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New References for Neonatal Weight by Gestational Age and Sex, Holguín, Cuba
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ABSTRACT
INTRODUCTION Birth weight is considered to be the best predictor of an infant's health status in the neonatal phase. In the Americas, several studies have set the foundation for determining references birth weights. In Cuba there is a report on anthropometric patterns in neonates in 1990 from a maternity ward in Havana, but there are no updated neonatal weight distribution curves by gestational age and sex, as suggested by WHO.

OBJECTIVE Create birth weight percentile distribution tables and curves for neonates by gestational age and sex in Holguín Municipality, capital of the eastern Cuban province of the same name.

METHODS A retrospective longitudinal study was designed in a universe of 16,018 neonates born alive, delivered within a gestational range of 30 to 42 weeks in the maternity unit of the V.I. Lenin University General Hospital in Holguín Municipality between January 2008 and December 2012. Included were neonates born in the study hospital living in Holguín Municipality; neonates from multiple births were excluded. Variables included gestational age, sex, and birth weight. Gestational age- and sex-specific weight percentile distribution tables and curves were constructed based on observed values. A third-degree polynomial was applied via weighted least squares regression to smooth distribution curves. Analysis of variance was conducted to compare four years (2008, 2009, 2010 and 2011) and the coefficient of variation was calculated for each week of gestation.

RESULTS The average weight of neonates of both sexes rose from week 30 to week 42. The coefficient of variation between weeks 34 and 42 was 11.6%–19% in girls and 12.1%–21.3% in boys. The 10th percentile value at 36 weeks of gestation was 2140 g for girls and 2200 g for boys. For girls, cutoff points for the 10th percentile (small for gestational age infant) were higher at 34–42 weeks and for boys at 36–42 weeks. Applying our cutoff points to this population identified 47% more low birth weight infants than did previously applied standards.

CONCLUSIONS Marked differences were found when comparing our tables with tables from other countries. The higher references values for the 10th percentile (compared to previous ones in Cuba) in mean more neonates fall in the low birth weight category, providing greater opportunities to reduce morbidity and mortality in this high-risk group.

KEYWORDS Birth weight, gestational age, chronologic fetal maturity, low birth weight infant, small for gestational age infant, reference growth curves, growth tables, Cuba

INTRODUCTION
There is general consensus that anthropometric measures (mainly birth weight, crown-rump length and head circumference) are useful parameters for monitoring fetal growth and a neonate’s nutritional status.[1–4] Intrauterine growth parameters are important when establishing short- and medium-term postnatal prognosis.

Population studies as well as studies of selected neonatal groups are needed to assess whether an infant has attained satisfactory growth and nutritional status and to identify at-risk groups. This necessity is corroborated by multiple investigations (including those by Lausman in Canada,[5] Polloito[6] and Lagos[7]) that examine potential neonatal complications from intrauterine growth restriction, such as respiratory distress, hypothermia, hypoglycemia and necrotizing enteritis. Other disorders can also occur in early childhood (cardiovascular diseases, arterial hypertension, diabetes mellitus and kidney problems, etc.). Studies by Mañalich,[8] Susuki,[9] Fattal[10] and Pérez[11] elucidate some of the evidence related to these.

Assessment of birth weight alone, however, started to lose ground after studies by Lubchenco[12] and Battaglia and Lubchenco[13] began to examine weight in relation to gestational age (in weeks) and growth percentile curves, making it possible to identify the following categories: small for gestational age (SGA) if the infant’s birth weight is below the 10th percentile (P10); appropriate for gestational age (AGA) if the infant’s weight is in the 10th–90th percentile range; and large for gestational age (LGA) for infants whose birth weight exceeds the 90th percentile. In light of the lack of any previously established standards, these new standards were rapidly accepted and applied, especially here in the Americas.

As time passed, however, new weight standards related to gestational age (in weeks) were proposed by Latin American authors such as Alarcón,[14] González,[15] Pazcusso,[16] Parra,[17] and Urquía,[18] who presented evidence that P10 figures were higher than those found by Battaglia and Lubchenco.[13] After 1995, when WHO established criteria to set these standards,[1] numerous studies were conducted in Latin America with country-specific populations; Parra,[17] Ticona,[19,20] and more recently, Villamonte[21] in Peru; Montoya in Colombia,[22] San Pedro in Argentina,[23] and Lagos and Juez in Chile.[24–26]

Intercountry differences observed in their results may be due, among other factors, to variations in features of the population studied, varying demographic and environmental factors, sample size and varying inclusion/exclusion criteria applied by the researchers.[27–30]

In Cuba, the situation of standards relating weight and gestational age has not progressively developed since the curves proposed by Dueñas in 1990.[31] Dueñas is important historically and scientifically, not only because he was the first Cuban to design weight percentile curves by week of gestational age, but also because he realized the importance of these curves for identifying newborn infants whose weight for gestational age was less than P10, given this group’s greater risk of morbidity and mortality.[32–35] No other weight-for-gestational-age curves have been designed in Cuba since.

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We consider Dueñas’ curves[31] no longer unsuitable for several reasons. First, they were designed more than two decades ago; second, Dueñas’ small study sample was not representative of the universe at that time (as he acknowledges); and third, more recent criteria for constructing such curves have been established. Esquivel, in a comprehensive review of all growth monitoring studies in the country from the 1970s on, concluded that Cuban newborns have been getting bigger.[36]

No national or regional studies have been conducted in our country that would allow comparison with the reference values determined in our work. Cuba’s 2010 Consensus on Diagnostic and Therapeutic Procedures in Gynecology and Obstetrics[37] contains no mention of reference weights by gestational age for Cuban infants, but refers only to reports by foreign authors, such as Hadlock[2,3] and Usher,[4] among others. Cuba’s 2010 Pediatric Consensus refers only to Dueñas’ curves.[38]

For all these reasons and in light of WHO’s recommendation that each perinatology service or area construct its own references,[1] we decided to formulate weight-for-gestational-age tables and curves for our hospital’s area of service.

**METHODS**

A retrospective longitudinal study was designed whose universe consisted of the 16,018 infants born alive in the maternity unit of the V.I. Lenin University General Hospital in Holguín Municipality, January 2008–December 2012. In 2012, only infants born at 36 weeks or less were included, due to the need to increase the number of cases in this age group.

Included were neonates born in the study hospital living in Holguín Municipality. Neonates from multiple births were excluded. Also excluded were any cases with omissions or errors in gestational age or weight in the infant’s records. Infants with histories of conditions that could affect intrauterine growth were not excluded.

The study database was set up with information from the Municipal Statistics Department’s registry of live births. Study variables included gestational age, birth weight and sex. Gestational age was determined from date of last menstrual period and corrected, if necessary, by early sonogram (between 13–16 and 20–22 weeks of pregnancy), in accordance with nationally established criteria for antenatal control and followup of all pregnant women.[37]

Weight was determined in grams. Neonates in the study hospital are weighed immediately after birth in the delivery room by experienced nurses, under direct supervision by obstetricians. The dial scales used are routinely calibrated by the Provincial Metrology Department.

To determine weight curves for gestational age and sex, values were determined for the 3rd, 5th, 10th, 25th, 50th, 75th and 90th percentiles. To smooth the curves, a third-degree polynomial was obtained via weighted least squares regression. Mean weights, standard deviations and weight distribution by gestational age and sex were determined for each of these percentiles.

For data validation, analysis of variance was conducted to compare the years 2008, 2009, 2010 and 2011; no unexpected effects were found to influence results, and the coefficient of variation (CV) for each table was calculated, which was considered to be stable when there was no more than 10% variation in each week of gestation. The normality test was also conducted to determine if weight was normally distributed. Calculations were performed with SYSLAT MY-STAT v.12 (2009) and Excel (Microsoft Office).

**Ethics**
The study was approved by the scientific council and medical ethics committee of the Holguín Municipal Health Department.

**RESULTS**

Weight distribution curves by gestational age and sex for the 3th, 5th, 10th, 25th, 50th and 90th percentiles are displayed in Figures 1 and 2. Mean birth weight for both sexes increased from week 30 to week 42. Table 1 shows a predominance of births in weeks 39 and 40 for newborn girls (29.4% and 27% respectively). Mean weights were 3222 g (SD 381) in week 39 and 3331 g (SD 398) in week 40.
As of week 35, weight variation began to decline in both sexes, as demonstrated by diminishing CVs (Table 2).

Figure 1 shows weight distribution for newborn girls by gestational age (in weeks). At 36 weeks, P10 for this group was 2140 g, and showed a steady rise until week 42. Applying these values, 9.4% of newborn girls fall under P10 and 9.8% above the 90th percentile. Weight distribution for newborn boys by gestational age (Figure 2) shows that P10 was 2200 g at 36 weeks, with increasing values up to week 42. Based on these values, 9.8% of infant boys are below P10 and 8.3% are above the 90th percentile. Applying our cutoffs to the universe of newborns, 47.3% more low birth weight infants were identified than would have been by Dueñas’ curves (1538 vs. 811).

Mean birth weight in most weeks was less for infant girls than for boys, although the mean difference between the two sexes was only 84 g from week 35 to week 42. In the SGA group, a slight increase of 26.6% in infant girls and 29.3% in infant boys between weeks 36 and 41, surpassing the results reported by Dueñas (22.2% for both sexes).[31] A similar trend was also observed in studies by San Pedro in Argentina[23] and González in Chile[15] (38.4% and 32.8% respectively; again, for both sexes). The greater increases in mean weights over this period of intrauterine development are important in explaining these studies’ higher 10th-percentile values as compared with ours.

The cutoff point for P10 can vary, according to different authors (Ayerza,[27] Alarcón[14]), due to various factors, including study design, specific population characteristics, ethnicity and maternal characteristics (such as weight and height). These authors noted that boys’ birth weights tended to be higher than girls’, which is consistent with our findings. P10 values found by Lubchenco[12] were below those reported in studies by Ayerza,[27] González,[15] and Ticona,[19] Lubchenco detected only 2.2% of SGA for both sexes at week 40. The portion of SGA (9.1%) found in our study falls within the range of 7%–11% reported by Latin American authors such as Urquia,[18] Lagos[24] and Juez.[25]

Our study showed an average weight increase of 26.6% in infant girls and 29.3% in infant boys between weeks 36 and 41, surpassing the results reported by Dueñas (22.2% for both sexes).[31] A similar trend was also observed in studies by San Pedro in Argentina[23] and González in Chile[15] (38.4% and 32.8% respectively; again, for both sexes). The greater increases in mean weights over this period of intrauterine development are important in explaining these studies’ higher 10th-percentile values as compared with ours.

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Other studies presented higher cutoff points than ours for P10 at 36 weeks, but these were for both sexes combined. San Pedro of Argentina presented a cutoff point of 2190 g,[23] which was 10 g less than our equivalent cutoff for boys, but higher than ours calculated for both sexes combined. Hadlock in the USA found 2335 g,[2] the Latin American Center for Perinatology in Uruguay indicated 2324 g[39] and Alexander in the USA determined a cutoff point of 2354 g,[40] all values higher than either of our sex-specific cutoffs.

Variability in weeks 36 and 40 in both sexes in our study is consistent with that described by González, who found CVs of 16.6% and 12.1%, respectively, in those weeks,[15] and by Juez, who reported CVs of 13.9% at...
36 weeks and 11.2% at 40 weeks.[25] CVs in our study approached stability as gestational age progressed.

It is important to note that the low number of neonates born in weeks 30–34 (5.6% of total neonates) is a possible source of bias in our study, and caution should be exercised in interpreting the values calculated for this gestational age. WHO’s technical report recommends a minimum of 200 cases for each week of gestation,[1] which is extremely difficult to attain in studies in perinatology services and areas with few births. In his work, Alarcón,[14] noted that the Chilean Pediatric Society, in establishing criteria for preparing such growth curves, recommended a minimum of 100 neonates for each gestational age. Our work meets this standard from week 35 on. In an attempt to solve this problem, some authors (such as Pittaluga) have designed curves based solely on neonates born at 36 weeks of gestation or earlier, for greater statistical efficiency.[32]

Our inclusion criteria were also very broad; neonates whose mothers had risk factors that could affect fetal weight (such as pre-eclampsia, hypertension and diabetes mellitus) were not excluded, which could introduce a negative bias in reporting SGA.[41,42] However, other researchers have also used this design, including González, who studied more than 2 million neonates in Chile without excluding fetal weight risk factors,[15] and Juez, also in Chile, who likewise included them.[25]

This study has enabled construction of weight percentile distribution curves and tables by gestation age (in weeks) and sex, specific to the population of Holguín Municipality, Cuba. It also fills an information gap since such curves were not previously available here.

**CONCLUSIONS**

Values were established for new reference weights by gestational age and sex, enabling formulation of percentile distribution curves and tables. Differences were found when our tables were compared with tables from other countries. The increased detection of newborns under P10 (SGA infants) enables clinical and epidemiological actions that can help reduce morbidity and mortality in this high-risk neonatal group.

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