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ORIGINAL ARTICLE

Nutrition and Growth

Growth charts for use at birth and in the neonatal period: Recommendations of the French Neonatal Society

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Abstract

Introduction: The use of different growth charts can lead to confusion in discussions between professionals. There are obstetric charts (of fetal growth) and neonatal charts (of measurements at birth and of postnatal growth). These charts can be descriptive (derived from an unselected population) or prescriptive (derived from of a population at low risk and with optimal conditions for growth).

Objectives: (1) To describe available charts for infants at birth and in the neonatal period and compare them, and (2) to recommend one or more charts for use in neonatology in France.

Methods: Bibliographic research was conducted on MEDLINE and completed by the guidelines of professional societies.

Results: Antenatal information about fetal growth restriction (FGR) or fetuses identified as small-for-gestational-age using Intrauterine charts must be integrated into the identification of newborns at risk, but the use of Intrauterine charts to evaluate birthweight is not recommended to allow consistency with postnatal charts used in neonatal practice. Z-score variations using the updated Fenton postnatal charts are the most appropriate for the assessment of birthweight and postnatal growth for infants born preterm. These charts are sex-specific, include the three measurements (length, weight, and head circumference) and enable longitudinal follow-up of growth up to 50 weeks of corrected age and are linked to the WHO charts at term. The French Audipog charts, although are individualized, accessible online and can be used in maternity units to evaluate birthweight for term infants, but do not allow the follow-up of postnatal growth, while Fenton charts may be used to evaluate birthweight and postnatal growth in the first month for hospitalized term infants.

Conclusion: The updated Fenton charts are the neonatal charts that best suit the objectives of pediatricians in France for monitoring the growth of preterm newborns. The use of the Audipog charts at term remains an alternative in maternity wards, while Fenton charts can be used for hospitalized term newborns.

Abbreviations: BMI, body mass index; BW, birthweight; EFW, estimated fetal weight; ESPGHAN, European Society for Paediatric Gastroenterology, Hepatology, and Nutrition; EUGR, extra-uterine growth restriction; FGR, fetal growth restriction; HC, head circumference; IG, intergrowth; IUGR, intrauterine growth retardation; LGA, large-for-gestational-age; SGA, small-for-gestational-age.

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birthweight postnatal growth, fetal growth, newborn, preterm infant

1 | INTRODUCTION

Harmonious fetal and neonatal growth is associated with a favorable outcome for newborns. Use of a chart over time is necessary to characterize and assess this growth. Nonetheless, there are numerous intrauterine growth charts, derived from ultrasound measurements, charts evaluating growth at birth (birthweight [BW], height and head circumference [HC], and postnatal growth charts). These can be either descriptive (or references: derived from an unselected population) or prescriptive (or growth standards: describing ideal growth based on population selected for their low risk). This profusion leads to variable quality in the diagnosis of fetuses or newborns with abnormal growth and makes communication between professionals of the perinatal period difficult. Depending on the charts used, the proportion of individuals detected by similar thresholds vary, and so do the indications for monitoring and treatment, and the discourse given to families. Under these circumstances, harmonization of growth charts seems necessary.

The primary objectives of this work are to: (1) describe the tools available for evaluating body measurements at birth and monitoring postnatal growth, (2) compare them with one another, and (3) to recommend the use of charts in France.

2 | METHODS

We searched the literature using MEDLINE and the Cochrane Library in English or French since 2000 except for some older publications frequently cited in the literature and completed it with a manual search of the references from selected publications. We sought to identify the principal charts used to assess growth at birth and postnatally in the scientific literature. We also looked for studies that compared the validity and performance of weight, length, and HC at birth to intrauterine growth charts and guidelines from international scientific and professional societies.

We used the following keywords, separately and combined, in as many stages as necessary: fetal/Intrauterine growth, fetal/Intrauterine growth restriction, fetal/Intrauterine growth retardation, small for gestational age, birthweight, low birthweight, large for gestational age, macrosomia, references, standards, growth charts, growth curves, biometric measurements, anthropometry, growth velocity, growth trajectories, preterm births, neonatal outcomes, neurodevelopmental outcomes, fetal programming, and metabolic syndrome.

To choose the charts to include in this review, we collected those used by the studies establishing

What is Known

- The choice of a growth chart is fundamental for identifying newborns at particular neonatal risk.
- The availability of multiple intrauterine, birthweight, or postnatal growth chart in the literature makes comparisons difficult.

What is New

- The most appropriate birthweight and postnatal charts for monitoring the growth of preterm newborns in the French population are the Fenton charts.
- The Audipog charts are French birthweight charts that can be used in maternity wards to identify term newborns at risk, while Fenton charts may be used for assessing growth at birth and in the first month among hospitalized term newborns.

associations between Intrauterine growth, postnatal growth, and intermediate and long-term neonatal morbidity and mortality.

The definitions and terminology (Table S1) we use are clarified in a glossary already published elsewhere.¹

3 | FINDINGS**3.1 | Growth assessment at birth****3.1.1 | Weight, length, and HC**

BW is the measurement that makes classically it possible to identify newborns at particular risk (small-for-gestational-age, SGA) with a birthweight below the 10th percentile on neonatal curves or large-for-gestational-age (LGA) with a birthweight >90th percentile who require appropriate monitoring and management. Other birth parameters as length at birth is correlated with adult height.² A small HC at birth is associated with a higher risk of nonoptimal neurological development.³

3.1.2 | What charts to choose at birth: Intrauterine (prenatal or obstetrical) or neonatal (postnatal)?

Intrauterine charts are constructed from estimated fetal weight (EFW), calculated by a formula based

on three ultrasound-measured indicators (HC, abdominal circumference, and femur length) at different points during gestation. These longitudinal charts depend on the precision of the ultrasound measurements and of the formula used to derive EFW from these measurements.

Charts of measurements at birth are constructed from measures of the newborn's weight, length, and HC. Their value is limited at the extreme gestational ages because sample sizes are limited, and preterm newborns are different from the in utero population due to their frequent abnormal intrauterine growth (due to placental insufficiency for example). This can result in discrepancies between thresholds between intrauterine and newborn charts and reduces the identification of SGA babies among preterm neonates.⁴

Preterm fetuses classified with FGR based on EFW may thus be classified non-SGA by their BW without any errors of obstetric or neonatal measurements occurring.⁴ The identification of FGR during pregnancy (using a definition based on the velocity of fetal growth⁵) is more important in terms of mortality and outcome than the classification as SGA or non-SGA (which are one point definition that depend on the choices of chart and threshold).⁵⁻⁷ A multicenter analysis performed among preterm neonates born at 22–29 weeks and using three fetal charts (NICHD, WHO, and intergrowth [IG]) and one chart of BW measurements (Vermont Oxford Network) found that the fetal growth charts were not superior to BW charts for identifying risks of neonatal complications.⁸ Another study showed that only FGR newborns diagnosed before birth from customized fetal growth charts and confirmed by a postnatal SGA <3rd percentile on neonatal charts were at risk of neonatal morbidity.⁹ Finally, another study classified preterm newborns as SGA or LGA with four charts: two neonatal charts (Fenton and IG) and two EFW curves (WHO 2016 and the customized GROW)¹⁰ found that the percentage of SGA and LGA newborns <37 weeks varied from simple to double or even triple depending on the chart used.

Antenatal information about FGR must be integrated into the identification of newborns at risk, even when the measurements at birth reported on the postnatal charts exceed the 10th percentile. However, while integrating their information, the use of obstetric curves is not recommended by the SFN for birth measurements

3.2 | Postnatal growth assessment

3.2.1 | When and why should postnatal growth be defined?

As well as birth parameters, postnatal growth is associated to newborns' outcome and monitoring this is

important.^{11,12} Traditionally, it is primarily the weight that is monitored. Concerning height, shortness at discharge is associated with shortness in childhood^{13,14} and nonoptimal neurologic development at 2 years.¹⁵ Poor HC growth was associated with a higher risk of nonoptimal neurological development at the age of 2 years.³

However, the different methods of characterizing growth make comparisons between studies difficult.¹⁶ The analysis of weight variations depends on the milestones chosen: variations in the water intake physiologically required in the first days of life,¹⁷ weight variation during the first month of life corresponding to parenteral and/or enteral nutrition,¹⁸ and then the progression from parenteral to enteral nutrition.¹⁹ The interactions between extrauterine growth and comorbidities remain difficult to assess.²⁰ There appears to be a “growth/nutrition effect” independently associated with the neurodevelopment outcome of preterm infants.²¹ Ehrenkranz et al.¹¹ showed that early postnatal growth was positively associated with neurological development in preterm newborns. Moreover, cognitive performance at 5 years of age was lower among the preterm newborns with insufficient postnatal growth compared with those with better postnatal growth.¹²

Nonetheless, expected growth in preterm newborns comes up against difficulties related to definitions, reference populations, and cut-offs. The optimal growth target for preterm infants is not totally determined. To date, there are no randomized controlled trials to confirm the unidirectional link between growth and neurodevelopment, an acceleration in growth in preterm SGA infants is not associated with a better neurologic prognosis.²⁰ When neonatologists aim to maintain the best growth possible through aggressive nutrition, side effects (cardiovascular and metabolic morbidities) can occur,²² as suggested by the concept of fetal programming (or developmental origins) of adult diseases in adulthood.

3.2.2 | Postnatal growth characterization method

Weight gain reported as g/kg/d

This method varies according to the date of the first measurement, the denominator used, and the number of subdivisions of the period. Patel described this method with an exponential model.²³ Another effective complex model involves calculating the ratio of the weight gain between the birth and discharge.²⁴ Fenton et al. compared several methods for assessing growth velocity and showed that a threshold of 15 g/kg/d was poorly correlated with the growth charts of both Fenton and Olsen²⁵ due to the nonconstant human growth through gestation and infancy.

z-score variation (Δz -scores)

The z-scores measure the difference in the means with a postnatal data chart that takes gestational age into account. The Δz -scores for a given period determine the growth trajectories: regular (Δz -score = 0), catch-up (Δz -score > 0), or extrauterine growth restriction (EUGR) (Δz -score < 0). A study shows a discordance in more than one-third of the population studied between the g/kg/d method according to Patel's model and the Δz -score for weight according to Fenton's charts and that Δz -score was more suitable to analyze the population of preterm.²⁶ Landau-Crangle et al. published a **calculator** (<https://www.growthcalculator.org>) that enables clinicians to generate daily individual growth trajectories and targets for preterm infants, while taking the initial weight loss into account and aiming growth for the target weight at 42 weeks.²⁷

3.2.3 | Which growth charts to be used in the neonatal period

International guidelines on growth charts

Few guidelines exist specifying which measurements should be taken at birth—or how. The Canadian Paediatric Society (CPS) proposed the use of Fenton's neonatal growth charts for assessing birth measurements and for monitoring the growth of preterm newborns.²⁸ For postnatal growth monitoring, the WHO charts (<https://www.who.int/tools/child-growth-standards>) are recommended by several professional societies (the French society's committee on nutrition²⁹ in 2009 for the first year of life, the ESPGHAN in 2013, and the Canadian Society in 2010 for term newborns with a BW exceeding 2500 g.^{28,30}

3.2.4 | Charts used in France (Table 1)

Measurements at birth can be assessed by two descriptive charts (Audipog³⁷ and Fenton³⁸ and two prescriptive charts (IG for newborns and IG for preterm).^{39,40} The postnatal growth charts include the WHO⁴¹ and AFPA growth curve⁴² for term newborn and IG prescriptive charts⁴⁰ and Fenton charts³⁸ for preterm.

Audipog is a descriptive French charts of birth measurement, sex-specific and customized widely used in French maternity. From 1999 to 2005, the Audipog database included 209836 infants between 24 and 42 weeks. Abnormal biometric data, stillbirth, and congenital malformations were not included. In the end, the study covered 203,062 records for weight, 172,016 for height, and 168,100 for HC. Its disadvantage was its limited number of extreme preterms (<28 weeks) and the fact that its LMS was not published preventing its

use for calculating z-scores. Furthermore, this curve is a birth measurement curve and cannot be used to monitor neonatal growth.

Revised Fenton growth chart is a descriptive sex-specific charts of birth and growth measurements constructed from a meta-analysis of six neonatal cohorts (not French one). 3,986,456 newborns were included among whom 34,639 < 30 weeks. It is not a customized chart and for term newborns, it is not a birth measurement chart, but a growth model that merges with the WHO charts. Due to the incorporation of two distinct data sets based on the preterm and the term infants in these growth charts, it created an evident disjunction between the two reference data sets. The revised preterm growth chart, harmonized with the WHO Growth Standard at 50 weeks, may support an improved transition of preterm infant growth monitoring to the WHO charts specifically focusing on the fetal-infant growth reference disjuncture between 37 and 50 weeks.

Intergrowth charts are prescriptive birth measurement and postnatal growth charts, international, multi-ethnic and longitudinal. French population was not included. Among 59,137 pregnant women screened, 20,486 (35%) were enrolled in the study. "Normal" birthweight varied across countries ranging from 2900 g in India to 3500 g in the United Kingdom.

The AFPA growth curves are descriptive, sex-specific postnatal growth charts constructed for the French general population and monitoring growth from 1 month to 18 years. It cannot be used for monitoring growth in the neonatal period due to the lack of collected data in the first month of life.

The WHO growth charts are prescriptive postnatal growth charts, international, multiethnic, and longitudinal, but without French cohort included. The data at birth were pooled at term to define point 0 at birth, without distinguishing between 37 and 41 weeks. Moreover, data in WHO curves were collected at birth to 7 days, and 7–14, 14–28, 28–42, and 42–60 days. The tables of weight velocity from birth to 60 days presented physiological weight losses that occur in the early postnatal period but are not usually included in available reference data and depends of what percentage of birth weight was lost and the successful initiation of lactation.

Table 2 summarizes their various advantages and disadvantages.

3.2.5 | Comparison between charts (Table 2)

For preterm newborns

Use of the Fenton and IG postnatal charts produces significant differences in the evaluation of the growth of hospitalized preterm newborns.^{43,44} In a recent

TABLE 1 Population and purpose, advantages and disadvantages of birth and postnatal charts used in France.

Charts	Population and purpose	Advantages	Disadvantages
Birth parameters charts			
Audipog (Mamelle 1996)	Sex-specific and customized birth measurement charts, French general population (descriptive). Last updated in 2008. 203,062 data items for weight, 172,716 for length, and 168,100 for head circumference.	French general population, sex-specific, customized, and validated for clinical and laboratory data.	Limited numbers for the extreme gestational ages (not usable <28 weeks). Unpublished LMS (skew, median, and standard deviation) formula prevents its use in software for calculating z-scores or in computerized patient files. No comparison with international charts. No recent publications.
Olsen (Olsen 2010)	Sex-specific birth measurement charts, general US population (descriptive). 257,855 newborns between 22 and 42 weeks, in 248 hospitals in 33 states; from 1998 through 2006. 11,377 preterm infants (<30 weeks).	Large numbers of preterm infants <30 weeks. LMS parameters published and can be imported into software files for prescription and/or patient files, with automatic calculation of the z-score. Data available, used by numerous publications.	US population. Noncustomized charts.
Postnatal growth charts			
AFPA 2018 charts in French portable health records (Heude 2019)	Sex-specific postnatal growth charts for the French general population (descriptive). Included in French portable child health records since April 2018. 2,500,000 measurements of weight, 2,000,000 of length, and 1,200,000 of head circumference, from 261,000 children aged from 1 month to 18 years.	French general population, sex-specific, recent. Monitoring growth from 1 month to 18 years.	Only data from children with a birth weight >2500 g were used. No data at birth. These charts cannot be used for monitoring growth in the neonatal period.
WHO (WHO, 2006)	Postnatal growth charts, international, multiethnic, and longitudinal, 1997–2003 (prescriptive). Selection of pregnancies of nonsmoking mothers of a good socioeconomic level, with no neonatal morbidity and subsequent breastfeeding. Longitudinal follow-up from birth to 2 years with 21 measurements. Six countries: Brazil, Ghana, India, Norway, Oman, USA. 882 mother–child pairs were included.	Pregnancies at low risk, with no disease that could affect fetal growth. Standardized measurements for length, weight, and head circumference. Follow-up of children to 2 years to assess their growth and development to validate the low-risk character of the sample. Postnatal charts allowing follow-up of longitudinal growth from birth to 24 months. Chart validated in the general population French. ¹ The only chart recommended by international professional societies. Published LMS allowing the calculation of z-scores.	No French cohort included. “Normal” mean weights vary between countries. Related limited sample size. Details of the birth measurements as a function of gestational age have not been published. The data were pooled at term to define point 0 at birth, without distinguishing between 37 and 41 weeks. These data therefore do not permit either the calculation of birth weight z-scores or the use of these charts to assess the term newborns' birth measurements according to gestational age.
Intergrowth newborn (Villar 2014)	Birth measurement and postnatal growth charts, International, multiethnic longitudinal, 2009–2014 (prescriptive). Same method as the WHO charts. Eight countries: Brazil, China, India, Italy, Kenya, Oman, the United Kingdom, and the United States.	Pregnancies at low risk, with no disease that could affect fetal growth. Standardized and controlled measurements of length, weight, and head circumference within 12 h after birth (calibration of material, inter- and intraobserver variations measured).	No French cohort included. “Normal” mean weight varied between countries, ranging from 2900 g in India to 3500 g in the United Kingdom.

(Continues)

TABLE 1 (Continued)

Charts	Population and purpose	Advantages	Disadvantages
	20,486 mother-child pairs were included.	Follow-up of children to 2 years to assess their growth and development to validate the low-risk character of the sample. Postnatal charts allowing follow-up of longitudinal growth from birth to 24 months with continuum with fetal charts because it's the same population Large cohort.	
Intergrowth preterm (Villar 2015)	Birth measurement and postnatal growth charts, international, multiethnic, longitudinal (prescriptive). Same method as the WHO charts Cohort modified in 2016 to increase the sample born at less than 33 weeks ($n = 408$).	Longitudinal charts allowing follow-up of growth for preterm newborns.	No French cohort included. Addition of preterm newborns with prenatal risk factors (pre-eclampsia, cesarean birth, higher neonatal mortality rate). Very small number of subjects for births before 28 weeks ($n = 82$ for the birth weight chart). No information about the parenteral nutrition protocols during hospitalization.
Fenton (Fenton 2013)	Sex-specific charts of birth and growth measurements (descriptive). Constructed from a meta-analysis of six neonatal cohorts: three European (Germany/Scotland/Italy), two North American (USA-Canada), and one Australian: Voigt et al., ³¹ Kramer et al., ³² Olsen et al., ³³ Roberts et al., ³⁴ Bonellie et al., ³⁵ and Bertino et al. ³⁶ 3,986,456 newborns including 34,639 < 30 weeks, 3012 at 24 weeks. Modeled and combined with the WHO charts, harmonized with the WHO charts at 50 weeks.	The largest cohort including preterm infants <30 weeks. LMS parameters published, can be imported into software files for prescription and/or patient files, with automatic calculation of the z-score. Data available, used by numerous publications. Postnatal charts allowing follow-up of longitudinal growth from birth to 50 weeks for preterm infants with birth gestational age <37 weeks.	Noncustomized charts. No French cohort included. For term newborns, it is not a birth measurement chart, but a growth model that merges with the WHO charts.

study,⁴⁵ the Fenton and IG charts were not comparable for classifying SGA and LGA newborns. More preterm newborns were classified as SGA by IG and more LGA by Fenton charts. In a recent study, one in five newborns classified with EUGR with Fenton's charts were considered to have normal growth with IG, and one in four of the newborns classified SGA with IG were growing normally according to the Fenton charts.⁴⁶ Another study⁴⁷ compared IG with the Fenton charts and conclude that IG charts overestimated the FGR rate and underestimated the EUGR rate for BW; the reverse was true for HC. Finally, in another study, Fenton's chart predicted postnatal growth better except at 2 weeks of life, because it did not consider the water losses of the first days.⁴⁸

For term newborns. Comparisons of the IG and Fenton charts⁴⁵ and GROW customized fetal chart⁴⁹ showed that the IG charts underestimated the number of SGA term newborns and overestimated the number of LGA

newborns. Moreover, the comparison of the performance of three different charts (one Sweden descriptive chart based on birth registry, a customized chart, and IG)⁵⁰ for neonatal morbidity showed that all three charts performed well in detecting an increased risk of morbidity, with different percentile thresholds for the national and customized charts compared with IG. Another study comparing classification as SGA and LGA according to the Fenton, IG neonatal charts, WHO 2016 and customized GROW EFW charts¹⁰ showed that the best specificity rate for neonatal comorbidity was found for the newborns classified with appropriate growth by Fenton, but the sensitivity was lower.

4 | CONCLUSION

The choice of growth charts is guided by the objectives of professionals of the perinatal period. Using EFW charts in the postnatal period to evaluate birthweight is

TABLE 2 Comparison of charts.

Studies	Charts compared	Population	Results
Growth charts for preterm infants			
Tuzun, 2018	Intergrowth neonatal and postnatal growth charts versus Fenton 2013	<i>n</i> = 248 <32 weeks 2011–2016 Turkey Single-center	1/4 SGA IG were appropriate for gestational age in Fenton without excess neonatal comorbidities. 1/5 EUGR in Fenton had normal growth in IG.
Reddy, 2019	Intergrowth newborn and postnatal growth charts versus Fenton 2013	<i>n</i> = 603 <32 weeks 2015–2017 India Single-center Retrospective FGR and EUGR defined by at least weight and length and/or HC <10th percentile at birth and at discharge	For weight and length: IG screened more FGR than Fenton. For HC: Fenton screened more FGR than IG. FGR IG and not Fenton had more comorbidities (sepsis, retinopathy of prematurity)
Samarani, 2020	Intergrowth versus Fenton 2003	<i>n</i> = 318 at birth, <i>n</i> = 216 at 2 weeks and <i>n</i> = 141 at term. term at birth 27–36 weeks. 2010–2017 Lebanon Single-center	Weight–length and HC at birth, 2, 4, 37 weeks Comparison of two charts for monitoring growth during hospitalization. Controversial results with Fenton more effective for predicting growth <2 weeks and at 4 weeks or more. IG more effective at 2 weeks.
Boghossian, 2018	Three fetal weight charts (NICHD, WHO, IG) 1 birthweight chart (Vermont Oxford Network)	<i>n</i> = 156,587 <30 weeks 2006–2014 USA (Vermont Oxford Network) Multicenter	Antenatal charts are not superior to postnatal charts for identifying newborns at risk of neonatal complications.
Fernandez-Rodriguez, 2019	Intergrowth versus Olsen SGA (<3rd p. on the customized fetal chart (GROW))	<i>n</i> = 95 <34 weeks 2014–2015 Spain Single-center	24% SGA antenatal. SGA in 48% of case with Olsen and 35% with IG. Only those SGA in antenatal and postnatal charts had neonatal comorbidities.
Marques, 2020	Intergrowth versus Fenton 2013	<i>n</i> = 14,056 including 857 <37 weeks 2006–2015 Portugal Multicenter	Comparison SGA <10th p. and LGA >90th p. according to the chart used. More preterm newborns classified SGA with IG (22.5% vs. 26.3%). More preterm newborns classified LGA with Fenton (3.8% vs. 3.3%).
Kim, 2020	Intergrowth PPFS versus Fenton	<i>n</i> = 1356 <28 weeks 2013–2015 Korea KNN (Korean Neonatal Network)	Comparison of EUGR according to the charts used. The diagnosis of FGR was more frequent with the Fenton charts, but FGR with comorbidities was more frequently associated with IG (z-score difference at discharge: 1.44 ± 1.21 for Fenton versus 1.03 ± 1.33 for IG).
Cartwright, 2020	Two fetal charts (WHO, customized GROW) two postnatal charts (Fenton, Intergrowth)	<i>n</i> = 2711 33–36 weeks 2006–2013 New Zealand Single-center	Comparison SGA <10th p. and LGA >90th p. for moderately preterm infants according to the chart used: SGA 5.7%, 11.1%, 16.5%, and 21.8%; LGA 15.9%, 12.5%, 21.6%, and 11%, respectively, for Fenton, IG, WHO, and GROW.
El Rafei, 2021	Weight percentiles at discharge according to Fenton and IG charts; difference in z-score between birth and discharge on Fenton and IG charts and according to the velocity of weight gain according to Patel's model	<i>n</i> = 6792 <32 weeks 19 regions in 11 European countries	Birth weight at discharge <10th p. in Sweden for 24% of newborns on the Fenton charts and 13% on IG. In Portugal, 60% on the Fenton charts versus 43% with IG. The difference in the z-score for weight between birth and discharge was very well correlated with the measurements based on the z-score differences for both the Fenton and IG charts (Spearman's $\rho = -0.90$ for Fenton and -0.84 for IG, $p < .01$), but not with the velocity of weight gain according to Patel's model ($\rho = -0.38$, $p = .25$).

(Continues)

TABLE 2 (Continued)

Studies	Charts compared	Population	Results
Growth charts for term infants			
Marques, 2020	Intergrowth versus Fenton 2013	<i>n</i> = 14,056 including 857 <37 weeks 2006–2015 Portugal Multicenter	Comparison SGA <10th p. and LGA >90th p. according to the chart used. More preterm newborns were classified LGA with Fenton (13.1% vs. 5.5%). More term newborns were classified LGA with Fenton (9.6% vs. 1.7%).
Vieira, 2019	Postnatal national versus customized chart (Gardosi) versus Intergrowth	<i>n</i> = 212, 101 37–42 weeks 2006–2015 Sweden (birth registry) Multicenter	The three charts performed well for detecting neonatal morbidity and mortality but with different percentile thresholds Morbidity of SGA newborns: <9.9/<10/<25th p. Morbidity of LGA newborns: >89.9/<87.5/<96.9th p.
Pritchard, 2020	Intergrowth versus antenatal customized chart (GROW)	<i>n</i> = 71, 487 37–42 weeks 1994–2016 Australia Single-center	SGA <10 p. IG, SGA z-score <1 SD IG, SGA <10th p. customized GROW <10th p. IG detected fewer SGA than the customized GROW (4.6% vs. 10.6%). z-score <1 SD IG closer to customized GROW (8.2% vs. 10.6%). Strong difference for newborns for obese mothers, who were better detected with customized GROW.
Cartwright, 2020	Two fetal charts (WHO, customized GROW) two postnatal charts (Fenton, Intergrowth)	<i>n</i> = 45 505, 33–40 weeks 2006–2013 New Zealand Single-center	Comparison SGA <10th p. and LGA >90th p. according to the chart used: SGA 3.8%, 4.8%, 9.7%, and 11.5%; LGA 11.7%, 20%, 16.3%, and 9.3% for respectively Fenton, IG, WHO, and GROW. Analysis of neonatal comorbidities (NICU >48 h for acute complication, respiratory support >4 h, 5-min Apgar <7, neonatal death) by gestational age category (33–37, 37–39, 39–41 weeks) and according to SGA/LGA diagnosis: optimal screening of SGA or LGA at high risk of neonatal comorbidities by the combined use of Fenton and GROW charts (sensitivity 38.8%, specificity 82.4%, PPV 9.1%, NPV 96.7%).

Abbreviations: EUGR, extrauterine growth restriction; FGR, fetal growth restriction; HC, head circumference; IG, INTERGROWTH; LGA, large for gestational age; NPV, negative predictive value; P, percentile; PPV, positive predictive value; SGA, small-for-gestational age.

not recommended. Antenatal information about growth restriction must be integrated into the identification of newborns at risk regardless the measurements at birth reported on the neonatal charts.

The updated Fenton charts, based on measurements at birth and of postnatal growth meet the needs of French pediatricians best. They allow a longitudinal follow-up of growth up to 50 weeks of corrected age, merging with the WHO charts. The Audipog charts have the advantage of being individualized, widely used in French maternity and accessible by internet but do not allow the follow-up of postnatal growth. The IG prescriptive newborn charts have not been validated in the French general population. They underestimate the number of SGA and overestimate the number of LGA newborns.

As we await birth measurement charts modeled on the French general population to enable continuity between the professionals in the neonatology unit and those in the maternity ward, the use of Fenton charts merging with the WHO charts allows a satisfactory compromise.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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