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Department of Developmental Paediatrics, Medical University of Lublin
Department of Biophysics, Medical University of Lublin

WANDA FURMAGA-JABŁOŃSKA, MARIA KOZŁOWSKA, ADAM ORZECHOWSKI

Longitudinal analysis of head growth in Low-Birth-Weight Children according to their chronological and gestational age

In spite of numerous investigations there is still little information about postnatal developmental dynamics of Low Birth Weight (LBW) Children. This results from the fact that some studies refer only to the chronological age of the studied children, without considering the differences in their gestational age. The group of LBW children is not homogenous with respect to their gestational age. And this results in significant heterogeneity of their course of physical growth.

Developmental prognoses for this group of children differ depending on the duration of pregnancy and biological maturity after birth (8,9,12,14). Problems with establishing reference systems for LBW infants emerge from the fact that in numerous papers concerning this issue, biological maturity of newborns is not considered, and in the case of premature newborns, their gestational age is not considered (3,6,7). Disregarding gestational age in evaluation of physical development of LBW infants may lead to misinterpretation of developmental phenomena and thus influence possible clinical aspects of diagnosis (6,10).

The purpose of this study is to examine the growth of head circumference in relation to chronological and gestational age in the three groups of LBW children, using longitudinal data.

MATERIAL AND METHODS

The study consisted of 283 LBW newborns (134 boys and 149 girls), born in Lublin. Gestational age of the investigated children was assessed in two ways, i.e. on the basis of the last present menstruation in the mother and according to somatic- neurological maturity traits in the newborn after birth, evaluated with Dubowitz's scale (5). Considering the gestational age and percentile position of newborns' birth weight in relation to their gestational age according to Cieślik et al. (4) three groups were created:

1. Appropriate-for-Gestational Age preterms (group I – 181 newborns) – born below 37 weeks of gestation with body weight between 10 – 90 perpercentile according to gestational age (AGA preterms).

2. Full-term newborns with symptoms of intrauterine growth retardation (group II – 70 newborns) – born between 37^{th} and 42^{nd} weeks of gestation, with body weight less than 10 perpercentile according to gestational age (S-f-D-newborns).

3. Small–for–Gestational Age preterms (group III – 32 newborns) – born below 37 weeks of gestation, with body weight less than 10 perpercentile according to gestational age (SGA preterms).

Head circumference was measured through methopion and opisthocranion in all the infants at birth and at 1, 2, 3 ,4, 6, 9 12, and 24 months (± 10 days tolerance) of their chronological age. The correction of chronological age to gestational age (corrected age), as well as the anthropometric data normalization was performed in AGA preterms (group I) and SGA preterms (group III), with the assumption that all the newborns started their extrauterine life after 40 weeks of gestation. This procedure was not performed for group II because they were full term newborns, only with symptoms of intrauterine growth retardation.

The obtained sets of data were then analyzed statistically (mean – M, standard deviation – S, variance – V). Analysis of variance (ANOVA) was applied for comparing the mean values between groups in the specific months. Significance of differences between the groups was tested by means of Duncan's test. The data were plotted against Polish reference growth charts for full-term newborns in order to compare the head growth in the three groups of LBW newborns, i.e. AGA preterms (group I), S-f-D newborns (group II) and SGA preterms (group III) in relation to Polish normals and between one another (4,13).

RESULTS

Real values of head circumferences according to chronological age and the values adjusted to the gestational age in the three groups of low birth weight newborns were plotted against the Polish reference growth charts. At birth (without considering the gestational age of the studied children), mean head circumferences in the AGA preterms (group I) and SGA preterms (group III) were below the 3rd perpercentile, however in S-f-D newborns (group II), it placed between 3rd and 10th perpercentile (Fig. 1,2). During 1st month of life only in the boys

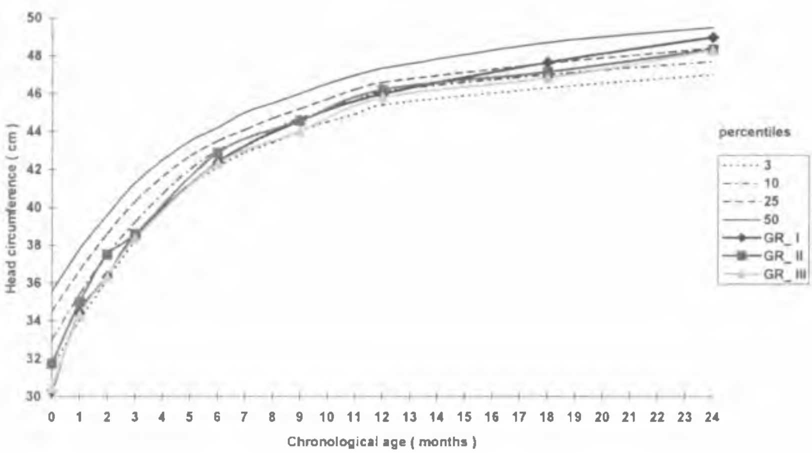

Fig. 1. Head circumference in the three groups of boys with Low-Birth-Weight according to their chronological age

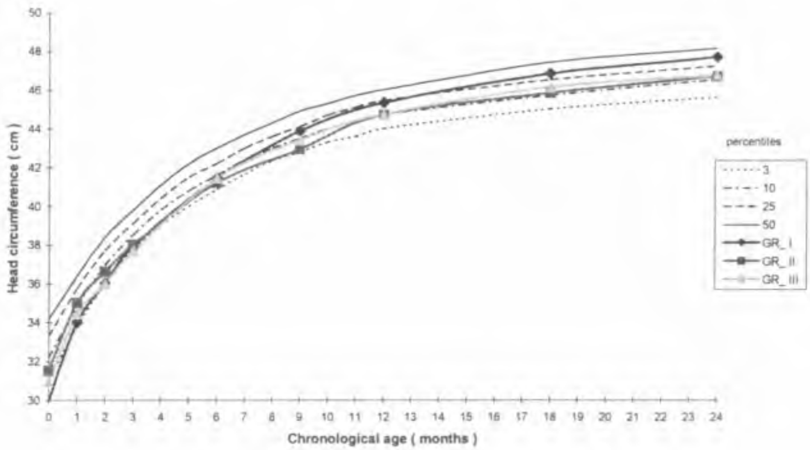

Fig. 2. Head circumference in the three groups of girls with Low-Birth-Weight according to their chronological age

with intrauterine growth retardation (group II), mean values of head circumference were placed within wide norms reaching the values between 10–25 perpercentile (Fig. 1). Mean head circumference in the Ist and IIIrd groups, both forboys and girls during the 1st month placed in the lowest range of the growth charts, i.e. between 3–10 percentile. Except for the preterm girls (group I), who reached 10–25 percentile level at 12th month, it remained in this low position (3–10 percentile) until the 12th month of age (Fig. 1,2). Initially the fastest growth velocity in S-f-D newborns (group II) in the 3rd and following months was considerably slowed down in comparison to the other groups. This resulted in the lowering of the developmental curve of head circumference to the level between 3–10 percentile and maintaining at this level until 12th month of age. Between 1st and 2nd years of life the greatest dynamics of head circumference growth was observed in boys and girls from AGA preterms (group I) and this caused a quick shift of mean value for head circumferences in this group from the level between the 3rd and 10th percentile during the 1st year of life, to the range over 25 percentile during 2nd year of life (Fig. 2,3). Mean head circumferences during 2nd year of life, both for boys and girls from group II (S-f-D newborns) and group III (SGA-preterms), exceeded the 10th percentile (Fig. 1,2).

Adjustment of data to gestational age changed the courses of curves (Fig. 3,4). In AGA preterms (group I) normalized mean values of head circumference in the first months of corrected age were placed in the narrow growth standard, i.e. above percentile 25. The girls exceeded the 50th percentile in the first, and the boys in the third month of corrected age (Fig. 3,4). In the group I of AGA preterms after the period of development according to this level, the developmental dynamics was slowed down. In girls the developmental curve between 2nd and 6th months of life was lowered to the level below percentile 25, and in boys this phenomenon was present between 3rd and 6th months of corrected age when developmental curve reached the level between percentile 3 and 10 (Fig. 3,4). Starting from the 6th month of corrected age in boys and girls from group I, a phenomenon of acceleration of head circumference growth was observed. This resulted in placing the children of group I in the mean developmental standard, i.e. between perpercentile 25–50 at the end of the longitudinal study

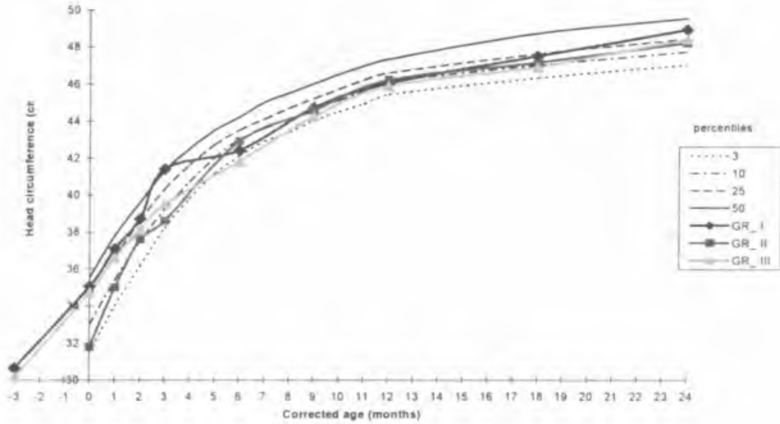

Fig. 3. Head circumference in the three groups of boys with Low-Birth-Weight according to their corrected age

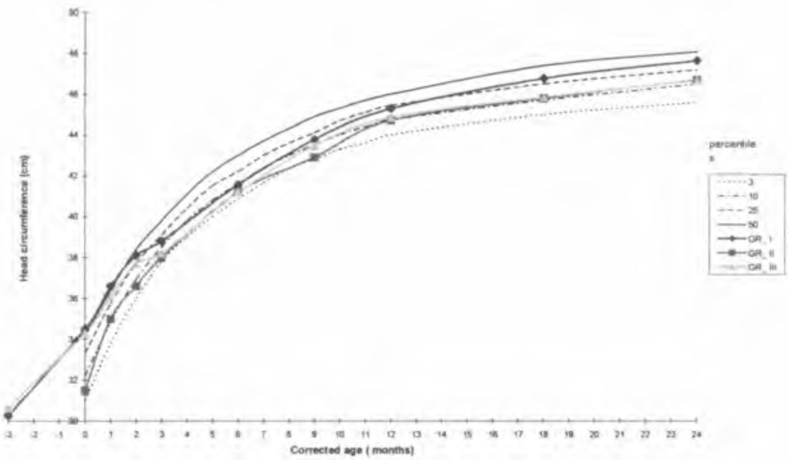

Fig. 4. Head circumference in the three groups of girls with Low-Birth-Weight according to their corrected age

(Fig. 3,4). Full "catch-up growth" occurred only in boys from AGA preterms (group I), who during the 2nd year of life reached the same perpercentile position for head circumference as during the first months of the corrected age (Fig. 3). The head circumference growth in SGA preterms (group III) was similar, though on the lower percentile level. The head circumference growth curve in girls during the first two months and in boys – only during the first month of the corrected age was placed over the 25th perpercentile defining the narrow growth standard (Fig. 3, 4). Next, in girls it lowered to reach the limiting value of 3 percentile during the 6th month of corrected age and in boys it was found below the 3rd percentile. From that time the head circumference growth in group III slightly accelerated. During the 2nd year of corrected age the boys from group III reached again (as on the onset of the study) the limit of the narrow growth standard (25 percentile); however, head circumference of the girls was found in the lower range of the growth charts than at the beginning of the study, i.e. between 10–25 percentile. Only in the S-f-D newborns from group II at the end of the 2nd year of life, the head circumference growth level was higher than at birth (Fig. 3, 4).

Head circumference growth curves for real values (with reference to chronological age) and for normalized values (with reference to gestational age) for AGA preterms (group I) and SGA preterms (group III) were assessed by superposing them on to the Polish reference growth charts. (Fig. 5,6,7,8). The real values of head circumfrence in boys and girls from group I at birth were placed below 3rd percentile, and they maintained on the 3rd percentile level still in the 1st, 2nd and 3rd months of life (Fig. 5,6). After adjusting these values to gestational age, the normalized values of head circumference reached the level of 50 percentile in girls during the first 2 months and in boys during the first three months of corrected age. After this period, developmental dynamics considered with reference to corrected age slowed down in relation to biological standard. In the 6th month of life the decrease of adjusted values of head circumference to the level between percentile 3 and 10 in both sexes, was noted. At this time the equalization of both developmental curves, i.e. the real values curve (not considering gestational age) and the normalized values curve (considering gestational age), was observed (Fig. 5,6). During the following 6 months of life the real and adjusted values of head circumference at the following stages of longitudinal studies, reached a higher percentile position,

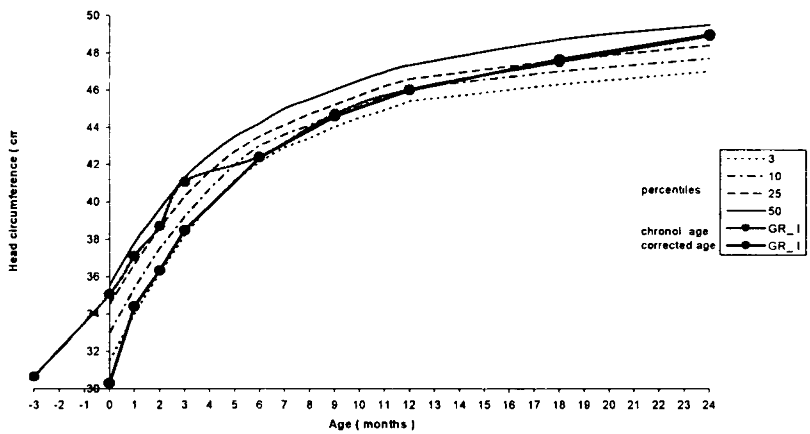

Fig. 5. Comparison of head circumference in Low-Birth-Weight boys from group I according to chronological and corrected age

Figure 6.

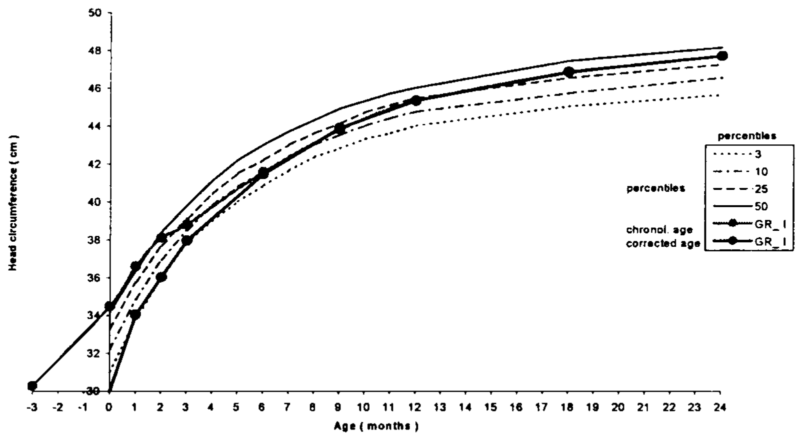

Fig. 6. Comparison of head circumference in Low-Birth-Weight girls from group I according to chronological and corrected age

which accounted for the acceleration of growth of this parameter. At the end of 2nd year of life the real and adjusted values of head circumference in AGA preterms (group I) reached the range of narrow growth standard (> 25 percentile), however, only in boys the phenomenon of full "catch-up growth" was present, and the adjusted values were on the same developmental level as on the day of physiological birth (Fig. 5, 6).

Figure 7.

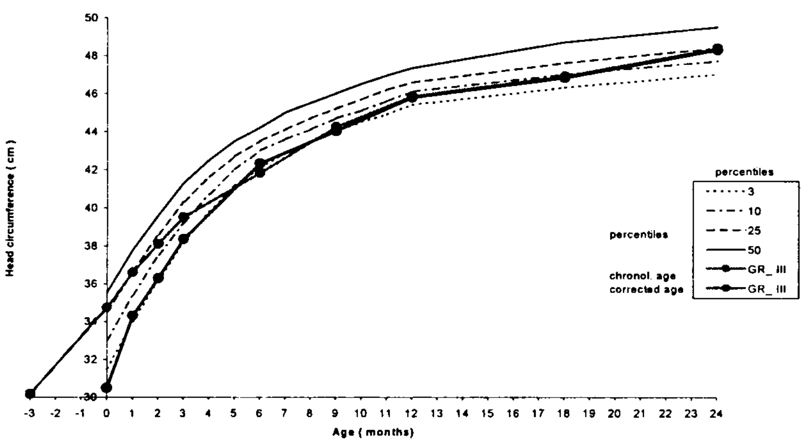

Fig. 7. Comparison of head circumference in Low-Birth-Weight boys from group III according to chronological and corrected age

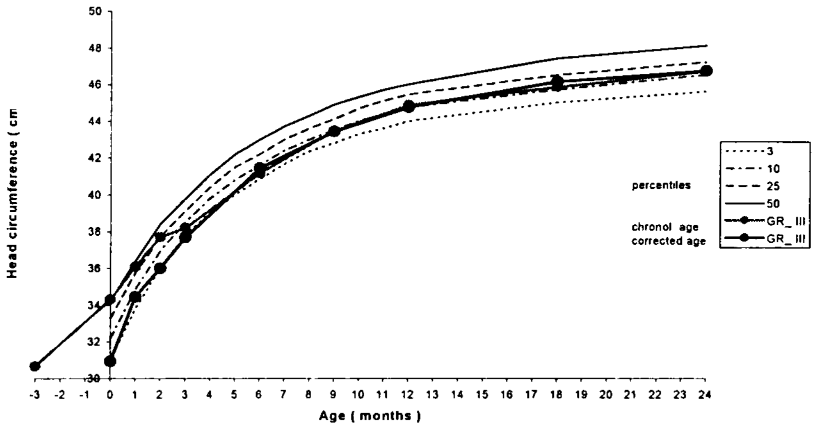

Fig. 8. Comparison of head circumference in Low-Birth-Weight girls from group III according to chronological and corrected age

Head circumference growth course in pre-term newborns with intrauterine growth retardation (group III) with reference to chronological and corrected age, was similar to group I-AGA preterms. After adjustment to gestational age, head circumference in girls during 1st and 2nd months of life was placed in the level between 25–50 percentile, whereas the head circumference in boys from group III placed initially, until the 3rd month of corrected age, at the level of 25 percentile and then – below the 25 percentile. Between the 3rd and 6th months head circumference dynamics slowed down and the growth curve with reference to corrected age lowered till the level of 3 percentile in girls and below 3 percentile in boys (Fig. 7,8). Between 4th and 5th months of life both growth curves crossed and then levelling of real and normalized values took place both in boys and in girls from group III. At the end of 2nd year of life neither real nor normalized values of head circumference in children from group III exceeded the level of 25 percentile which limits the narrow growth standard (Fig. 7, 8).

DISCUSSION

Low birth weight is a strong risk factor of poorer physical and psychomotor development of the infant (2). Problems with establishing reference systems for low birth weight infants emerge from the fact that in numerous papers concerning this issue, biological maturity of newborns is not considered, and in the case of premature newborns, their gestational age is not considered (3,6). Disregarding gestational age in evaluation of physical development of low birth weight infants may lead to false assessment and false developmental prognoses (6,10). Developmental prognoses for this group of children differ depending on the duration of pregnancy and biological maturity after birth (8,9,12,14). In the present paper two years' observations comparing the head circum-ference growth in three groups of low birth weight infants with reference to Polish growth patterns, are presented. Physical development indices are the most important measure of the child's health, and monitoring of head circumference when there is the fastest brain growth, may be a screening test for potential neurodevelopmental disorders (15).

The initial statistical analysis concerned real values of head circumferences measured during the following months of chronological age of children without considering their gestational age. Then, for the preterm infants, i.e. AGA preterms (group I) and SGA preterms (group III) the real values were calculated for gestational age of each child, normalized values were obtained and then analyzed statistically. Real and normalized values were plotted against the Polish reference growth charts and in this way head circumference growth in the same preterm infants was compared using two methods, i.e. without considering infants' gestational age and after considering gestational age. Head circumference growth of preterm infants (groups III and I) with reference to chronological and gestational age was compared with the development of this trait in the S-f-D new-borns (group II). Different head circumference growth during two years of observation was confirmed in three groups of low birth weight infants. At the time of physiological birth, without regarding gestational age of the investigated infants, AGA preterms (group I) had statistically significant smallest head circumference as compared with S-f-D infants (group II) and SGA preterms (group III). However, after adjustment of the data to gestational age it appeared that at the time of physiological birth head circumferences of AGA preterms (group I) and SGA preterms were statistically significantly bigger than head circumferences of S-f-D newborns (group II). Moreover, mean head circumferences in group I at physiological birth were placed on 50 percentile, reaching the mean value for full-term newborns. The results of the authors' study are consistent with Brandt (3) and Altigani's (1) reports, stating that preterms' head circumferences after adjustment of data to gestational age are the same as of full term infants. However, in our studies the equalization of real and standardised parameters of head circumferences occurred in group I in the 6^{th} months, and in group III – between 4^{th} and 5^{th} months of life, whereas in Karlberg's et al. (11) studies these parameters got equal in the 12^{th} week of extrauterine life. The results of longitudinal studies carried out in many countries confirm the tendency for accelerated rate of preterms' development, emphasizing a particular quick head circumference growth in these infants as compared to the full-term infants (6). This tendency was also observed during the longitudinal studies by analyzing the real data of head circumferences without considering gestational age in AGA and SGA preterms (groups I and III). In the previous paper the authors described the phenomenon of accelerated head circumference growth in groups I and III, which took place during the 1^{st} month of life of chronological age and next between 1^{st} and 2^{nd} years of life. The dynamics of head circumference growth after adjustment of data to gestational age in groups I and III, is slightly different. During two years' longitudinal studies in group I and group III of preterms, the change of head circumference growth rate was observed. After initial quick growth velocity, a deceleration and lowering of high percentile positions of head circumference followed in group I and group III preterms. Next, in about the 6^{th} month of extrauterine life the head circumference growth rate increased. This phenomenon may be related to the initial intrauterine maintenance of head circumference growth rate of preterms and acceleration of the growth rate in extrauterine life. However, in the 2^{nd} year of life only the head circumference of boys from group I reached the same percentile position as during the physiological birth. The infants from group II – S-f-D infants reached higher values of head circumferences in the 2nd year of life as compared with the values at birth.

When analyzing the results of the study on head circumference growth of low birth weight infants, it can be stated that the pre-term infants during the first months of extrauterine life demonstrate the interuterine growth rate. The reports concerning the accelerated development of pre-term infants during their first months and years of life should be then questioned. This is also proved by the fact that at the end of 2^{nd} year of life the mean head circumference values after adjusting to gestational age in groups I and III (AGA and SGA preterms), except for boys from group I, did not reach such a high percentile position as at the term of physiological birth. The study, however, confirmed the reports stating that interuterine growth deceleration of full-term infants may be partly compensated for and this is supported by the acceleration of head circumference growth velocity in this group of infants (group II) observed during two years' longitudinal studies (2,11). According to the opinion of the authors, comparing the development of preterm infants to growth standards for full-term infants as well as prognosing the development of low birth weight infants without considering their gestational age, will lead to misinterpretation of developmental phenomena in this group.

CONCLUSIONS

1. Considering the chronological and corrected age, a different course of head circumference growth in the two groups of preterms (group I and III) was observed
2. With reference to chronological age the head circumferences in children from groups I and III reached in the 2nd year of life a higher percentile position than at birth.
3. After adjustment of anthropometric parameters to gestational age in AGA and SGA preterms (groups I and III), only the mean head circumference of boys from group I reached in the 2nd year of corrected age the same level of growth as at the time of physiological birth.
4. In the 2nd year of life the mean head circumference of S-f-D newborns (group II) reached a higher growth level than at birth.

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SUMMARY

Head growth in 283 LBW (< 2500 g) children was longitudinally analyzed from birth till the 24th month of life. The studied children were divided into three groups: AGA preterms (181 children), SGA preterms (32 children) and S-f-D newborns (70 children). The data for chronological age and corrected for gestational age were statistically analyzed by analysis of variance and Duncan's test. Means of head circumference were plotted against percentile charts for boys and girls respectively. Considering the chronological and corrected age, a different course of head growth in preterms was observed. According to chronological age, the head circumference in AGA and SGA preterms reached in the second year of life a higher percentile position than at birth. After correction of the data to gestational age the mean values of head circumference in two groups of preterms were placed at a lower percentile position than at the time of birth. The group of S-f-D newborns presented the highest velocity of head growth: in the 2nd year of life the mean head circumference in this group reached a higher growth level than at birth.

Długofalowa analiza wzrastania obwodu głowy u dzieci urodzonych z małą masą ciała w odniesieniu do wieku płodowego i chronologicznego

W trzech grupach dzieci urodzonych z masą ciała poniżej 2 500 g (LBW, Low- Birth-Weight) przeprowadzono długofalowe badania obwodu głowy od urodzenia do 24 miesiąca życia. Wśród 283 dzieci było 181 wcześniaków z masą ciała odpowiednią do wieku płodowego (AGA, Appropriate-for-Gestational Age), 32 wcześniaki z masą ciała za małą do wieku płodowego (SGA, Small-for-Gestational Age) i 70 dzieci urodzonych o czasie z małą masą ciała (S-f-D, Small-for-date). Dane antropometryczne uzyskane w kolejnych miesiącach badań normalizowano do wieku płodowego badanych dzieci i odniesiono do polskich norm rozwojowych. W analizie statystycznej posługiwano się analizą wariancji i testem Duncana. Obserwowano różnice w przebiegu krzywych wzrastania obwodu głowy w trzech grupach dzieci urodzonych z małą masą ciała, analizowanych w odniesieniu do wieku płodowego i chronologicznego. W 24 miesiącu życia obwód głowy wcześniaków (AGA i SGA) w odniesieniu do wieku chronologicznego osiągnął wyższą pozycję centylową, podczas gdy po znormalizowaniu danych do wieku płodowego wartości obwodu głowy plasowały się w niższych kanałach siatek centylowych niż przy urodzeniu. Największą dynamiką rozwojową charakteryzowało się wzrastanie obwodu głowy u noworodków urodzonych o czasie z hipotrofią wewnątrzmaciczną (S-f-D), których średni obwód głowy w 24 miesiącu życia osiągnął wyższy niż przy urodzeniu kanał centylowy.