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Assesment of catch-up growth of small for gestational age neonates born at gestational age > 34 weeks in the first nine months of infancy

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ABSTRACT

Background: Small-for-gestational-age (SGA), defined as infants whose birth weight is less than 10th percentile of the reference, is widely known to have higher risk for perinatal morbidity, growth restriction leading to persistent short stature, neurodevelopmental problems such as low intelligence quotient (IQ), and pubertal disorder in later life. In this study catch up growth was assessed for the first nine months of infancy.

Method: This was a hospital based Prospective observational cohort study. A total of 170 newborns admitted in the postnatal ward was included in the study. Follow up appointments scheduled which corresponded to their vaccination schedule at 6 weeks,10 weeks,14 weeks, and at 9 months. Anthropometric measurement was taken within the first 24 hrs of life and plotted on growth chart (weight, length, head circumference) and the average of the three readings was noted. Anthropometry measurements were plotted on WHO growth charts for term babies and Fenton chart for preterm babies.

Results: Catchup growth was achieved by 38 (27.7%) participants at 10 weeks, 33.6% by 14 weeks, 65% by 6 months and 72.3% by 9 months of age while 27.7% participants didn't achieve catchup growth. Comparison of weight at birth and at 9 months and between term and preterm were statistically significant with p value of <0.001.

Conclusion: Catch-up growth (CUG) was achieved in a substantial proportion of infants, particularly for weight (72.3%), length (68.6%), and head circumference (81.8%) by nine months. However, a notable percentage of infants did not achieve CUG, highlighting the need for targeted nutritional and healthcare interventions.

Keywords: *Small for gestational age; term; preterm; catch up; prospective observational study ; chi-square test*

1. INTRODUCTION

Foetal growth restriction has a negative impact on both short- and long-term growth and developmental outcomes and is a significant indicator of neonatal health for both preterm and full-term newborns. A reference population with normal foetal growth is typically used to compare the birth weight with the predicted weight for the same gestational age. [1]

It is well known that infants classified as small-for-gestational-age (SGA), whose birth weight is less than the 10th percentile of the reference, are more likely to experience perinatal morbidity, growth restriction that results in long-term short stature, neurodevelopmental issues like low IQ, and pubertal disorders later in life. [2] Around 16% of people worldwide have SGA,

with rates ranging from 7% in developed nations to 27% in low- and middle-income nations, when 91.7% of babies were born at full term. [3,4]

Numerous studies have demonstrated the impact of maternal traits on intrauterine and postnatal growth, including age, parity status, educational attainment, and medical conditions (such as nutritional status or anaemia sickness during pregnancy). Growth has also been demonstrated to be impacted by variations in feeding practices. It has been demonstrated that infants who are solely breastfed grow better than their classmates who are formula-fed.[2].

SGA is linked to a number of developmental problems, including short height, obesity, metabolic problems, and cognitive developmental deficits. It can also indicate a newborn's growth risk. [5,6] When compared to infants delivered appropriately for gestational age (AGA), SGA was linked to a higher risk of neonatal and postneonatal deaths, according to the Child Health Epidemiology Reference Group. [7]

Based on the timing and severity of the damage, symmetrical (proportionate) and asymmetrical (disproportionate) phenotypes are distinguished in aetiology for small for gestational age (SGA) newborns. Inhibiting causes like as viral infections, genetic defects in cellular development, and chemical exposure during the first trimester of pregnancy cause symmetrically growth-retarded foetuses. Conversely, a late pregnancy injury results in asymmetrical development retardation in the newborn. A infant with symmetric growth retardation in the first trimester will have changes in weight, length, and head size. If the trauma or nutritional shortage occurs later in pregnancy, the brain will not be damaged, but the kid will be shorter and lighter, resulting in asymmetric growth retardation.[8]

Studies around the world have shown that babies with symmetric growth retardation had smaller head circumferences than asymmetric infants. In the postnatal years, when SGA is somewhat more common—affecting 77-90% of Indian LBW kids—longitudinal anthropometric data on the head growth of symmetric and asymmetric SGA babies from India and other developing countries are lacking. SGA babies had poorer neurodevelopmental results over the long term in addition to higher rates of perinatal, neonatal, and post-neonatal mortality and morbidity.[8]

The acceleration of growth that happens after birth in babies born short for gestational age (SGA) is known as catch-up growth (CUG). The gradual reduction in the weight gap between a person and the reference mean for a healthy population is known as weight catch-up. International guidelines for defining catch-up growth do not exist. The improvement in weight to the typical range of -2 to +2 weight-for-age Z score (WAZ) is one of the relative definitions of catch-up. Better immunological function, avoidance of the metabolic effects of early intrauterine growth retardation, avoidance of persistent short height, and improved neurobehavioral outcomes are all linked to catch-up growth in SGA newborns. For SGA infants to be managed appropriately, it is essential to have a correct understanding of the elements that both favourably and negatively affect CUG.[9] According to the majority of authors, the first six months of life for weight and the first nine months of life for length—when breast milk or formula would be the infant's main source of nutrition—are the windows for accomplishing catch-up growth in SGA infants. This idea suggests that there may be a crucial time to determine the course of long-term growth.[10]

2. METHOD

This was a hospital based Prospective observational cohort study. A total of 170 newborns admitted in the postnatal ward was included in the study. Informed consent was obtained from the guardians and follow up appointments scheduled which corresponded to their vaccination schedule at 6 weeks,10 weeks,14 weeks, and at 9 months. Newborns with addresses in Greater Noida and its vicinity was preferred while recruitment as it was convenient for their follow up. Dropout rates was minimized by sending reminders for follow up visits over the phone or via text message. Anthropometric measurement was taken within the first 24 hrs of life and plotted on growth chart (weight, length, head circumference) and the average of the three readings was noted. Nude body weight was recorded using an electronic weighing scale to the nearest 10 g. Length was recorded using an infantometer to the nearest 0.1 cm, and the occipitofrontal circumference was measured using a non-stretchable tape. Anthropometry measurements were plotted on WHO growth charts for term babies and Fenton chart for preterm babies. The collected data was be entered in Microsoft Excel and then was analysed and statistically evaluated using SPSS-22 version. Quantitative data was expressed by mean, standard deviation or median with interquartile range and depends on normal distribution, difference between two groups was tested by student t test or Mann Whitney U test. Qualitative data was expressed in percentage and difference between the proportions was tested by chi square test or Fisher's exact test. Pearson correlation coefficient was used to correlation between two quantitative variables. Univariate and Multivariate analysis was carried out, using the odds ratio (OR) to test for associations between various factors and poor catchup growth. 'P' value less than 0.05 was considered to be statistically significant.

3. RESULT

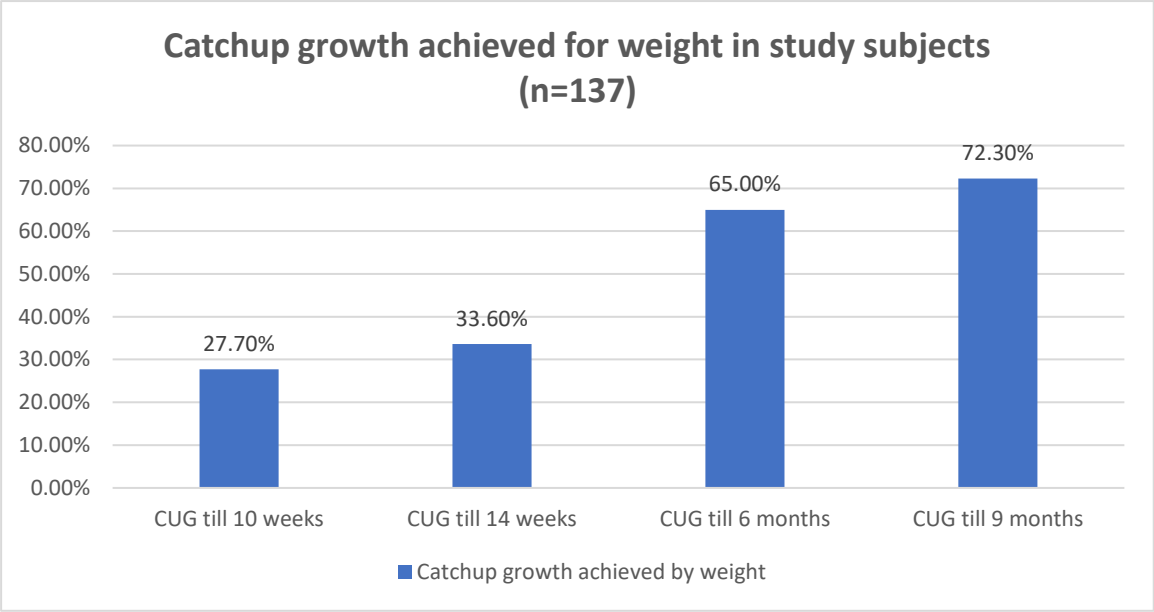
	Growth achieved (n=99)	**Growth not achieved (n=53)**	**p value**
Mean maternal age	26.54±3.57	26.18±3.49	0.60**
Parity			
0 (n=83)	57 (68.7%)	26 (31.3%)	0.38
1 (n=25)	18 (72%)	7 (28%)	
2 (n=24)	19 (79.2%)	5 (20.8%)	
3 (n=5)	5 (100%)	0	
Mode of delivery			
LSCS	59 (78.6%)	16 (21.4%)	0.06
NVD	40 (64.5%)	22 (35.5%)	
No of baby			
Single	99 (73.3%)	36 (26.7%)	0.07*
Twin	0	2 (100%)	
Birth order			
1	58 (67.4%)	28 (32.6%)	0.30
2	21 (75%)	7 (25%)	
3	19 (86.4%)	3 (15.6%)	
4	1 (100%)	0	
Gestational age			
Preterm	2 (20%)	8 (80%)	**<0.01***
Term	97 (76.4%)	30 (23.6%)	
Type of growth			
Asymmetric	94 (77%)	28 (23%)	**<0.01***
Symmetric	5 (33.3%)	10 (66.7%)	

Chi square test or Fisher exact test* was used while for mean age comparison unpaired t test was used**

Catchup growth achieved for weight	**No.**	**%**
CUG till 10 weeks	38	27.7%
CUG till 14 weeks	46	33.6%
CUG till 6 months	89	65.0%
CUG till 9 months	99	72.3%
CUG not achieved	38	27.7%

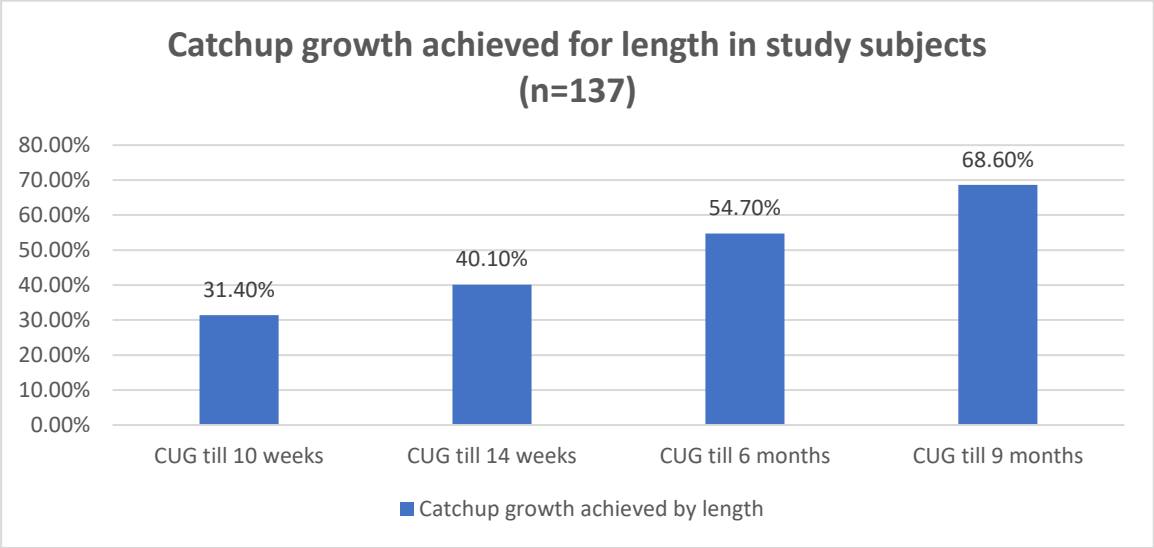
Using weight, catchup growth was achieved by 38 (27.7%) participants at 10 weeks, 33.6% by 14 weeks, 65% by

6 months and 72.3% by 9 months of age while 27.7% participants didn't achieve catchup growth.



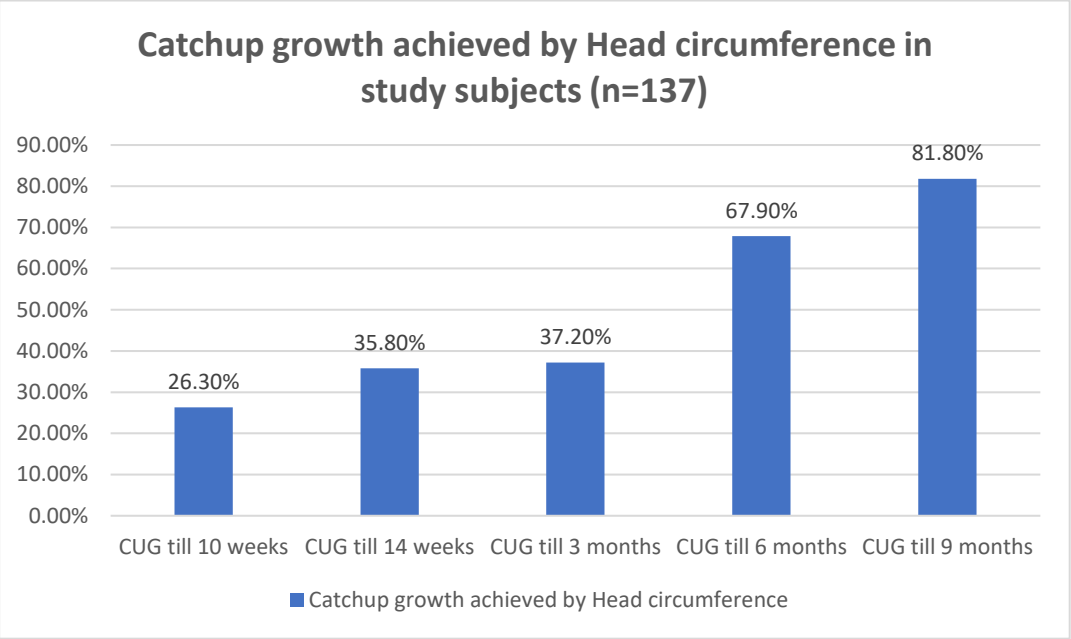
Catchup growth achieved for length	No.	%
CUG till 10 weeks	43	31.4%
CUG till 14 weeks	55	40.1%
CUG till 6 months	75	54.7%
CUG till 9 months	94	68.6%
CUG not achieved	43	31.4%

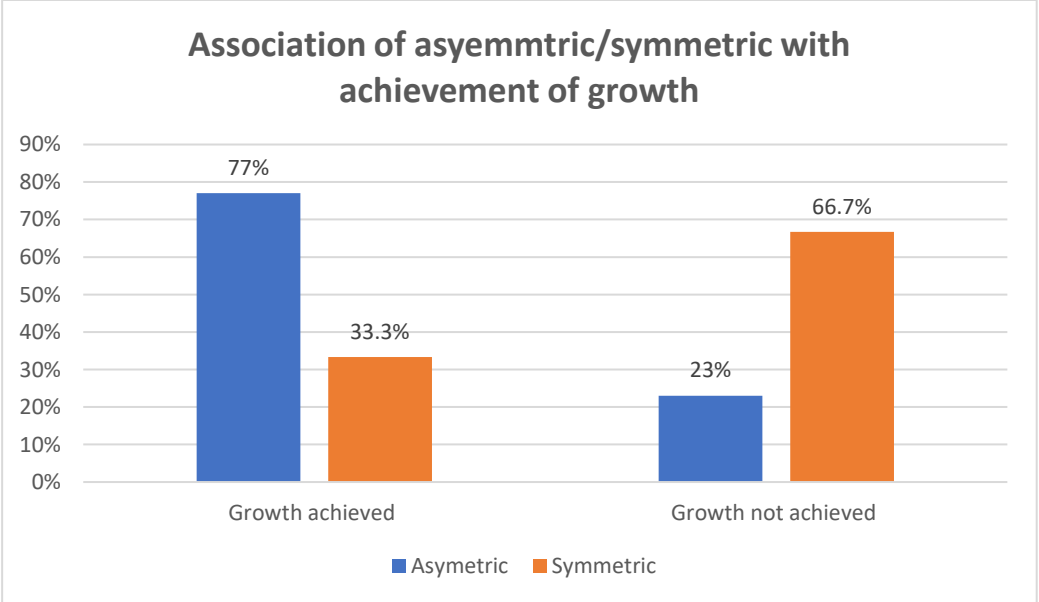
Using length catchup growth was achieved by 43 (31.4%) participants at 10 weeks, 40.1% by 14 weeks, 54.7% by 3 months and 68.6% by 9 months while 31.4% participants didn't achieve catchup growth.

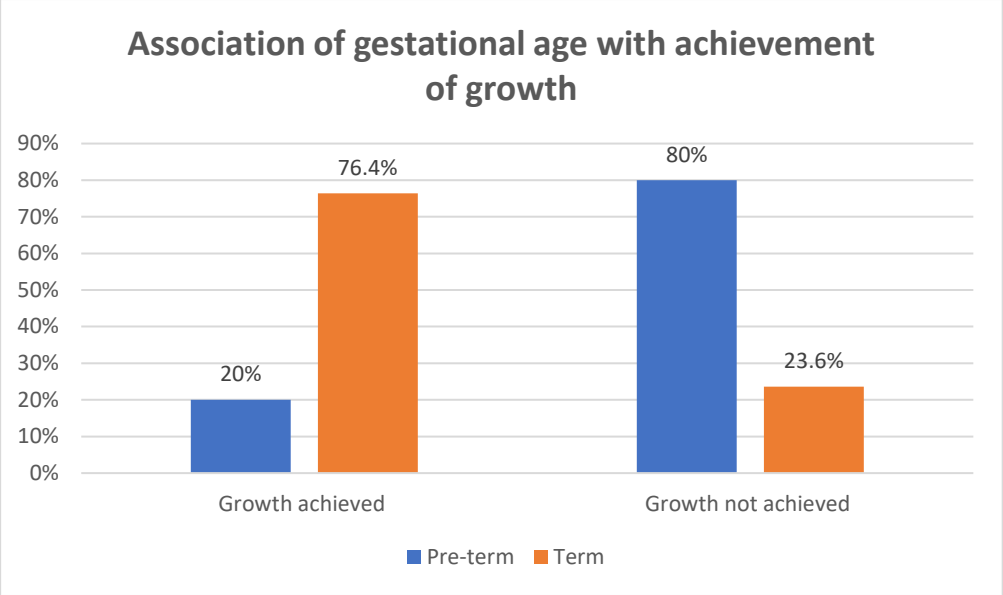


Catchup growth achieved for Head circumference	**No.**	**%**
CUG till 10 weeks	36	26.3%
CUG till 14 weeks	49	35.8%
CUG till 3 months	51	37.2%
CUG till 6 months	93	67.9%
CUG till 9 months	112	81.8%
CUG not achieved	25	18.2%

Using head circumference catchup growth was achieved by 36 (26.3%) participants at 10 weeks, 35.8% by 14 weeks, 37.2% by 3 months 67.9% by 6 months and 81.8% by 9 months of age while 18.2% participants didn't achieve catchup growth.

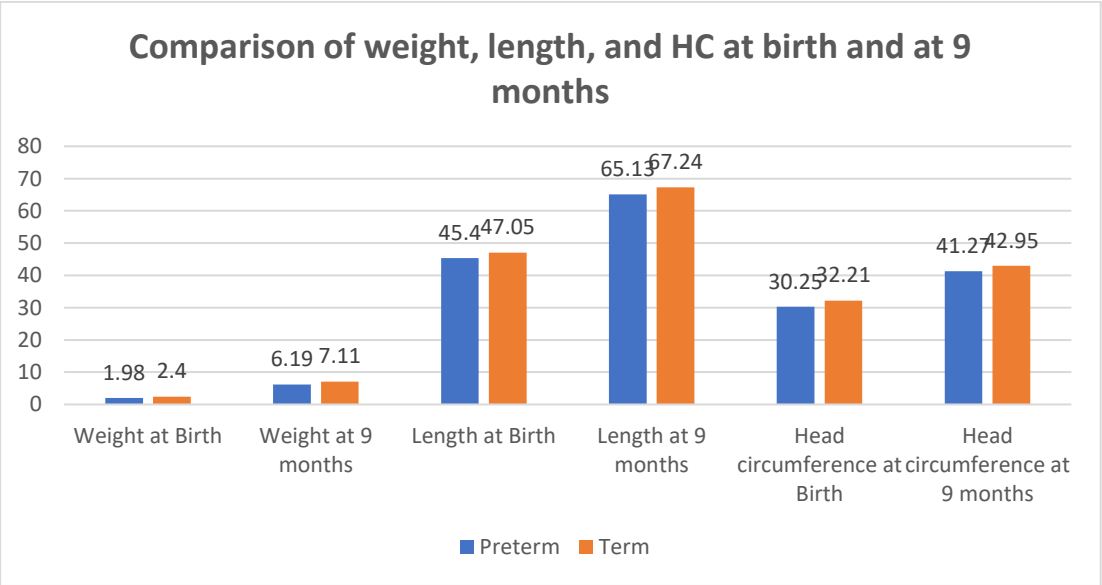


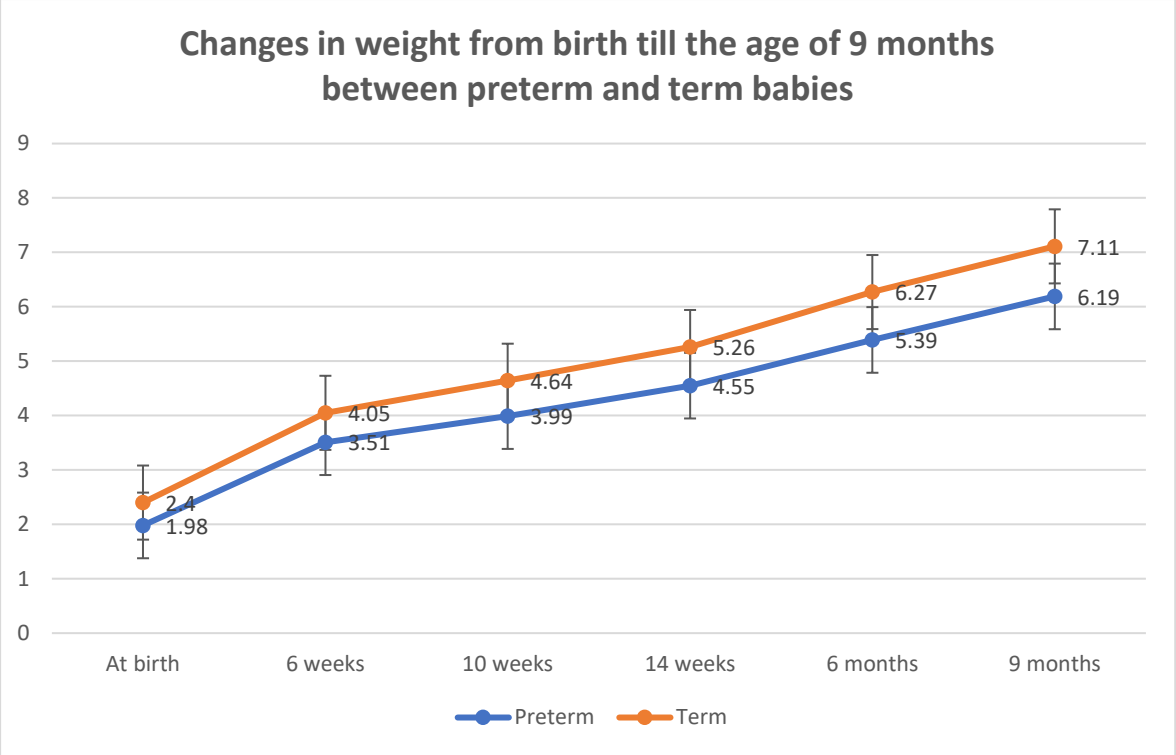


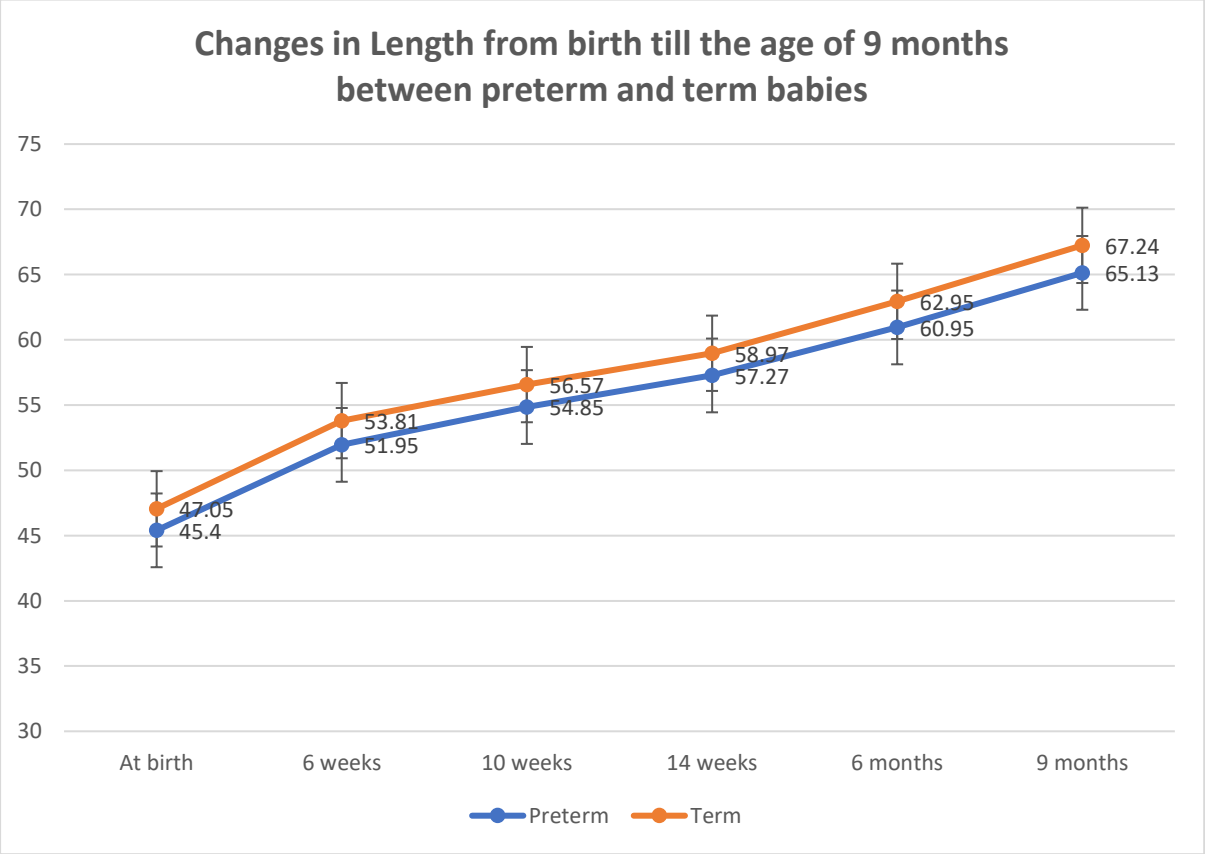


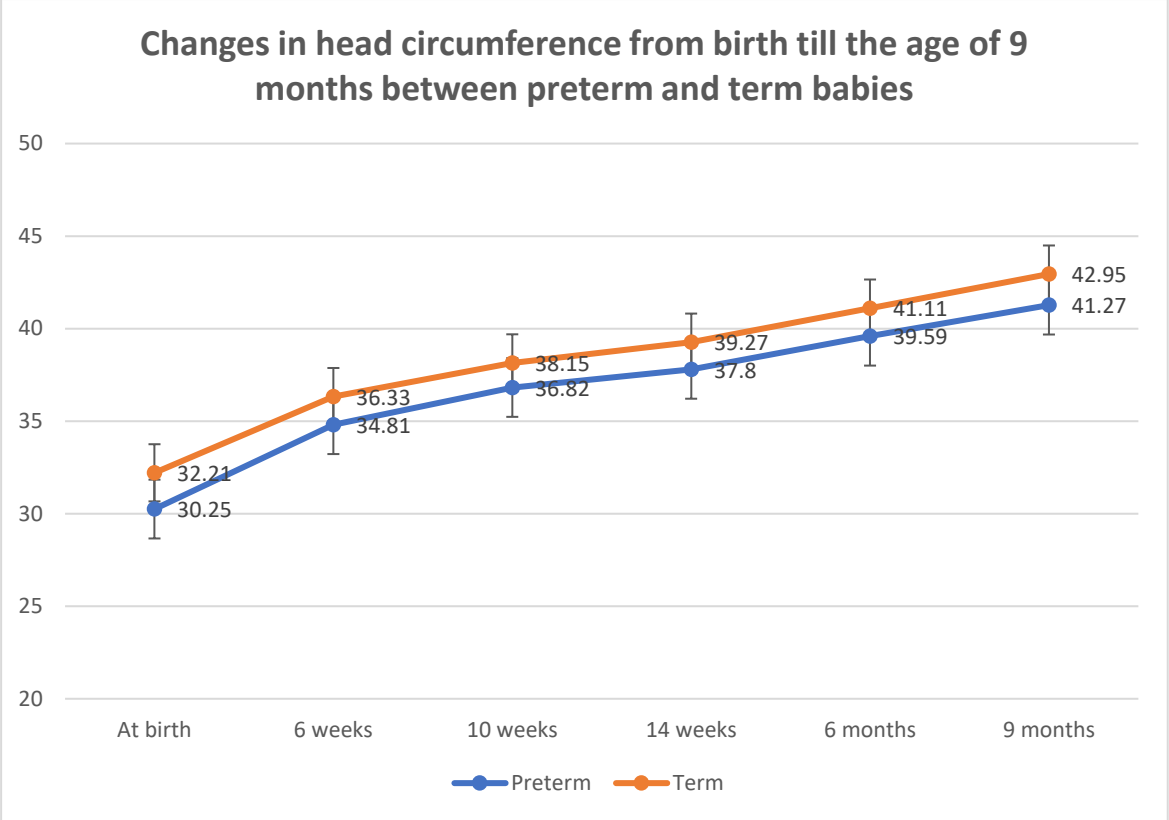
	Preterm	Term	p value
Weight at Birth	1.98±0.26	2.40±0.23	**<0.001**
Weight at 9 months	6.19±0.91	7.11±0.58	**<0.001**
Length at Birth	45.40±1.59	47.05±1.15	**0.01**
Length at 9 months	65.13±1.69	67.24±1.99	**<0.001**
Head circumference at Birth	30.25±1.08	32.21±1.38	**<0.001**
Head circumference at 9 months	41.27±0.91	42.95±1.34	**<0.001**

The study also revealed significant differences in growth parameters between preterm and term infants. Term infants consistently exhibited higher average weights, lengths, and head circumferences both at birth and at 9 months. The p-values, all below 0.01, indicate that these differences are statistically significant.




Changes in weight from birth till the age of 9 months between preterm and term babies
9
8
7
6
5
4
3
2
1
0
2.4
1.98
4.05
3.51
4.64
3.99
5.26
4.55
6.27
5.39
7.11
6.19
At birth
6 weeks
10 weeks
14 weeks
6 months
9 months
Preterm
Term


Changes in Length from birth till the age of 9 months between preterm and term babies
75
70
65
60
55
50
45
40
35
30
47.05
45.4
53.81
51.95
56.57
54.85
58.97
57.27
62.95
60.95
67.24
65.13
At birth
6 weeks
10 weeks
14 weeks
6 months
9 months
Preterm
Term



4. DISCUSSON

The present study was a longitudinal cohort study of All SGA babies admitted in the Post Natal Ward with a gestational age of more than 34 weeks in the paediatric department of our study hospital. Total of 170 babies were recruited who fulfilled the inclusion criteria and were followed for nine months after birth for growth assessment by recording weight, length, and head circumference. Out of 170 babies, 33 were lost to follow-up and remaining 137 babies analysed after completion of study.

Due to their limited growth in pregnancy, full-term but small-for-gestational-age (SGA) babies are more likely to experience ongoing growth deficiencies after delivery as well as possible neurological issues.[11] SGA babies were selected who were born after a gestation of more than 34 weeks, monitored till 9 months of postnatal age and took their anthropometric measurements as part of a longitudinal observational study. Catch up growth is defined as an increase in weight to bring it within the normal range of -2 to +2 weight for age Z score (WAZ). At 9 months it was observed that about 72% had attained catch up growth related to weight.

Most of the infants in our study were preterm and had asymmetric SGA. During the first six weeks, it was seen that the newborns were underweight. A WAZ score greater than -2 SD was achieved by 10 weeks in 27.7 %, at 14 weeks in 33.6%, at 6 months in 65%, at 9 months in 72.3% of the study group.

Catch up growth for length is defined as a change in length for age z-score (LAZ) of >0.67 between two-time points, or achieving a LAZ of >2 SD or growth above the third percentile for LAZ of the WHO 2006 growth standards at any time during follow-up.[6,12,13] Among the newborns in this study 31.4% showed catch up growth in length by 10 weeks, 40.1 % showed catch-up growth in length by 14 weeks, 54.7 % showed catch up growth in length by 6 months, and 68.6% showed catch-up growth in length by 9 months., Zhang et al[1].'s study published in the year 2024 found a similar result for the babies weight and length with findings suggestive that both the z-score for weight and length reaching to normal with increasing age of the baby although the study had a larger sample size and various patterns of attainment of this score were identified among male and female babies. In their extended follow-up study, Nguyen et al.[14] found that the weight of SGA newborns increased quickly during the first six months of life, but that the babies' catch-up development did not fully occur until they were about six years old. Most late preterm and small-for-gestational-age newborns showed notable increases in weight and length by 3 and 6 months of corrected age, according to the study by G. Vizzari et al.[15]

The vast majority of full-term infants born small for gestational age (SGA) showed catch-up growth by 24 months, according to the study by Bouferoua F et al published in the year 2023.[16] In particular, about 89.7% of these infants had all three

growth metrics—height, weight, and head circumference—exceeding -2 standard deviations when evaluated using Sempé norms. Similarly, almost 87.9% of the neonates and infants satisfied the same requirements for catch-up growth in accordance with WHO norms. According to Teodoro Durá-Travé et al.'s study [17], babies who were SGA or had extremely low birth weight showed catch-up growth in their third and fourth years of life. Among the newborns studied above, a steady rise in head circumference was also noticed. Catch up growth for head circumference in this study was achieved in 26.3% by 10 weeks, 35.8% by 14 weeks, 67.9% by 6 months, and 81.8 % by 9 months. Kaur et al. noticed a similar pattern.[8] The study assessed head circumference growth velocity in symmetric SGA, asymmetric SGA, and AGA infants across different age intervals. From birth to 1 month, symmetric SGA males had the highest growth velocity of head circumference (3.64 ± 0.71 cm/month), followed by asymmetric SGA males (3.54 ± 0.89 cm/month) and AGA males (3.08 ± 1.02 cm/month), with a similar trend in females. Between 1 to 3 months, asymmetric SGA males grew faster (3.49 ± 0.90 cm/2 months) than symmetric SGA (3.05 ± 0.86 cm/2 months) and AGA (2.85 ± 0.78 cm/2 months). At 3 to 6 months, AGA infants had the slowest growth, while symmetric and asymmetric SGA infants maintained slightly higher rates. Growth velocity declined across all groups from 6 to 9 months.[8]

Analysis of growth parameters of term neonates in comparison with growth parameters of preterm neonates revealed that term infants had significantly higher anthropometric parameters (weight, length, head circumference) at birth and 9-month compared to preterm infants ($p < 0.05$ for all comparisons). At birth, preterm infants had a lower average weight of 1.98±0.26 kg compared to 2.40±0.23 kg in term infants ($p < 0.001$). Even at 9 months, this difference persisted, with preterm infants weighing 6.19±0.91 kg, significantly less than term infants at 9 months weighing 7.11±0.58 kg ($p < 0.001$). Similarly, length at birth was lower in preterm infants (45.40±1.59 cm) than in term infants (47.05±1.15 cm, $p = 0.01$), and at 9 months, preterm infants measured 65.13±1.69 cm, while term infants were at 67.24±1.99 cm ($p < 0.001$). Head circumference also followed similar trend, with preterm infants measuring 30.25±1.08 cm at birth compared to 32.21±1.38 cm in term infants ($p < 0.001$). By 9 months, the head circumference of preterm infants increased to 41.27±0.91 cm, but they remained significantly smaller than term infants, who had an average head circumference of 42.95±1.34 cm ($p < 0.001$). Although both groups exhibited growth over time, preterm infants consistently remained smaller in all parameters at 9 months. Significant variations in growth metrics between preterm and term new-borns were also found in this study. Average weights, lengths, and head circumferences were consistently larger in term infants at birth and nine months. These differences are statistically significant, as indicated by the p-values, which are all less than 0.01. Since the normal babies had a baseline advantage due to their higher birth weight, length, and head circumference, a subsequent increase was noticeable over baseline. However, in addition to the baseline characteristic, increase in growth parameters are also linked to several other characteristics, which was evaluated in our study and found that catch-up growth was not substantially correlated with maternal age. Additionally, there was no statistically significant correlation between parity, birth order, or manner of delivery. Catch-up growth was, however, strongly influenced by gestational age and the kind of intrauterine growth restriction (IUGR) this showed that compared to term newborns, preterm infants had a far lower chance of achieving catch-up growth. Likewise, compared to infants with symmetric IUGR, those with asymmetric IUGR had a higher chance of achieving catch-up. The study by Nurani et al[2] compared growth parameters between term small-for-gestational-age (SGA) and term appropriate-for-gestational-age (AGA) infants at birth and 6 months. At birth, SGA infants had significantly lower weight (2244.5 ± 387.4 g vs. 3143.4 ± 339.8 g, $p < 0.001$), length (45.4 ± 2.9 cm vs. 49.1 ± 1.8 cm, $p < 0.001$), and head circumference (31.5 ± 1.5 cm vs. 33.9 ± 1.4 cm, $p < 0.001$) compared to AGA infants. By 6 months, SGA infants remained significantly smaller in weight (7009.4 ± 593.4 g vs. 7880.5 ± 938.8 g, $p < 0.001$) and length (65 ± 2.7 cm vs. 68.5 ± 3.1 cm, $p < 0.001$). However, head circumference differences were no longer significant (42.7 ± 1.1 cm vs. 42.9 ± 3.1 cm, $p = 0.824$), suggesting catch-up growth of head circumference by 6 months. Overall, SGA infants demonstrated growth but remained smaller than AGA infants at 6 months. Small for gestational age (SGA) newborns' catch-up growth (CUG) varies. Approximately 85–90% attain CUG, mostly in the first 24 months, due to enhanced growth hormone sensitivity and compensatory hyperinsulinemia. Asymmetric SGA, which indicates dietary sparing throughout late gestation, greater birth anthropometrics, and term gestation are all predictors of successful CUG. On the other hand, symmetric SGA and preterm SGA, which indicate early growth restriction, frequently have decreased CUG potential. Despite reaching CUG, rapid postnatal weight growth may increase the risk of metabolic syndrome by altering adipogenesis and insulin resistance.[1,2,18,19,20]

However, no specific percentile should be set as a growth goal; individual variability is expected. The study also highlights that preterm infants often have higher body fat percentages at term-equivalent age compared to term infants, but this difference diminishes over the following months. It recommends that, after early postnatal weight loss, preterm infants should grow similarly to fetuses and then term-born infants, aligning approximately with growth chart curves. Individualized nutrition and growth assessments are crucial for each high-risk infant.[2]

Persistent short stature and developmental delays can be associated with failure to attain CUG, which may be caused by compromised cellular proliferation during crucial growth stages.

5. CONCLUSION :

The study provides important insights into the growth patterns of small for gestational age (SGA) infants, considering

multiple maternal and neonatal factors. Catch-up growth (CUG) was achieved in a substantial proportion of infants, particularly for weight (72.3%), length (68.6%), and head circumference (81.8%) by nine months. However, a notable percentage of infants did not achieve CUG, highlighting the need for targeted nutritional and healthcare interventions. Preterm infants and those with symmetric SGA had lower rates of catch-up growth, suggesting that early identification and intervention are crucial for improving outcomes in these high-risk groups. The findings highlight the need for continued nutritional support and healthcare follow-up to ensure optimal growth and development in these vulnerable infants. Further research is recommended to explore long-term developmental outcomes beyond infancy, especially in those who fail to achieve adequate catch-up growth.

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