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Serum vitamin D status in term appropriate-for-gestational age and small-for-gestational-age infants receiving routine vitamin d supplementation – a prospective observational study

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To the Editor,

Vitamin D is essential for normal skeletal growth and general health during infancy. Although a daily supplementation of 400 IU is recommended for all infants, it remains uncertain whether this recommendation is equally adequate for term babies of small for gestational age (SGA). These infants often begin life with lower nutrient reserves and greater nutritional demands during the growth period of the recapture, and are increasingly recognized as a distinct high-risk group that warrants closer nutritional surveillance in early childhood.[5] Several published studies have described vitamin D status in preterm cohorts or examined cross-sectional associations between maternal vitamin D and birth weight, while others have characterized postnatal growth in term SGA infants without reference to vitamin D status.[6,7] However, longitudinal data directly comparing serum vitamin D trajectories between term AGA and SGA infants receiving an identical routine supplementation regimen remain scarce, particularly from the Indian subcontinent. Therefore, we wish to share observations from our prospective observational study comparing serum vitamin D levels and growth among term appropriate for gestational age (AGA) and SGA infants

during the first three months of life. To our knowledge, this is among the first studies in the Indian population to prospectively compare serial (birth and three-month) serum vitamin D status between term AGA and SGA infants under a routine 400 IU/day supplementation protocol, offering a real-world perspective distinct from prior work focused on preterm cohorts, single time point sampling, or catch-up growth outcomes considered in isolation.

The study included 60 term newborns (30 AGA and 30 SGA) born at our tertiary care teaching hospital between February 2024 and February 2025. A sample size of 60 infants (30 AGA and 30 SGA) was determined based on a power calculation assuming a 20% difference in mean serum vitamin D levels between the groups, with 80% power and a level of significance of 5%. This anticipated difference was based on previously published evidence reporting lower vitamin D levels in association with SGA. Ertl et al. reported approximately 22% lower maternal 25-hydroxyvitamin D levels in pregnancies resulting in SGA infants compared to AGA pregnancies[11]. Based on these findings, a 20% difference was considered a reasonable and conservative estimate for the sample size calculation. The infants were classified according to birth weight for gestational age. AGA babies were defined as those with birth weight between the 10th and 90th percentiles for gestational age, whereas SGA infants were defined as those with birth weight below the 10th percentile for gestational age according to INTERGROWTH-21st growth standards.[10] The study included term infants with a gestational age of 37 to 42 weeks. A convenience sampling technique was used, eligible term neonates were screened consecutively by the principal investigator, and infants fulfilling the predefined inclusion and exclusion criteria were enrolled after obtaining written informed consent from their parents. Equal numbers of infants with AGA and SGA were recruited. Although eligible AGA infants were readily available, eligible male newborns with SGA were encountered less frequently; therefore, recruitment was continued until the required number of infants with SGA infants was achieved.

Eligible infants enrolled (n = 60) AGA (n = 30) | SGA (n = 30) 3 month follow-up during routine vaccination visit Included in final analysis (n=60)

Accordingly, expected baseline differences were observed in birth weight and birth length. Other baseline demographic characteristics were not systematically evaluated as part of the study and are therefore not reported. Serum 25-hydroxyvitamin D concentrations were measured on the third day of life and again at three months. All infants received the recommended oral vitamin D supplementation of 400 IU/day after discharge. Anthropometric measurements, including weight and length, were recorded at birth and at follow-up using standardized techniques. Data were analyzed using IBM SPSS Statistics version 25. Continuous variables are presented as mean ± standard deviation, and comparisons between the AGA and SGA groups were made using independent-samples t-tests. A two-sided p-value <0.05 was considered statistically significant.

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At birth, mean total serum vitamin D concentrations were significantly lower in infants with SGA than in AGA infants. At three months, vitamin D concentrations increased in both groups, with significantly higher levels in AGA infants compared to SGA infants (Table 1).

Table 1. Descriptive statistics of serum vitamin D levels in infants with AGA and SGA

Variable	**AGA (n=30)**			**SGA (n=30)**			**p**
	Mean	SD	Range	Mean	SD	Range	
At birth total vitamin D (ng/mL)	22.27	14.83	6.61–69.05	14.86	8.96	9.20–46.14	0.03
3 months total vitamin D (ng/mL)	71.45	16.76	9.72–87.75	40.32	17.01	16.81–87.75	<0.001

The AGA infants had a higher mean weight and length than the SGA infants at birth and at three months (Table 2).

Table 2. Descriptive statistics of weight and length in babies with AGA and SGA

Variable	**AGA (n=30)**			**SGA (n=30)**		
	Mean	SD	Range	Mean	SD	Range
Birth weight (kg)	3.08	0.19	2.82–3.69	2.32	0.14	2.10–2.70
Birth length (cm)	48.73	1.74	45–51	46.10	0.99	44–50
3 months weight (kg)	6.37	0.26	5.68–6.70	4.93	0.20	4.40–5.20
3 months length (cm)	63.12	1.96	58–66	57.53	1.26	55–60

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These findings indicate that differences in vitamin D status between AGA and SGA infants may persist during early infancy despite routine supplementation.

Our observations are consistent with previous studies showing that neonatal vitamin D status is influenced by maternal vitamin D levels and fetal growth.[1,2] Similar findings have also been reported among infants at increased nutritional risk, where standard supplementation did not consistently achieve vitamin D sufficiency.[3,4] More recent evidence reinforces these observations. A 2025 prospective cohort from Romania found that despite prenatal counseling, fewer than half of mothers consistently used vitamin D-containing supplements during pregnancy, and neonatal vitamin D status closely tracked maternal supplementation patterns rather than gestational risk category alone, underscoring how variable maternal adherence can shape the vitamin D status an infant is born with.[9] Likewise, a 2022 evidence synthesis on vitamin D intake in infants and young children noted considerable heterogeneity in achieved serum concentrations even among infants receiving comparable supplemental doses, attributing this variability to differences in baseline stores, feeding pattern, and sun exposure rather than dose alone.[8] Parallel work on postnatal growth in term SGA infants, including a two-year Algerian cohort and an Indian birth cohort, has shown that the pace of catch-up growth is itself shaped by feeding behavior and nutritional factors similar to those that could plausibly influence vitamin D status, lending indirect support to our finding that SGA infants remained both smaller and more vitamin D deficient than AGA infants despite receiving an identical supplementation dose.[6,7] Taken together, these findings suggest that the persistent gap we observed between infants and SGA infants may not reflect a true failure of the 400 IU/day recommendation itself, but rather the influence of unmeasured, modifiable factors operating differently across the two groups. While the observed differences in our study are noteworthy, they should be interpreted with caution.

Several factors not captured in our study design could plausibly have contributed to, or confounded, the differences we observed. Maternal vitamin D status during the third trimester is a major determinant of neonatal stores at birth, since fetal 25-hydroxyvitamin D is derived almost entirely from placental transfer; mothers of babies with SGA, particularly those with placental insufficiency or hypertensive disorders of pregnancy, may themselves have had lower circulating vitamin D, which would lower the vitamin D at birth independent of any supplementation administered after delivery.[1,2] Infant feeding practice is a second plausible confounder: exclusively breastfed babies depend almost entirely on supplemental drops for vitamin D intake, since human milk itself is a poor source, while feeding pattern and maternal supplementation behavior have both been shown to differ between AGA and SGA infants.[9] Sunlight exposure is a third relevant factor, since cutaneous synthesis contributes meaningfully to infant vitamin D status even in the first months of life, and cultural practices around exposure to infant sun exposure, clothing, and time spent outdoors can vary between families regardless of gestational age category. Finally, although all infants in our cohort were prescribed the same 400 IU/day regimen, we did not formally verify adherence; unverified or partial adherence is a recognized source of variability in supplementation studies,

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as illustrated by recent cohort data in which fewer than half of mothers reported consistent use of prescribed vitamin D supplements despite counselling.[8] Because these factors were not systematically measured in our study, we cannot determine the extent to which each contributed to the AGA-SGA difference we observed, and this remains an important limitation.

Several additional limitations deserve consideration. This was a single-center observational study with a relatively small sample size and a follow-up period limited to three months. Beyond the factors discussed above, we did not assess biochemical markers of bone metabolism and seasonal variation in sunlight exposure in the enrolment months was not analyzed separately. Furthermore, our study was not designed to compare different vitamin D supplementation regimens or evaluate dose-response relationships. Therefore, our findings should not be interpreted as evidence that higher doses of vitamin D are required for infants with SGA.

However, to our knowledge this prospective comparison of serial vitamin D status between term AGA and SGA infants receiving identical routine supplementation is among the first of its kind from an Indian tertiary care setting, and the persistence of lower vitamin D concentrations among SGA infants despite routine supplementation raises an important clinical question that deserves further investigation. Well-designed multicenter prospective studies with larger sample sizes, longer follow-up, systematic assessment of maternal vitamin D status, infant feeding practices, sunlight exposure, and supplementation adherence, together with randomized evaluation of alternative supplementation strategies, are needed to determine whether these differences have long-term clinical significance and whether current recommendations are equally appropriate for all term infants.

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Declarations

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Author contributions

Conceptualization, B.C. and A.F.Z.; Methodology, B.C., A.F.Z. and V.V.M.; Software, B.C.; Validation, B.C. and S.S.; Formal Analysis, A.F.Z. and K.A.A.; Investigation, B.C., S.S. and A.F.Z.; Resources, A.F.Z.; Data Curation, A.F.Z., and V.V.M.; Writing – Original Draft Preparation, B.C. and A.F.Z..; Writing –

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Conflicts of interest

The authors declare no competing interests.

Data availability

The data sets generated and/or analyzed during the current study are not publicly available because they contain individual-level infant clinical data, but they are available from the corresponding author on reasonable request and subject to institutional approval.

Ethics approval

The study was carried out according to the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the SRM Medical College Hospital and Research Center (SRMIEC-ST0724-5084). Written informed consent was obtained from parents or legal guardians before enrollment.

Use of AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT (Open AI) to assist with language refinement. After using these tools, the authors reviewed and edited all content as needed and assume full responsibility for the content of the published article.

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