retardation; Postnatal growth; Catch-up growth; Short stature.

———————— ◆ ————————

Fadila Bouferoua, Pediatric Department « A », Beni Messous hospital, Algiers, Algeria

I. INTRODUCTION

Children born small for gestational age (SGA) are defined as having a birth weight and/or length standard deviation score (SDS) of < −2, based on data from an appropriate reference population [1].

SGA is an heterogeneous group due to the varied nature of the cause including nutritional, hormonal, vascular, and genetic factors.

Parameters at birth are important predictors of infant and adult health [2]. Increased birth height and weight and decreased neonatal mortality are frequently associated with improved health and economic status. Among newborns with low birth weight, those born SGA have attracted particular attention because of the question of catch-up growth during childhood and adulthood. The rates of infants born at term, but small for gestational age (SGA), varies from 7% in developed countries to 41.5% in countries from South Asia [3],[4]. The study of Karlberg *et al* in 1995 reported that 85% of SGA infants, defined as a birth height < -2 standard deviation scores (SDS), achieved catch-up growth at 6 months [5]. Moreover, at one year, 13.4% of these infants still had a height < -2 SDS and at age of 18 years they were only 7.9%. In a recent systematic review of 11 studies in term SGA infants, Campisi *et al* evaluated the prevalence of catch-up growth. Despite the various definitions of SGA and catch-up growth, the authors estimated that the median prevalence of catch-up growth was 87.4% [2].

In Algeria, the statistics from the Ministry of Health are those of overall low birth weight. The rate of low birth weight (whatever gestational age) was 7.9% in 2011 in our maternity. Infants with low birth weight do not have follow-up in specialized consultations except for those hospitalized at birth. As a result, many children with no identifiable disease history are referred to our pediatric consultation at the age of 8–9 years to explore growth retardation. In Algeria, the approval of growth hormone treatment was obtained in 2011, but there is no reimbursement by social insurance for this expensive treatment, hardly accessible to the population concerned.

The purpose of this prospective study was to identify the population of SGA infants born at term using well-established and predefined criteria, to follow up their height and weight outcomes and to estimate the rate of children with no catch-up growth at the age of two years. The goal is to manage these children as soon as possible as recommended in the 2007 and 2023 European Society of Pediatric Endocrinology guidelines [1], [6].

II. MATERIALS AND METHODS

Type of study and patients

This was a prospective cohort study in a population of SGA infants born at term followed for a period of two years. The primary objective was to evaluate the rate of catch-up growth during this period. The secondary objectives were to identify predictive factors associated to catch-up growth at age of two years.

Neonates were recruited at the maternity ward of Béni Messous hospital, Algiers. Term neonates with gestational age between 37 and 42 weeks age (WA), from a single pregnancy and with a birth weight below the 10th percentile were included. Neonates were excluded in case of multiple pregnancies, malformative syndromes, neonatal asphyxia, syndromic intrauterine growth retardation, sex differentiation anomalies with undetermined sex and infants who received treatment that could modify growth.

The follow-up consultations of the patients were carried out in the maternal and child protection unit of the Pediatric department of Béni Messous hospital at 1, 3, 6, 12, 18 and 24 months after birth.

The study was conducted in accordance with the Declaration of Helsinki and was accepted by the hospital Ethics Committee as an observational, quality improvement project not requiring formal ethical approval. Participants were informed of the purpose of the study and gave their consent to participate in the study and for the use of their medical data and those of their children for research purposes. They were informed that their participation in the study was voluntary and that they could withdraw at any time without interfering with their medical care and that of their child.

Data collected:

The following data were recorded at inclusion and at follow-up visits: mother demographics (age, educational level, socio-professional category), mother's self-reported weight before pregnancy, mother's height, pregnancy (parity, medical history, obstetrical history, smoking, alcohol intake); infant characteristics: birth height, birth weight, birth head perimeter, ponderal index, etiology of SGA and height of father.

Methodology for obtaining anthropomorphic measurements:

In the newborn, anthropometric measurements of weight, length and head circumference were taken at 24 hours of life. Weight was measured to an accuracy of 10 grams using a mechanical baby scale model SECA® which was calibrated each day. Length was measured to an accuracy of 1 mm with a measuring rod in the form of a SECA® model mat, with the newborn lying supine, lower limbs extended, one person holding the head in a fixed position against the support board head, with a second person maintaining the thighs and the knees in extension. Head circumference was measured with a tape measure, taking the largest circumference through the from the frontal bosses to the occiput. In those babies who had been identified by hospital staff as SGA, their measurements were checked and verified by the lead investigator (FB).

Growth standards and calculations used:

For foetal growth standards, and in the absence of national standards for the Maghreb Countries including Algeria, we used the personalized and gender specific French Audipog intrauterine growth curves [7].

For evaluation of postnatal growth, we calculated standard deviation scores for Weight, Supine Length/Height and Head Circumference Using Both French and World Health Organization (WHO) data. French reference data were from Sempé and Pédron [8] and were calculated using "Growth XP Lite" software (https://www.growthxp.com/elementor). WHO child growth standards were derived from WHO-Child-Growth-Velocity-Standards-Final.doc (https://apps.who.int/iris/rest/bitstreams/52342/retrieve) and calculated using "Who Anthro" software (https://www.who.int/tools/child-growth-standards/software) [9].In the few cases with missing data, these were not imputed.

Catch-up growth was defined in accordance with the 2001 Consensus Statement of Lee et al as increase in height velocity (cm/year) above the mean for chronological age and sex [10].

We assessed catch-up growth in two ways: by calculating the 6-monthly change in SDS for weight, length, and head circumference up to the age of 24 months; and by calculating the SDS difference between both infant size at birth and at 24 months with mid-parental height SDS.

Definition of standards and variables used in data analysis

Perinatal: As stated above, term was defined as gestational age between 37 and 42 weeks. SGA was defined as weight and/or length < 10th percentile for the population standards used, this cut-off being chosen as the most widely accepted and used for newborn population studies [11], [12], [13]. SGA was considered severe when weight and/or height was < 3rd percentile.

Statistical analyses

Data were collected and stratified to demonstrate relative prevalence in older mothers (>34 years), short and borderline short mothers, under and overweight (BMI <18.5 and >25 kg/m^2) mothers, primiparous and high parity status (>4 deliveries) mothers. Etiology of SGA, where known, was recorded.

A multivariate logistic regression analysis was performed to define the predictors of catch-up growth in term infants small for gestational age. Variables that were statistically significant in univariate analysis at a threshold ≤ 0.1 were entered into the overall logistic regression model (multivariate analysis).

Statistical analysis was performed using Stata 9.2 software (Statacorp, College Station, Texas, USA).

III. RESULTS

Baseline characteristics

During the enrollment period (from 1 December 2012 to 31 March 2014), 11,667 births were registered in the maternity of Beni Messous hospital; infants with low birth weight whatever the term were 8.3% (n=967) and term SGA infants were 3.9% (n=457).

Of the 457 infants enrolled in our study, 11 were excluded of the analysis (lost to follow-up, n=10; craniosynostosis, n=1); 446 (97.6%) newborns were followed until the end of the study.

The mean (SD) age of women at inclusion was 30.2 (5.8) years and 60.2% were primiparous (**Table 1**). Their mean height was 156.3 (3.8) cm and 5.2 % of them had a height < 150 cm. The mean pre-pregnancy BMI was 25.5 (3.8) kg/m^2 and was > 25 kg/m^2 in 54.3%. The mean father's height was 169.8 (5.0) cm.

Obstetrical history was reported in 18.7% of women and 13.1% had a history of SGA. The etiological diagnosis of the birth of an SGA infant was established in 36.5% of cases: placental causes (n=101; 22.1%), chronic diseases (n=26; 5.7%) or anemia (n=12; 2.6%) (**Table 1**).

The mean pregnancy gestation, as estimated by the Ballard score, was 38.3 weeks. Mean (SD) [range] birth weight was 2211.1 (201.8) [1300–2470] grammes, equating to -2.6 (0.5) SDS (WHO standards) and -2.5 (0.7) SDS (Sempé standards). Mean birth length was 43.2 (1.2) [39–46.5] cm, equating to -3.3 (0.6) SDS (WHO standards) and -3.2 (0.9) SDS (Sempé standards). Mean head circumference was 31.5 (1.4) [27–35] cm, equating to -1.8 (0.9) SDS (WHO standards) and -1.4 (0.9) SDS (Sempé standards). SGA was symmetrical in 43.3% of cases and asymmetrical (head circumference at the expected value) in 56.7%. Mean (SD) ponderal index was 2.7 (0.2) g/cm^3 and < 3rd centile in 26.3% of infants **(Table 2).**

Table 1. Baseline characteristics of mothers with infants who were born at term and small for gestational age.

Number	**N=457**
Mean (SD) age (years)	30.2 (5.8)
Age stratification (%)	
18–34 yrs	349 (76.4)
> 34 yrs	108 (23.6)
Mean (SD) height (cm),	156.3 (3.8)
Height stratification (%)	
< 150 cm	24 (5.2)
150–160 cm	388 (84.9)
> 160 cm	45 (9.9)
BMI (kg/m^2) stratification (%)	
< 18.5	4 (0.9)
18.5–25	205 (44.9)
> 25	248 (54.2)
Parity, n (%)	
1	275 (60.2)
2–4	171 (37.4)
> 4	11 (2.4)
Etiology of SGA birth, n (%)	
Placental causes	101 (22.1)
Chronic disease	26 (5.7)
Anemia	12 (2.6)
Other	28 (6.1)
Idiopathic	187 (40.9)
Indeterminate	103 (22.6)

BMI, body mass index; SGA, small for gestational age

Table 2. Baseline characteristics of infants born small for gestational age at term. Mean (SD) values are shown

Characteristics	N=457
Female sex, n (%)	255 (55.8)
Birth weight (g)	2211.1 (201.8)
Birth length (cm)	43.2 (1.2)
Head circumference (cm)	31.5 (1.4)
Asymmetrical SGA, n (%)	259 (56.7)
Ponderal index, Mean (SD)	2.7 (0.2)
Stratification, n (%)	
<3rd centile	120 (26.3)
≥ 3rd centile	337 (73.7)
Weeks' gestation (Ballard score)	38.3 (1.1)

SGA, small for gestational age

Evolution of weight, height and head circumference from birth to 24 months

The mean SDS for weight at 3 months of age (n=448) was -1.4 (1) SDS (WHO standards) and -0.8 (1.1) (Sempé standards) with a ponderal gain of 1.1(1.2) SDS (WHO standards); at 24 months (n=446) weight SDS values were -0.8 (0.7) and 0.6 (0.8), respectively (**Fig. 1**). At 6 months, 91.3% of infants had weight SDS values ≥ -2 SDS. At 24 months, mean body weight was 11 (0.9) kg, with 94.8% (423 of 446; OMS standards) and 96.6% (431 of 446; Sempé standards) infants showing recovery of weight, i.e. weight ≥ -2 SDS.

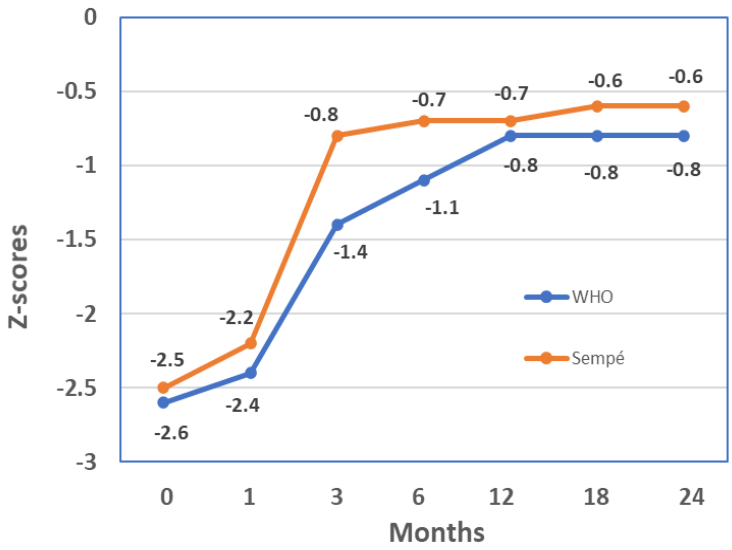

Fig. 1. Evolution of the weight of infants from birth to 24 months (according to WHO and Sempé and Pédron standards). Results are given as mean standard deviation scores.

The mean SDS for supine length at 6 months of age was -1.1 (1) (WHO standards) and -0.4 (1.1) (Sempé standards) with a statural gain of 2.2 SDS (WHO standards). At 24 months, the mean SDS values were -0.8 (0.7) and -0.4 (0.7) respectively (**Fig. 2**). At 24 months, the mean height was 83.2 (2.4) cm. 87.9% (392 of 446; OMS standards) and 92.2% (411 of 446; Sempé standards) of infants had height ≥ -2 SDS.

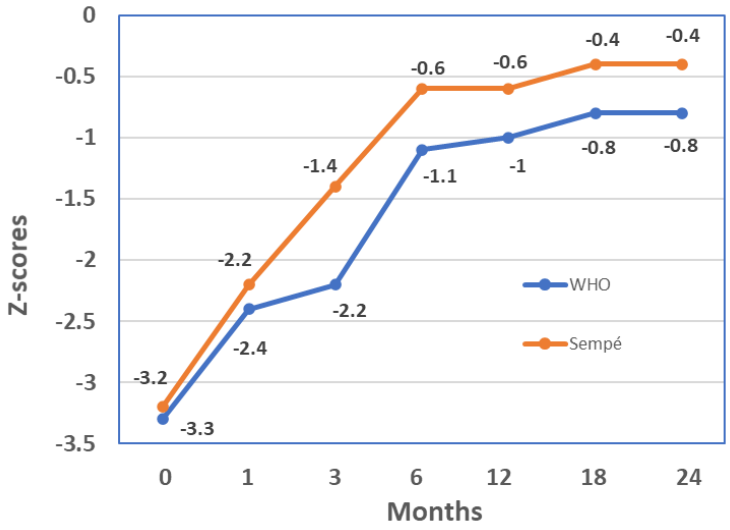

Fig.2. Evolution of the height of infants from birth to 24 months (according to WHO and Sempé and Pédron standards). Results are given as standard deviation scores.

The mean head circumference SDS at 1 month of age was -1.5 (1.0) (WHO standards) and -1.5 (1.1) (Sempé standards); at 24 months, the mean scores were -0.6 (0.7) SDS and 0 (1) SDS, respectively (**Fig.3**). At 24 months, mean head circumference was 48.4 (1.2) cm: with 97.1% (433 of 446; OMS standards) and 96.0% (428 of 446; Sempé standards) of infants having head circumference ≥ -2 SDS.

At 24 months, 392 of 446 (87.9%) children had parameters ≥ -2 SDS (OMS standards) for all three growth parameters (height, weight and head circumference); 54 (12.1%) children failed to show full catch-up growth (i.e., one of the three growth parameters was < -2 SDS).

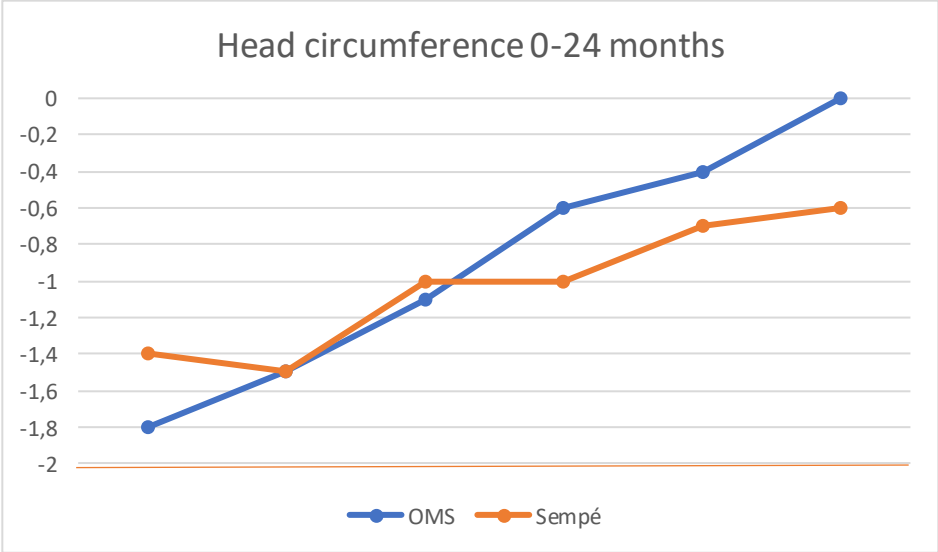

Fig.3. Evolution of the head circumference of infants from birth to 24 months (according to WHO and Sempé and Pédron standards), given as mean standard deviation scores.

Factors associated to catch-up growth at 24 months

At 24 months, 392 of 446 (87.9%) children had parameters ≥ -2 SDS (OMS standards) for the three parameters (height, weight and head perimeter); 54 (12.1%) children did not catch-up growth (i.e., one of the three parameter was < -2 SDS).

In a univariate analysis, maternal height, history of SGA, ponderal index, severity of SGA, difference between mid-parental height and both birth length and height aged 24 months, and duration of breast-feeding were significantly associated with short stature at 24 months (**Table 3**).

In the multivariate analysis, the independent predictors associated with failure of catch-up growth at 24 months were maternal height, difference between mid-parental height SDS and birth length SDS, height at 24 months < - 2 SDS below the mid-parental height, history of SGA, ponderal index < 3rd centile and duration of breast feeding < 3 months (**Table 4**).

IV. DISCUSSION

During the enrollment period, we recorded 967 (8.3%) low birth weight infants; 457 were born at term with SGA, representing 3.9% of births. These birth rates of SGA infants are close to that of developed countries, which range from 2.5% to 9% [14],[15]. In non-industrialized countries, the rate of births with SGA can be as high as 24.1% [4],[16],[17],[18],[19]. In the Maghreb, the prevalence of low birth weight was estimated to be 5.6% in Tunisia, of which three quarters were SGA cases, and in another study the SGA rate was estimated to be 6.1% [20],[21]. The overall incidence of low birth weight reported by UNICEF in developing countries is 14.3% [22]. Children born at term with SGA with catch-up growth at 24 months of age were compared with children with no catch-up. These comparisons allowed us to identify factors predictive of short stature at 24 months.

We observed that 89.7% of children born at term with SGA had an overall catch-up growth according to Sempé standards and 87.9% according to WHO standards with all three parameters (height, weight, head perimeter) above -2 SDS at 24 months. Therefore, according to Sempé and WHO standards, 10.3% and 12.1% of the study population showed persistent retardation, respectively. These data are comparable to those reported in the literature, with rates ranging from 8% to 13% for failure of catch up in SGA children [23],[24],[25],[26].

Our study identified independent predictive factors at birth in SGA newborns that predict failure to catch up at the age of 2 years. These parameters were maternal height, history of SGA, ponderal index and difference between mid-parental height and birth lenght as reported in previous studies [27]. We also identified two parameters during follow-up that predicted postnatal growth: breastfeeding for 3 months and height at 24 months less than – 2 SDS below the mid-parental height SDS.

Table 3. Factors associated with catch-up growth at 24 months on univariate analysis in 457 infants who were small for gestational age at term.

Characteristics	OR (95% CI)	P-value	Signifiance
Mother's height,			
< 150 cm	9.05 (3.50-23.42)	27.10^{-7}	**S**
≥150 cm			
Mothers BMI			
< 18.5	0.7(0.4-1.3)	1	NS
≥18.5			
Parity			
<2	0.8(0.44-1.5)	0.46	NS
≥2			
History of SGA			
Yes	0.28 (0.13-0.57)	763.10^{-7}	**S**
No			
Severe SGA			
SGA < 3rd centile	0.4 (0.18-0.90)	0.012	**S**
SGA ≥ 3rd centile			
Ponderal index,			
< 3rd centile	4.51 (2.40-8.52)	10^{-8}	**S**
≥ 3rd centile			
Sex			
Male	0.65 (0.34-1.23)	0.156	**NS**
Female			
Type SGA			
Symmetrical	1.58 (0.85-2.95)	0.117	**NS**
Asymmetrical			
SPC <4	1.2 (0.7-2.2)	0.90	NS
≥4			
MPH - Birth length			
<2.2	3.49 (1.80-6.78)	3.10^{-5}	**S**
≥2.2			
Breastfeeding,			
< 3 months	2.86 (1.52-5.42)	304.10^{-6}	**S**
≥ 3months			
MPH - Length at 24 months			
<-2SDS	20.40 (3.33-150.25)	35.10^{-5}	**S**
≥- 2SDS			

BMI, body mass index; SDS, score of standard deviation; SGA, small for gestational age.
SPC, socio-professional category; MPH, mid-parental height

Table 4. Independent factors associated with catch-up growth at 24 months (multivariate analysis) in 457 infants who were small for gestational age at term.

Characteristics	B	SE	Wald	P value	OR	CI (OR: 95%)	
Mother's height	2.048	0.576	12.652	0.00	7.751	2.508	23.955
History of SGA	1.448	0.456	10.076	0.002	4.255	1.740	10.402
Ponderal index	1.214	0.392	9.600	0.002	3.368	1.562	7.259
MPH -Birth length	1.295	0.412	9.899	0.02	3.652	1.630	8.183
Breastfeeding	1.046	0.402	6.785	0.09	2.847	1.296	6.256
MPH -Length 24 months	4.350	1.235	12.396	0.00	77.449	6.878	872.140

SDS, score of standard deviation; B, non-standardized coefficient, SE, standard error, OR, odds ratio, CI, confidence interval, SGA, small for gestational age; MPH, mid-parental height

In the literature, target height, birth height, sex, symmetrical or asymmetrical SGA, maternal smoking, maternal height and gestational age have been reported as predictive factors of catch-up growth [28], [29], [30], [31], [32], [33], [34], [35], [36]. Therefore, our results are comparable to those in the literature for target height, maternal height and history of SGA; however, they are discordant for birth height, which was not a predictive factor in our analysis [34],[37], [38], [39],[40]. Maternal smoking has also been identified as a predictive factor of short stature at the age of 2 years [41], [42],[43]; in our study, this factor was not found, but smoking was probably underreported. The relationship between breastfeeding duration and catch-up growth in infants with SGA is controversial [28], [31], [33], [35],[44], [45],[46]. To explain the discrepancies between our results and literature, it should be noted that the definition of SGA in these studies is heterogeneous due to a lack of consensus and different cut-offs used.

Head perimeter growth was the most rapid: 35% of children maintained a perimeter < -2 SDS at 1 month of age, whereas it was 54% for weight and 62% for height at the same age (Fig.4). A weight ≥ -2 SDS was achieved at 6 months by 78.7% of the study population and 60% for height (Fig 2,3), thus indicating slower growth for height than for weight, which is consistent with other studies [35],[47], [48],[49] .

The growth profile of the infants with SGA shows very rapid growth in the first few months of life, from 3 to 9 months, followed by a slowdown between one and two years [40],[50], [51], [52], [53], [54], [55],[56]. Thus, children who do not catch up in the first six months and the first year are likely of not catching up later [29], [47], [54],[57]. As reported in many studies, weight and height gain within the first six months is critical for postnatal growth [33], [34], [38], [39], [44], [58], [59],[60].

Studies that evaluated growth gain in SGA infants after 2 years of age are rare, but they indicate that only a small proportion achieves normal growth beyond this limit [32], [36], [58]. Currently, most authors agree that the pivotal point is 2 years of age [61]. Studies in SGA newborns have supported these findings by showing a significant influence of height at 2 years of age on adult height, with a 5- to 7-fold increase in the risk of remaining small at that age [34], [40], [60], [62].

Although our results are comparable to other studies in the world, we remain very cautious in terms of making a distinction between SGA and IUGR. Distinguishing those babies who are SGA owing to IUGR is important. Use of personalized growth curves at birth, where the newborn infant is his/her own reference, and comparison of size at 2 years with parental heights, which were available in 91% of cases in our cohort, are useful with respect to the recognition of IUGR. Continuing follow-up until the age of 4 years is also necessary in order to differentiate SGA due to constitutional small size from IUGR with no catch-up growth. This latter group of children are the population in whom growth hormone treatment may be appropriate, as per the published SGA guidelines [1],[6].

This study has some limitations. It has been performed in a unique center and there is no guarantee that the rates of prevalence of term SGA infants can be generalized to all maternity centers in Algeria. The strengths of this study are its prospective design and the systematic record of all births during 16 months in our hospital, meticulous measurement by a single observer in infants found to be SGA, and successful follow-up of the anthropological parameters of almost all enrolled infants over two years.

In conclusion, this study provides data concerning the epidemiology of SGA births in Algeria and the factors associated with post-natal growth. These results are in favor of setting up a national program, integrating obstetricians and pediatricians for a joint action for the ante- and postnatal follow-up of SGA infants, so that those children failing to show catch-up growth can be identified , and whose heights from 4 years of age continue to fall at least two or more SD below the mid-parental heights, in order to propose reserving growth hormone therapy for them.

Competing interests: The authors declare no competing interest.

Authors' contributions: Study concept: FB; Study design: FB; Data collection and processing: FB; Analysis and interpretation: FB; Literature search: FB ; Manuscript writing: FB. All authors approved the final version of the manuscript.

Funding: The authors declare that this study received no financial support.

REFERENCES

1. Lee PA, Chernausek SD, Hokken-Koelega AC, Czernichow P. International small for gestational age advisory board consensus development conference statement: management of short children born small for gestational age, April 24-October 1, 2001. Pediatrics. (2003) 111:1253–61. doi: 10.1542/peds.111.6.1253
2. Campisi SC, Carbone SE, Zlotkin S. Catch-Up Growth in Full-Term Small for Gestational Age Infants: A Systematic Review. Adv Nutr. 2019;10:104-11.
3. Tudehope D, Vento M, Bhutta Z, Pachi P. Nutritional requirements and feeding recommendations for small for gestational age infants. J Pediatr. 2013;162:S81-9.
4. Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. Lancet Glob Health. 2013;1:e26-36.

5. Karlberg J, Albertsson-Wikland K. Growth in full-term small-for-gestational-age infants: from birth to final height. Pediatr Res. 1995;38:733-9.
6. Kolega H, et al. International Consensus Guideline on Small for Gestational Age: Etiology and Management From Infancy to Early Adulthood. Endocr Rev 2023;44 ;44(3):539-565. doi: 10.1210/endrev/bnad002.
7. Mamelle N, Boniol M, Rivière O, Joly MO, Mellier G, Maria B, Rousset B, Claris O. Identification of newborns with fetal growth restriction (FGR) in weight and/or length based on constitutional growth potential. Eur J Pediatr 2006; 165: 717–25 doi: 10.1007/s00431-005-0045-4.
8. Sempé M, Pédron G, Roy-Pernot MP. Auxologie : méthodes et séquence, Laboratoires Théraplix 1979 Vol 1 (205p)
9. WHO child growth standards: growth velocity based on weight, length and head circumference: methods and development.
10. Lucas A, Fewtrell MS, Davies PS, Bishop NJ, Clough H, Cole TJ. Breastfeeding and catch-up growth in infants born small for gestational age. Acta Paediatr 1997;86(6):564-9. doi: 10.1111/j.1651-2227.1997.tb08935.x
11. Victora CG, Barros FC, Horta BL, Martorell R. Short-term benefits of catch-up growth for small-for-gestational-age infants. Int J Epidemiol 2001;30(6):1325-30. doi: 10.1093/ije/30.6.1325.
12. Harding J E, McCowan L M E. Perinatal predictors of growth patterns to 18 months in children born small for gestational age. Earl Hum Dev 2003; 74: 13-26 doi 10.1016/s0378-3782(03)00080-x
13. Sizonenko SV, Borradori-Tolsa C, Huppi P. Retard de croissance intrauterin: impact sur le developpement et la fonction cerebrale. Revue médicale suisse. 2008:509-14.
14. Chiavaroli V, Castorani V, Guidone P, Derraik JG, Liberati M, Chiarelli F, et al. Incidence of infants born small- and large-for-gestational-age in an Italian cohort over a 20-year period and associated risk factors. Ital J Pediatr. 2016;42:42.
15. Balcazar H. The prevalence of intrauterine growth retardation in Mexican Americans. Am J Public Health. 1994;84:462-5.
16. Yasmin S, Osrin D, Paul E, Costello A. Neonatal mortality of low-birth-weight infants in Bangladesh. Bull World Health Organ. 2001;79:608-14.
17. Mabiala-Babela JR, Matingou VC, Senga P. [Risk factors for low birth weight in Brazzaville, Congo]. J Gynecol Obstet Biol Reprod (Paris). 2007;36:795-8.
18. Sania A, Spiegelman D, Rich-Edwards J, Okuma J, Kisenge R, Msamanga G, et al. The contribution of preterm birth and intrauterine growth restriction to infant mortality in Tanzania. Paediatr Perinat Epidemiol. 2014;28:23-31.
19. Letaief M, Soltani MS, Salem KB, Bchir MA. Épidémiologie de l'insuffisance pondérale à la naissance dans le Sahel tunisien. Santé publique. 2001;13:359-66.
20. Jihen J, Sourour Y, Habib F, Mondher K, Mohamed G, Abdellatif G, et al. Le retard de croissance intra utérin: définition, épidémiologie et facteurs de risque: particularités du gouvernorat de Sfax. Journal de l'Information Médicale de Sfax. 2008;19:21-9
21. Wardlaw TM. Low birthweight: country, regional and global estimates: Unicef; 2004.
22. Saenger P, Czernichow P, Hughes I, Reiter EO. Small for gestational age: short stature and beyond. Endocr Rev. 2007;28:219-51.
23. Lagerstrom M, Bremme K, Eneroth P, Janson CG. Long-term development for girls and boys at age 16-18 as related to birth weight and gestational age. Int J Psychophysiol. 1994;17:175-80.
24. Chatelain P, Peretti N, Lapillonne A, Nicolino M, Salle B, Alamercery Y, et al. New insights into the postnatal growth of infants born 'idiopathic' small for gestational age. J Pediatr Endocrinol Metab. 2001;14 Suppl 6:1515-9.
25. Mukhopadhyay K, Mahajan R, Louis D, Narang A. Longitudinal growth of very low birth weight neonates during first year of life and risk factors for malnutrition in a developing country. Acta Paediatr. 2013;102:278-81.
26. Hennessy E, Alberman E. Intergenerational influences affecting birth outcome. I. Birthweight for gestational age in the children of the 1958 British birth cohort. Paediatr Perinat Epidemiol. 1998;12 Suppl 1:45-60.
27. Villar J, Belizan JM, Spalding J, Klein RE. Postnatal growth of intrauterine growth retarded infants. Early Hum Dev. 1982;6:265-71.
28. Ounsted M, Moar V, Scott A. Growth in the first four years: III. The effects of maternal factors associated with small-for-dates and large-for-dates pregnancies. Early Hum Dev. 1982;7:347-56.
29. Westwood M, Kramer MS, Munz D, Lovett JM, Watters GV. Growth and development of full-term nonasphyxiated small-for-gestational-age newborns: follow-up through adolescence. Pediatrics. 1983;71:376-82.
30. Fitzhardinge PM, Inwood S. Long-term growth in small-for-date children. Acta Paediatr Scand Suppl. 1989;349:27-33; discussion 4.
31. Walther FJ. Growth and development of term disproportionate small-for-gestational age infants at the age of 7 years. Early Hum Dev. 1988;18:1-11.
32. Ashworth A, Morris SS, Lira PI. Postnatal growth patterns of full-term low birth weight infants in Northeast Brazil are related to socioeconomic status. J Nutr. 1997;127:1950-6.

33. Leger J, Levy-Marchal C, Bloch J, Pinet A, Chevenne D, Porquet D, et al. Reduced final height and indications for insulin resistance in 20 year olds born small for gestational age: regional cohort study. BMJ. 1997;315:341-7.
34. Harding JE, McCowan LM. Perinatal predictors of growth patterns to 18 months in children born small for gestational age. Early Hum Dev. 2003;74:13-26.
35. de Ridder MA, Engels MA, Stijnen T, Hokken-Koelega AC. Small for gestational age children without early catch-up growth: spontaneous growth and prediction of height at 8 years. Horm Res. 2008;70:203-8.
36. Albertsson-Wikland K, Karlberg J. Natural growth in children born small for gestational age with and without catch-up growth. Acta Paediatr Suppl. 1994;399:64-70; discussion 1.
37. Lam B, Karlberg J, Low LC, Yeung CY. Incomplete catch-up growth in low birthweight Chinese infants in Hong Kong. J Paediatr Child Health. 1995;31:428-34.
38. Hokken-Koelega AC, De Ridder MA, Lemmen RJ, Den Hartog H, De Muinck Keizer-Schrama SM, Drop SL. Children born small for gestational age: do they catch up? Pediatr Res. 1995;38:267-71.
39. Luo ZC, Albertsson-Wikland K, Karlberg J. Length and body mass index at birth and target height influences on patterns of postnatal growth in children born small for gestational age. Pediatrics. 1998;102:E72.
40. Smith DW, Truog W, Rogers JE, Greitzer LJ, Skinner AL, McCann JJ, et al. Shifting linear growth during infancy: illustration of genetic factors in growth from fetal life through infancy. J Pediatr. 1976;89:225-30.
41. Tenovuo A, Kero P, Piekkala P, Korvenranta H, Sillanpaa M, Erkkola R. Growth of 519 small for gestational age infants during the first two years of life. Acta Paediatr Scand. 1987;76:636-46.
42. Hindmarsh PC, Geary MP, Rodeck CH, Kingdom JC, Cole TJ. Factors predicting ante- and postnatal growth. Pediatr Res. 2008;63:99-102.
43. Lucas A, Fewtrell MS, Davies PS, Bishop NJ, Clough H, Cole TJ. Breastfeeding and catch-up growth in infants born small for gestational age. Acta Paediatr. 1997;86:564-9.
44. Amador-Licona N, Martinez-Cordero C, Guizar-Mendoza JM, Malacara JM, Hernandez J, Alcala JF. Catch-up growth in infants born small for gestational age--a longitudinal study. J Pediatr Endocrinol Metab. 2007;20:379-86.
45. Persson LA. Infant feeding and growth--a longitudinal study in three Swedish communities. Ann Hum Biol. 1985;12:41-52.
46. Arifeen SE, Black RE, Caulfield LE, Antelman G, Baqui AH, Nahar Q, et al. Infant growth patterns in the slums of Dhaka in relation to birth weight, intrauterine growth retardation, and prematurity. Am J Clin Nutr. 2000;72:1010-7.
47. Hediger ML, Overpeck MD, Maurer KR, Kuczmarski RJ, McGlynn A, Davis WW. Growth of infants and young children born small or large for gestational age: findings from the Third National Health and Nutrition Examination Survey. Arch Pediatr Adolesc Med. 1998;152:1225-31.
48. Touwslager RN, Gerver WJ, Mulder AL, Jansen AJ, de Bruin R. Longitudinal growth during the first years of life: what is normal? Horm Res. 2008;70:273-7.
49. Fitzhardinge PM, Steven E. The small-for-date infant I. Later growth patterns. Pediatrics. 1972;49:671-81.
50. Fancourt R, Campbell S, Harvey D, Norman AP. Follow-up study of small-for-dates babies. Br Med J. 1976;1:1435-7.
51. Davies DP, Senior N, Cole G, Blass D, Simpson K. Size at birth of Asian and white Caucasian babies born in Leicester: implications for obstetric and paediatric practices. Early Hum Dev. 1982;6:257-63.
52. Datta Gupta N, Deding M, Lausten M. The effect of low birth weight on height, weight and behavioral outcomes in the medium-run. Econ Hum Biol. 2013;11:42-55.
53. Kolsteren PW, Kusin JA, Kardjati S. Pattern of linear growth velocities of infants from birth to 12 months in Madura, Indonesia. Trop Med Int Health. 1997;2:291-301.
54. Maleta K, Virtanen S, Espo M, Kulmala T, Ashorn P. Timing of growth faltering in rural Malawi. Arch Dis Child. 2003;88:574-8.
55. Cho WK, Suh BK. Catch-up growth and catch-up fat in children born small for gestational age. Korean J Pediatr. 2016;59:1-7.
56. Karlberg JP, Albertsson-Wikland K, Kwan EY, Lam BC, Low LC. The timing of early postnatal catch-up growth in normal, full-term infants born short for gestational age. Horm Res. 1997;48 Suppl 1:17-24.
57. Itabashi K, Mishina J, Tada H, Sakurai M, Nanri Y, Hirohata Y. Longitudinal follow-up of height up to five years of age in infants born preterm small for gestational age; comparison to full-term small for gestational age infants. Early Hum Dev. 2007;83:327-33.
58. Seminara S, Rapisardi G, La Cauza F, Mattei P, Donzelli G. Catch-up growth in short-at-birth NICU graduates. Horm Res. 2000;53:139-43.
59. Karlberg J, Albertsson-Wikland K, Baber FM, Low LC, Yeung CY. Born small for gestational age: consequences for growth. Acta Paediatr Suppl. 1996;417:8-13; discussion 4.
60. Rapaport R, Tuvemo T. Growth and growth hormone in children born small for gestational age. Acta Paediatr. 2005;94:1348-55.
61. Jaquet D, Collin D, Levy-Marchal C, Czernichow P. Adult height distribution in subjects born small for gestational age. Horm Res. 2004;62:92-6.