

Comparative study between Fenton and Intergrowth 21 charts in a sample of Lebanese premature babies

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Abstract

Background: Different charts are used to assess premature growth. The Fenton chart, based on prenatal growth, was used in the intensive care unit of the Notre Dame des Secours University Hospital to assess premature newborns' development. Intergrowth21 is a new multidisciplinary, multiethnic growth chart better adapted to premature growth. Our objective was to compare both charts Fenton and Intergrowth21 in order to implement Intergrowth in our unit.

Methods: We analyzed 318 files of premature babies born who were admitted to the NICU from 2010 till 2017. Anthropometric data (weight, height and head circumference) converted to percentiles was filled on both charts from birth till 1 month of age.

Results: The results of the linear regression taking the weight at birth as the dependent variable, showed that the Fenton scale ($R^2=0.391$) would predict the weight at birth better than the Intergrowth 21 scale ($R^2=0.257$). The same applies for the height at birth and cranial perimeter at birth when taken as dependent variables. When considering the weight and height at 2 weeks, the results showed that the Intergrowth 21 scale would predict those variables better than the Fenton scale, with higher R^2 values higher in favor of the Intergrowth 21 scale for both weight (0.384 vs 0.311) and height (0.650 vs 0.585). At 4 weeks, the results showed that the Fenton scale would predict weight ($R^2=0.655$ vs 0.631) and height ($R^2=0.710$ vs 0.643) better than the Intergrowth 21 scale. The results obtained are adjusted over the newborns' sociodemographic and clinical factors.

Conclusion: The results of our study are controversial where the Fenton growth charts are superior to Intergrowth 21 before two weeks of age and at 4 weeks, whereas Intergrowth 21 charts showed higher percentiles for weight and height than Fenton charts at 2 two weeks of age. Further studies following a different design, such as a clinical trial or a prospective study, and conducted in multiple centers should be considered to enroll a more representative Lebanese sample of children and be able to extrapolate our results to the national level.

Introduction

Prematurity is becoming more frequent nowadays especially with the development of artificial fertilization methods ¹. In 2016, the Center for Disease Control and Prevention (CDC) declared that around one baby out of 10 is born premature ^{2,3}. The newborn's growth is an important marker and a screening method for a number of pathologies or deficiencies ⁴, which needs to be tracked through growth charts. The latter would lead to a better monitoring of the nutritional status, thus, may limit the depth and duration of diet-related growth restriction and its short- and long-term damages thereafter ³.

In fact, many charts have been developed, mostly based on intrauterine growth and rarely adapted to preterm newborns. Indeed, preterm babies are not fetuses as they no longer live in-utero ⁵. They present a physiological immaturity and regardless of their apparent independence, they have not yet acquired the growth and survival skills of full-term babies. Consequently, when assessed via common growth charts, these newborns remain under the 10th percentile for a long time and do not catch up with normal growth until the age of two to three years. For this motive, the actual trend is to supplement this population with a hypercaloric nutrition to compensate for this extra-uterine growth restriction. Still, despite this supplementation, most babies fail to reach their set growth goals.

In that scope, alarming studies have shown an association between prematurity and obesity in adulthood, with question marks raised about the link between "overfeeding" the preterm newborns, obesity and the cardiovascular complications later in life ⁶. In the neonatal population aged between 36 and 50 weeks of unadjusted age, the Fenton graph is considered one of the best charts for assessing longitudinal growth ⁷. Nevertheless, the Fenton curves showed two weaknesses: first, it does not reflect the adaptation of the premature newborn to extra-uterine life; second, of all it under or overestimates a newborn's growth.

The most commonly used chart at the hospital Center Notre Dame des Secours Byblos, is the Fenton chart 2003, which has not been updated till now. Between 2009 and 2014, the Intergrowth21 project has emerged as a successful growth chart and underwent rigorous processes that ensured that the data collected in the INTERGROWTH-21st project were of exceptionally high quality ⁸. Intergrowth 21 charts are used to create standards for postnatal growth of premature infants especially those born before 32 gestational weeks ⁹. While disagreements on the Fenton charts continue, the results of the Intergrowth 21st project were awaited with great interest. The "Intergrowth 21st Project" was a prospective multicenter, multi-ethnic study where low-risk women, non-smokers, with a normal pregnancy history, and without health problems that could affect fetal growth, were included ¹⁰. All maternal health care and nutritional needs were met. Birth and postnatal growth standards were developed from data collected from a cohort of uncomplicated pregnancies with normal growing fetuses ¹¹. These very strict selection criteria were mandatory, in order to create standards on how the normal growth of healthy premature babies should be.

In a recent systematic review, 61 longitudinal reference charts were identified and compared to the intergrowth 21 chart ⁹. When assessments were made with the new Intergrowth-21st postnatal growth charts, recent evidence has demonstrated that the use of the INTERGROWTH-21st

Preterm Postnatal Growth Standards reduced the diagnosis of extrauterine growth retardation^{9,12}. Many infants who were classified as having a restricted growth according to the Fenton charts, turned out to have a normal postnatal growth¹². Another important point is that, like the WHO growth standards, the Intergrowth 21st growth standards aim to produce graphs that describe optimal rather than average growth, which could be used worldwide.

Being in a developing country, a local validation before adapting Intergrowth 21st to our new born infants is necessary, especially to avoid the misclassification of their size, which may have an impact on their nutritional support. For these reasons, the objective of this study was to check which method (the universal Fenton 2003 curves or the intergrowth 21st curves) used in the neonatology department at CHU-NDS would predict better the height, weight and cranial perimeter of Lebanese premature babies. This study would help us evaluate a difference between the two curves in terms of extra-uterine growth restriction, intra-uterine growth restriction, reflected by the weight, length and head circumference at birth and verify later the convergence between the intergrowth 21st and the WHO curves of the child health record book around the sixth month of life.

Methods

Study design

This was a retrospective study, conducted in the Notre Dame des Secours University hospital. Medical records of premature newborns admitted to the neonatal unit over a seven-year period (2010 to 2017) were reviewed. The discretion of names and personal information has been respected. All preterm infants born alive before 37 weeks of gestation and admitted to the neonatology department within 24 hours of birth, were included in the study. Excluded were term newborns (born at 37 weeks of gestation or more), those admitted after 24 hours of birth to the neonatal intensive care unit (NICU) and those who died during hospitalization or were transferred to another hospital. All newborns suffering from a comorbidity who can affect normal growth such as bronchodysplasia, cardiovascular pathologies and placental insufficiency or any other prenatal diseases that are known that could alter the normal pattern of growth, were also excluded. Term infants were excluded because intergrowth 21 is a growth chart adapted only to preterm babies.

Data collection

Data was collected from files in the medical archive. The weight, height and head circumference of each child at birth, at 37 weeks of gestation, 2 weeks and 4 weeks of life were noted, and then marked on the percentile curves of the Fenton 2003 as well of the Intergrowth 21 chart. The weight and height were measured using a digital baby scale with a rod, whereas the head circumference was obtained via a measuring tape; the same measurement method was followed for all children. The follow-up data of each child after discharge were also collected from medical records of each child's pediatrician.

When the measurements fell on the curves between 2 standard lines of percentiles, the value was then approximated to an intermediate value between the two percentiles. Thus between the 3rd and the 10th percentile, it was considered on the 5th percentile; between the 10th and the 50th, it was considered on the 30th percentile; between 50 and 90, on the 70th percentile; between 90 and 97, on the 95th and for values below the 3rd percentile or above the 97th percentile, they were reported 2nd and 98th percentile respectively. This approximation was made for both charts, to avoid any bias.

The data collection took into account variables such as the date of birth of the new born, the length of stay at the hospital, the need for intubation, transfusion, iron supplementation, the cause of admission to the Neonatal Intensive Care Unit (NICU), consanguinity, medically assisted procreation (IVF), the delivery method and the complications of prematurity that may impair growth such as bronchopulmonary dysplasia, necrotizing enterocolitis, severe cardiac malformations and genetic abnormalities.

Statistical analysis:

Statistical analysis of data was performed using SPSS version 22 (SPSS Inc., Chicago, IL). The difference between the measures according to both charts for the same baby was assessed through linear regressions. Multiple linear regressions were conducted taking the weight, height and cranial perimeter as dependent variables and taking in each model one of the charts as an independent variable. The model that had a higher Nagelkerke R² value would predict the dependent variable more.

Results

Out of a total of 492 medical record extracted, 318 (64.63%) newborns aged between 27 and 36 weeks of gestation met the inclusion criteria. The distribution of gestational ages showed that 52.8 % of the newborns were between 34 and 36 gestational weeks whereas the remaining

newborns were under 33 gestational weeks (Figure 1). The most frequent cause of admission to the NICU was multiple pregnancies (32.4%), followed by placental insufficiency (22%), respiratory distress of different etiologies (22%) and infections (20.1%).

The majority of the newborns (98.4%) were admitted to the NICU of the Notre-Dame Des Secours hospital from maternity ward and 1.6% were transferred before birth from another hospital. The mean age of birth was 33.26 ± 2.10 weeks of gestation. Consanguinity was present in 11.6% of the cases and caesarean section accounted for 85.8% of deliveries. Moreover, 29.9% of the babies were intubated and 78.8% received more than 2 blood transfusions during their stay; 49.7% of infants were fed by breast milk and formula milk, 48.1% fed formula milk alone and only 1.3% were exclusively breastfed. We note that in-vitro fertilization methods accounted for 24.8% of pregnancies.

Difference between the two charts

The results of the linear regression taking the weight at birth as the dependent variable, showed that the Fenton scale ($R^2 = 0.391$) would predict the weight at birth better than the intergrowth 21 scale ($R^2 = 0.257$) (Table 1, Model 1). The same applies for the height at birth (Table 1, Model 2) and cranial perimeter (Table 1, Model 3) at birth when taken as dependent variables. In contrast, when considering the weight and height at 2 weeks, the results showed that the intergrowth 21 scale would predict those variables better than the Fenton scale, with R^2 values higher for the intergrowth 21 scale in both the weight (0.384 vs 0.311) (Table 1, Model 4) and height (0.650 vs 0.585) (Table 1, Model 5) compared to the Fenton scale. When considering the weight and height at 4 weeks, the results showed that the Fenton scale would predict the weight ($R^2 = 0.655$ vs 0.631) and height ($R^2 = 0.710$ vs 0.643) better than the Intergrowth 21 scale (Table 1, Models 6 and 7 respectively).

Discussion

Growth monitoring is an essential tool that reflects the overall health of neonates and especially preterm infants. It helps assessing the nutritional status as well as detecting pathological deviations. A meta-analysis, published in 2015, of 16 prospective cohorts of premature newborn comparing the 1991 US birthweight reference, the 1999–2000 US birthweight reference and the Intergrowth–21st standards, revealed a prevalence reduction of small for gestational age preterm newborn by more than a quarter, with no significant change in the risk of associated neonatal mortality¹³. Conversely, newer results from a retrospective study showed that the incidence of small for gestational age preterm newborns was higher with Intergrowth 21st standards compared to Fenton ones. The difference between the results of those studies¹² prompted us to conduct our study. Growth curves monitor height, weight, and head circumference progression, therefore a reference chart adopting growth curves that are applicable for all ethnicities and races using anthropometric measures should be used in order to provide adequate assessment¹⁴. In our study, a comparison of the weight and height percentiles of the whole sample showed that before two weeks of age, Fenton growth charts showed better results compared to the Intergrowth 21; after two weeks of age, Intergrowth 21 charts showed higher R^2 values for weight and height than Fenton charts.

The Fenton 2003 growth charts have been adopted in the NICU of the Notre Dame University hospital so far in order to follow the improvement of growth in preterm neonates especially those receiving parenteral nutrition according to the international nutritional guidelines. In most cases, these curves have shown these infants to have growth retardation despite adequate nutrition and introduction of amino acids, electrolytes and multivitamin complexes very early, therefore, exposing them to intensive parenteral nutrition for a long period of time and delaying their discharge from NICU. The main reason behind this is that Fenton growth charts assessment is based on intrauterine growth standards¹⁵, causing the overfeeding of these newborns to lead to obesity and metabolic syndrome later in life. On the other hand, the intergrowth 21 standards aimed to produce charts that set breastfeeding as the norm and described optimal rather than average growth, which could be used worldwide¹⁶.

Study limitations:

Our sample data was difficult to collect after hospital discharge, with patients lost to follow-up since pediatricians do not keep office records of their patients' growth and rely on medical files kept by the parents. Our study is retrospective, predisposing us to information bias since we didn't get the chance to collect all the data we need from some files. Plus, the effect of the maternal height and weight characteristics on the results was not studied and should have been investigated since increasing maternal height and weight are correlated with increased infant's birth weight. Further studies (clinical trial or prospective) should be considered to avoid the bias in the anthropometrics measurements. Multiple centers should be considered in the design to represent a more representative Lebanese sample of children. Also, prenatal diseases that could alter the pattern of growth should be considered.

Conclusion

The results of our study are controversial where the Fenton growth charts are superior to Intergrowth 21 before two weeks of age and at 4 weeks, whereas Intergrowth 21 charts showed higher percentiles for weight and height than Fenton charts at 2 two weeks of age. Further studies following a different design, such as a clinical trial or a prospective study, and conducted in multiple centers should be considered to enroll a more representative Lebanese sample of children and be able to extrapolate our results to the national level.

Declarations

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Competing interests

There's nothing the authors have to disclose.

Funding

None.

Ethical aspect

The study was conducted with the approval of the Ethics Committee of Notre Dame des Secours university Hospital Byblos. A written informed consent was obtained from children's parents.

Authors' contribution

MCFK conceived and designed the study. MS and GR performed the data collection and entry. GAF and SH involved to data interpretation and statistical analysis. MS, GR and JM wrote the manuscript. All authors critically revised the manuscript for intellectual content. All authors read and approved the final manuscript.

Availability of data and materials

There is no public access to all data generated or analyzed during this study to preserve the privacy of the identities of the individuals. The dataset that supports the conclusions is available to the corresponding author upon request.

Consent to publish

Not applicable.

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Table

Table 1: Linear regressions of factors associated with the baby's parameters at birth according to the Fenton and Intergrowth 21 charts.								
Model 1: Dependent variable: Weight at birth.								
Variable	Fenton scale				Intergrowth 21 scale			
	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
Intubation	-196.278	.001	-313.717	-78.839	-145.980	.027	-275.295	-16.666
Gender (male* vs. female)	-157.258	.004	-263.479	-51.038	-140.141	.020	-258.511	-21.770
In-vitro fertilization	-398.452	<0.001	-521.357	-275.548	-437.977	<0.001	-573.322	-302.631
Delivery method (normal* vs C-section)	-19.570	.793	-166.432	127.291	17.286	.836	-147.337	181.910
Cause of prematurity	20.384	.378	-25.087	65.855	-8.373	.740	-58.030	41.283
Consanguinity	37.530	.642	-121.321	196.381	85.564	.337	-89.577	260.705
Breastfeeding (no* vs yes)	33.230	.068	-2.498	68.958	42.203	.036	2.695	81.712
R2= 0.391				R2=0.257				
Model 2: Dependent variable: Height at birth.								
Variable	Fenton scale				Intergrowth 21 scale			
	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
Intubation	-1.053	.010	-1.855	-.251	-1.188	.006	-2.036	-.341
sexe	-.993	.008	-1.730	-.256	-.575	.147	-1.353	.203
IVF	-1.604	<0.001	-2.494	-.715	-1.573	.001	-2.506	-.641
Delivery (Cs or NVD)	-.301	.551	-1.295	.694	-.388	.463	-1.431	.654
Breastmilk	.144	.249	-.101	.389	.143	.273	-.114	.401
Cause of prematurity	.080	.601	-.223	.383	.081	.616	-.238	.400
Consanguinity	-.075	.895	-1.201	1.050	.332	.578	-.842	1.505
Length percentile at birth	.065	<0.001	.052	.078	.053	<0.001	.040	.065
R2= 0.368				R2=0.305				
Model 3: Dependent variable: Cranial perimeter at birth.								
Variable	Fenton scale				Intergrowth 21 scale			
	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
intubation	.391	.021	.060	.723	.194	.287	-.165	.554
Gender	-.237	.127	-.542	.068	.474	.010	.113	.836
IVF	-.183	.311	-.537	.172	-.071	.720	-.461	.319
Delivery (CS or NVD)	.012	.955	-.409	.433	.031	.896	-.428	.489
Cause of Prematurity	.076	.247	-.053	.205	.032	.656	-.109	.172
consanguinity	-.008	.972	-.478	.462	.018	.943	-.493	.530
Breast milk	.009	.865	-.094	.112	.069	.226	-.043	.180
Head	.042	.000	.037	.047	.035	.000	.030	.040

circumference at birth								
R2=0.498					R2=0.405			
Model 4: Dependent variable: Weight at 2 weeks.								
	Fenton scale				Intergrowth 21 scale			
Variable	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
intubation	-164.040	.010	-287.562	-40.517	-178.365	.003	-295.261	-61.469
Gender	-111.614	.063	-229.505	6.276	-35.214	.546	-149.985	79.556
IVF	-353.688	.000	-487.945	-219.430	-363.595	.000	-490.281	-236.909
Delivery (Cs or NVD)	-9.015	.917	-179.313	161.283	9.309	.909	-151.824	170.442
Cause of prematurity	36.339	.171	-15.846	88.525	47.720	.059	-1.849	97.288
consanguinity	22.674	.801	-154.905	200.254	44.992	.597	-122.662	212.646
Breast milk	-.757	.970	-40.738	39.223	-1.103	.954	-38.889	36.683
Weight percentile at 2 weeks of age	11.378	.000	7.927	14.830	11.141	.000	8.496	13.785
	R2= 0.311				R2=0.384			
Model 5: Dependent variable: Height at 2 weeks.								
	Fenton scale				Intergrowth 21 scale			
Variable	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
intubation	.673	.230	-.448	1.794	.771	.128	-.235	1.777
Gender	-.579	.239	-1.562	.403	-.136	.769	-1.066	.795
IVF	-1.872	.028	-3.528	-.217	-1.697	.029	-3.209	-.185
Delivery	-.984	.149	-2.339	.370	-.704	.261	-1.955	.547
Cause of prematurity	-.129	.570	-.588	.329	-.060	.770	-.474	.354
consanguinity	1.678	.059	-.070	3.426	1.177	.143	-.418	2.772
Breast milk	-.161	.335	-.495	.173	-.149	.331	-.455	.158
Length percentile at 2weeks	.058	.000	.037	.079	.054	.000	.037	.070
	R2= 0.585				R2=0.650			
Dependent variable: Weight at 4 weeks.								
	Fenton scale				Intergrowth 21 scale			
Variable	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
intubation	-349.864	.000	-511.389	-188.338	-287.552	.001	-456.257	-118.846
Gender	-214.487	.006	-366.769	-62.205	-104.602	.204	-266.918	57.714
IVF	-263.235	.003	-433.325	-93.146	-316.056	.000	-490.141	-141.971
Delivery	-49.404	.659	-270.890	172.083	-101.449	.380	-329.711	126.814
Cause of prematurity	60.329	.079	-7.030	127.689	96.435	.008	25.542	167.329
consanguinity	72.829	.508	-144.660	290.318	78.345	.491	-146.491	303.181
Breast milk	-10.813	.692	-64.785	43.160	-13.781	.625	-69.600	42.038
Weight percentile at 4 weeks	21.310	.000	17.484	25.136	18.974	.000	15.344	22.604

		R2= 0.655			R2=0.631			
Dependent variable: Height at 4 weeks.								
		Fenton scale			Intergrowth 21 scale			
Variable	Unstandardized Beta	p-value	Confidence Interval		Unstandardized Beta	p-value	Confidence Interval	
intubation	-1.278	.071	-2.668	.113	-.553	.465	-2.065	.959
Gender	-1.068	.055	-2.161	.024	-.559	.363	-1.784	.665
IVF	-1.518	.016	-2.734	-.302	-1.096	.121	-2.493	.300
Delivery	-.298	.703	-1.859	1.264	-1.735	.053	-3.494	.025
Cause of prematurity	-.215	.364	-.689	.258	-.259	.325	-.783	.265
Consanguinity	.317	.748	-1.660	2.294	1.860	.086	-.277	3.996
Breast milk	-.127	.513	-.516	.262	-.149	.490	-.580	.282
Length percentile at 4 weeks	.100	.000	.077	.124	.078	.000	.056	.100
		R2= 0.710			R2=0.643			

Figures

Organizational chart of the study

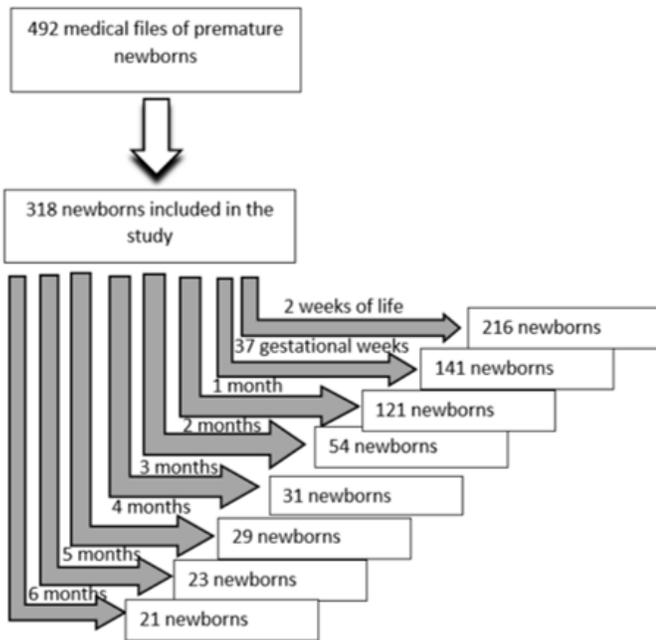


Figure 1

Organizational chart of the study.