*Original Articles*

# NORMS FOR PHYSICAL GROWTH OF THE FULL-TERM BABIES BORN FROM SINGLETON PREGNANCY IN PLEVEN

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## Summary

The aim of the study was to develop the norms for physical growth (birth weight-, birth height- and head circumference-for age) of the full-term babies born from singleton pregnancy in UMHAT „Dr. G. Stranski" – Pleven (total, by gender and gestational age at birth). A cross-sectional study was carried-out in 2017; 1092 live infants born from singleton pregnancy between 38 and 42 weeks were included in the study. We obtained information about three anthropometric measurements (birth weight-, birth height- and head circumference-for age). Data were processed by SPSS v.24.0. Norm group ranges (3, 5 and 7 groups) were developed for three indicators using percentile methods. Kruskal-Wallis test was used. The mean birth weight- and height-for age were higher for baby boys (P50, 3280 g and 50 cm) compared with baby girls (P50, 3150 g and 49 cm). Baby boys and girls weighed <2570 g at birth fell into the group „very slow growth" (P3). A „very fast growth" (P97) was found in baby boys weighed >4120 g at birth (vs. >3870 g for baby girls). Norm group ranges allow to identify the newborns with a higher risk and to focus efforts and health resources to them; it should be updated periodically.
**Key words:** birth-weight-for age, birth height-for age, head circumference-for age, norm group ranges, percentile

## Introduction

Nowadays, need of the local child growth standards discussed many times. These standards are very important for planning of the prevention programs and health care for children fall into the groups „very slow growth" and „very fast growth" in terms of birth weight and birth length [1].

It has been proven that physical growth indicators (including in the infants) are dynamic and it is inacceptable these indicators to be used for a long time. Therefore, the standards should be updated periodically and the studies should be repeated every 8-10 years [2] or 10-15 years [3].

In 2006, World Health Organization (WHO) published the new child growth standards (The WHO Child Growth Standards) [4] and over 140 countries had adopted them in 2011 [5]. The WHO Child Growth Standards replaced the CDC growth charts for United States (US CDC 2000 growth charts) [5, 6]. According to the WHO Child Growth Standards, the baby boys

have the higher values of the basic anthropometric indicators compared with the baby girls. The mean birth weight-for age in the baby boys has been 3400 grams, in brief g (2500÷4380 g min, max; vs. baby girls: 3287 g, 2507÷4067 g min, max). The mean birth height-for age in the baby boys has been 50.9 centimetres, in short cm (47.2÷54.6 cm min, max; vs. baby girls: 50.1 cm, 46.4÷53.9 cm min, max) [6].

It is not accepted to use the child growth standards developed by authors from other countries, due to the socioeconomic, climatic and geographical differences between countries.

On the other hand, the role of the acceleration should be taken into account in child growth standards developing; the acceleration has an impact on the human growth nowadays. Today the basic anthropometric indicators are higher compared with 100 years ago (birth weight-for age>300 g and birth height-for age>1.2 см). It has been considered that acceleration is a result from more intensive fetal growth and development [7].

Before the Bulgaria`s transition to democracy (1989), the studies of the infant growth and development have been carried-out in some regions of Bulgaria. Slavov et al. (1980) reported the results for the infant growth and development about 13 Bulgarian regions. These results are still used as guide by the healthcare professionals at the Maternity wards (including UMHAT „Dr. G. Stranski" – Pleven, Bulgaria) today [2].

The aim of the study was to develop the norms for physical growth of the full-term babies born from singleton pregnancy (birth weight-, birth height- and head circumference-for age) in UMHAT „Dr. G. Stranski" – Pleven (total, by gender and gestational age at birth).

## Materials and Methods

A cross-sectional study was carried-out in 2017. The study was approved by Research Ethics Committee of Medical University – Pleven.

One thousand ninety-two live full-term infants born from singleton pregnancy between 38 and 42 weeks of all 1248 births in UMHAT „Dr. G. Stranski" – Pleven, were included in the study. Five hundred seventy-five (52.66%) were baby boys and 517 (47.34%) – baby girls.

### *Including criteria*

Data about women in childbirth and live-born infants were collected from the pregnancy history: last menstrual period (LMP), expected date of delivery (EDD) and date of birth to estimate gestational age. Live-born babies in a normal single pregnancy were included in the study. The information was obtained only about the women with regular menstrual cycle and estimated delivery date precisely.

### *Excluding criteria*

- Women in childbirth and live-born infants with missing data;
- Infants born to mothers with common and gynaecological diseases;
- Twins;
- Stillbirths.

### *Grouping Variables*

- Gender;
- Gestational age was measured in gestational weeks (GW) and calculated from the first date of the LMP;
- Birth weight-for age of babies was measured immediately after delivery with weighing scales with 1 g accuracy [8-11];
- Birth height-for age (birth length) – we measured a recumbent length with length board (infantometer) [8-11].
- Head circumference-for age measure is obtained with a flexible non-stretchable measuring tape [9-11].

Data were processed by SPSS v.24.0.

Birth weight-, birth height-, and head circumference-for age percentiles (P) were calculated (a distribution was asymmetric) in infants (boys and girls) born between 38 and 41 GW. Number of live-born infants in ≤37 GW was a small to develop the anthropometric norms.

Norm group ranges were developed for birth weight-, birth height-, and head circumference-for age using percentile methods (3, 5 and 7 groups): 7 norm groups ($P_{25}$÷ $P_{75}$ norm values, <$P_{25}$ – 3 groups; >$P_{75}$ – 3 groups); 5 norm groups ($P_{10}$÷ $P_{90}$ norm values, <$P_{10}$ – 2 groups; >$P_{90}$ – 2 groups); 3 norm groups ($P_3$÷ $P_{97}$ norm values, <$P_3$ – 1 group; >$P_{97}$ – 1 group).

Kruskal-Wallis H test was used. We assumed the differences between groups as significant if the p-value was less than or equal to 0.05.

## Results

### *Mean birth weight- and height- and head circumference-for age – gender differences*

As shown in Table 1, the mean birth weight- and height-for age were higher for baby boys ($P_{50}$, 3280 g and 50 cm) compared with baby girls ($P_{50}$, 3150 g and 49 cm), there were statistically significant differences (p=0.001). $P_{50}$ head circumference-for age for baby boys and girls was 34 cm (p>0.05).

### *Lowered and raised weight values – gender differences*

Baby boys and girls weighed <2570 g at birth fell into the group „very slow growth" ($P_3$). A „very fast growth" ($P_{97}$) was found in baby boys weighed >4120 g at birth (vs. >3870 g for baby girls).

### *Lowered and raised height values – gender differences*

Baby boys and girls shorter than 47 cm fell into the group „very slow growth". Baby boys taller more than 53 cm, fell into the group „very fast growth" (vs. >52 cm for baby girls).

### *Lowered and raised head circumference-for age values – gender differences*

Third percentile head circumference-for age (values lower than 32 cm) of infants (boys and girls) showed the very slow-growth group. Very fast growth was found in 97th percentile head circumference-for age (>37 cm for baby boys, >36 cm for baby girls).

**Table 1.** Norm groups of the birth weight-, birth height- and head circumference-for age in infants (total, by gender)

| Variable | Cases (n) | $P_3$ | $P_{10}$ | $P_{25}$ | $P_{50}$ | $P_{75}$ | $P_{90}$ | $P_{97}$ |
|---|---|---|---|---|---|---|---|---|
| **Birth weight** | | | | | | | | |
| Total | 1092 | 2 540 | 2690 | 2900 | **3220** | 3540 | 3850 | 4050 |
| Boys | 575 | 2570 | 2700 | 2950 | **3280** | 3620 | 3980 | 4120 |
| Girls | 517 | 2500 | 2670 | 2880 | **3150** | 3400 | 3680 | 3870 |
| **Birth height** | | | | | | | | |
| Total | 1092 | 47 | 47 | 49 | **50** | 51 | 52 | 53 |
| Boys | 575 | 47 | 48 | 49 | **50** | 51 | 53 | 53 |
| Girls | 517 | 47 | 47 | 48 | **49** | 51 | 52 | 52 |
| **Head circumference-for age** | | | | | | | | |
| Total | 1068 | 32 | 33 | 33 | **34** | 35 | 36 | 37 |
| Boys | 562 | 32 | 33 | 34 | **34** | 35 | 36 | 37 |
| Girls | 506 | 32 | 33 | 33 | **34** | 35 | 36 | 36 |

Gender differences in anthropometric indicators were found in all norm groups and by gestational weeks at birth (Table 2).

There were statistically significant differences between reference values of birth weight, birth height and head circumference-for age ($P_{25}$-$P_{75}$, 7 norm groups) in infants born at 38, 39, 40 and 41 GW (p=0.001).

Birth weight reference ranges in boys born at 38 GW were from 2760 g to 3250 g (vs. 2720÷3140 g for baby girls) – Figure 1. Birth weight reference ranges were significantly higher at 39 and 40 GW; normal birth weight ranges were 3310÷3920 g at 41 GW in baby boys (vs. 3180÷3620 g for baby girls (p=0.001).

The results of the study showed that birth weight-for age in baby boys increased average of 630 g during the pregnancy (38-41 GW), respectively, birth height-for age –2 cm, and head circumference-for age – 1 cm (vs. 530 g, 2 cm, 2 cm for baby girls).

There were no statistically significant differences in reference values of birth height-for age by gender and gestational age (p>0.05). Birth height-for age normal ranges in baby boys were from 48 cm to 50 cm at 38 GW (vs. 47÷50 cm for baby girls), respectively ranges 50÷52 cm at 41 GW (vs. 48÷50 cm at 41 GW and 49÷52 cm for baby girls) – p=0.001.

There were no statistically significant differences in reference values of head circumference-for age by gender and gestational age. Head circumference-for age normal ranges in baby boys were from 33 cm to 35 cm at 38 GW (vs. 33÷34 cm for baby girls) and from 34

**Table 2.** Norm groups of the birth weight-, birth height- and head circumference-for age (by gender and GW)

| GW/Gender | Cases (n) | $P_3$ | $P_{10}$ | $P_{25}$ | $P_{50}$ | $P_{75}$ | $P_{90}$ | $P_{97}$ |
|---|---|---|---|---|---|---|---|---|
| **Birth weight** | | | | | | | | |
| **38 GW** | | | | | | | | |
| Boys | 145 | 2520 | 2570 | 2760 | **2960** | 3250 | 3550 | 3630 |
| Girls | 135 | 2250 | 2490 | 2720 | **2900** | 3140 | 3300 | 3380 |
| **39 GW** | | | | | | | | |
| Boys | 158 | 2640 | 2715 | 2980 | **3290** | 3630 | 3950 | 4090 |
| Girls | 131 | 2550 | 2680 | 2880 | **3140** | 3380 | 3700 | 3860 |
| **40 GW** | | | | | | | | |
| Boys | 165 | 2640 | 2820 | 3140 | **3330** | 3640 | 4050 | 4150 |
| Girls | 156 | 2540 | 2740 | 2965 | **3225** | 3470 | 3680 | 3850 |
| **41 GW** | | | | | | | | |
| Boys | 107 | 2800 | 3010 | 3310 | **3560** | 3920 | 4100 | 4260 |
| Girls | 95 | 2740 | 2820 | 3180 | **3430** | 3620 | 3900 | 4170 |
| **Birth height** | | | | | | | | |
| **38 GW** | | | | | | | | |
| Boys | 145 | 46 | 47 | 48 | **49** | 50 | 52 | 52 |
| Girls | 135 | 45 | 47 | 47 | **49** | 50 | 50 | 51 |
| **39 GW** | | | | | | | | |
| Boys | 158 | 47 | 48 | 49 | **50** | 51 | 53 | 53 |
| Girls | 131 | 47 | 47 | 48 | **50** | 51 | 52 | 52 |
| **40 GW** | | | | | | | | |
| Boys | 165 | 47 | 48 | 49 | **50** | 51 | 53 | 54 |
| Girls | 156 | 47 | 48 | 49 | **50** | 51 | 52 | 52 |
| **41 GW** | | | | | | | | |
| Boys | 107 | 48 | 49 | 50 | **51** | 52 | 53 | 54 |
| Girls | 95 | 47 | 48 | 49 | **50** | 52 | 53 | 54 |
| **Head circumference-for age** | | | | | | | | |
| **38 GW** | | | | | | | | |
| Boys | 143 | 32 | 33 | 33 | **34** | 35 | 36 | 36 |
| Girls | 131 | 32 | 32 | 33 | **33** | 34 | 35 | 36 |
| **39 GW** | | | | | | | | |
| Boys | 155 | 32 | 33 | 34 | **34** | 35 | 36 | 37 |
| Girls | 130 | 32 | 33 | 33 | **34** | 35 | 35 | 37 |
| **40 GW** | | | | | | | | |
| Boys | 162 | 33 | 33 | 34 | **34** | 35 | 36 | 37 |
| Girls | 154 | 32 | 33 | 33 | **34** | 35 | 36 | 37 |
| **41 GW** | | | | | | | | |
| Boys | 101 | 33 | 33 | 34 | **35** | 36 | 36 | 37 |
| Girls | 93 | 32 | 33 | 34 | **35** | 36 | 36 | 37 |

Norms were developed for infants born at 38-41 GW. The number of cases at ≤37 GW was a small.

cm to 36 cm at 41 GW (vs. 34÷36 cm for baby girls) – p>0.05.

## Discussion

Birth parameters are important measurements of fetal growth [12]. It reflects nutritional status and can be used as prognostic markers for future health, survival and a number of short and long-term effects of prenatal births [12-14]. Abnormal birth weight and height have been significant predictors for low birth weight [15], microcephaly, stunting in childhood [16], congenital heart diseases [12, 17, 18], cardiovascular diseases, metabolic complications, type 1 and 2 diabetes mellitus [19], obesity and hypertension in later life [20]. On the contrary, higher birth weight and larger head circumference have been associated with better cognitive abilities in early childhood [21]. A strong positive association have been found between birth weight and adult height, as well as between birth height and adult height [14].

Our study confirmed the results of previous studies about higher mean values of the anthropometric indicators over the last decades [22-29]. The physical growth of baby boys in that study was faster compared with baby girls (total and by GW) and these results were similar to others [2-4, 7, 20, 21, 30]. At the same time, our results were lower than these reported by N. Stanimirova (1998) and Stanimirova et al. (2007). Earlier, in 1973 the authors found that the mean birth weight-, birth height- and head circumference-for age in baby boys had been respectively 3440±340 g (vs. 3370±400 g in girls), 51.27±1.92 cm (vs. 50.78±1.65 g in girls) and 35.20±1.52 cm (vs. 34.21±1.09 g in girls) [31, 32].

Some authors associate the positive trends of birth weight with the changes of maternal characteristics (increasing of BMI, weight and height, decreasing of smoking) and obstetric factors (preterm obstetric induction and preterm Caesarean delivery) [27, 33, 34]. Negative trends in birth weight and fetal growth for singleton neonates were reported by S. Donahue et al. (2010) [35] and Morisaki et al. (2013) [36].

In preterm babies, weight loss (ranges 5.9÷9.7%) happened during the first 3-6 days after birth and it has taken longer (18-19 days) to recover birth weight [37].

In our study, the mean birth weight-, birth height- and head circumference-for age in baby boys (3280 g, 50.2 cm and 34 cm, vs. 3150 g, 49.2 cm and 34 cm for baby girls) were lower than WHO Child Growth Standards (3400 g, 50.9 cm and 34.6 cm for baby boys; 3287 g, 50.1 cm and 34.8 cm for baby girls) [4] and that continue during the first 3 months of life [30]. The difference of birth weight-for age was 120 g in baby boys, 0.7 cm – birth height-for age, 0.6 cm – head circumference-for age (vs. 137 g, 0.9 cm and 0.8 cm in baby girls). Our results were similar to Sutan et al. (2018) [12], Rashidi et al. (2018) [30] and different to Ramagopal Shastry et Poornima R. Bhat (2015). In Indian infants, mean anthropometric values have been lower than ours maybe due to poor maternal nutritional status [13]. It is important to take into account the role of other determinants as socioeconomic status, gravida status, geographic location, etc. [13, 20]. Some researchers found that head circumference is more affected by generic factors than other characteristics [38].

Compared to an earlier Bulgarian survey on growth monitoring [2], $P_{50}$ birth weight-for age was higher at 38 GW (2960 g for baby boys and 2900 g for baby girls) and 39 GW (3290 g for baby boys and 3140 g for baby girls) and lower at 40 GW (3330 g for baby boys and 3225 g for baby girls) and 41 GW (3560 g for baby boys and 3430 g for baby girls). Similar trends we found in birth height- and head circumference-for age although it was not exactly clear. It has been proven that anthropometric parameters increase with gestational age [19, 21], as well as maternal age, parity, gestational diabetes, etc. [21, 26, 32, 33]. Mean head circumference has been significantly different in babies born vaginally or by Cesarean sections; between females and males; between babies born in private and public hospitals according to gestational age [37]. It has been found significant linear, positive correlation (p<0.001) between birth weight and each of three anthropometric measurements (head circumference, chest circumference and length-for age) [15].

Our results can be explained with the double effect of acceleration on the mother and newborn who reach a functional prematurity early. It was confirmed by the higher values of birth weight-for age for infants fell into very slow-growth group (<2570 g) and very fast-growth group (>4000 g

for boys vs. >3870 g for girls), especially for the infants born at 38 GW. Probably, this is a reason for women requested Caesarean sections.

We have not found the studies of acceleration changes in pregnant women and their newborns together. Our assumptions about the anthropometric measurements in live-born infants should be supported by many researchers. In the future, norm group ranges should be discussed and assessed by obstetricians, neonatologists and paediatricians together.

## Conclusions

Anthropometric indicators reflect current and future health of the infants which partly depends on the healthcare in Bulgaria. There are many risk factors in the newborns, mothers and background affecting on the birth weight-, birth height-, head circumference-for age and other anthropometric indicators. The role of all indicators should be taken account together.

Our study confirms the results of previous studies about faster physical growth in baby boys than baby girls. The mean birth weight-for age in live-born infants is a higher at 38 GW (2960 g for boys and 2900 g for girls) and 39 GW (3290 g for boys and 3140 g for girls) compared with the current norms for physical growths in the newborns. Surprisingly, the mean values of the same indicator are lower in baby boys (3350 g and 3560 g) and baby girls (3225 g and 3430 g) at 40 GW and 41 GW compared with the current norms. At the same time, there are lower values of $P_3$ birth weight-for age (>2500 g) and $P_{97}$ birth weight-for age (>4000 g).

Norm group ranges allow to identify the newborns with a higher risk and to focus efforts and health resources to them. It is important the obstetricians, neonatologists and paediatricians to take a part in developing and assessment of norm group ranges; the last should be updated periodically.

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