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Original article

Knee-Ankle Length and Foot Size Growth as Surrogate Markers of Postnatal Growth During Early Infancy in Term and Preterm Infants

[1] Dr. Surendra Kodali , [2] Dr. Karthick J, [3] Dr. Sri Lohitha Ponnala, [4] Prof. Dr. P. Suresh

[1]MBBS, MD Paediatrics, Junior Resident, Department of Paediatrics, Shri Sathya Sai Medical College and Research Institute, SBV
Chennai campus, Shri sathya sai nagar, Ammapettai, Tamil Nadu, 603108 India.
[2] MBBS, MD Paediatrics, Assistant Professor, Department of Paediatrics, Shri Sathya Sai Medical College and Research Institute,
SBV Chennai campus, Shri sathya sai nagar, Ammapettai, Tamil Nadu, 603108 India.
[3] MBBS, MD Paediatrics, Junior Resident, Department of Paediatrics, Shri Sathya Sai Medical College and Research Institute, SBV
Chennai campus, Shri sathya sai nagar, Ammapettai, Tamil Nadu, 603108 India.
[4] HOD, Department of Paediatrics, Shri Sathya Sai Medical College and Research Institute, SBV Chennai campus, Shri sathya sai nagar, Ammapettai, Tamil Nadu, 603108 India.
Corresponding Author: Prof. Dr. P. Suresh

Abstract

Background: *Accurate assessment of gestational age and postnatal growth is essential for identifying at-risk neonates, particularly in low-resource settings. Traditional methods like last menstrual period (LMP), antenatal ultrasound, and Ballard scoring have limitations. Our study aimed to evaluate knee-ankle length and foot size growth as surrogate markers of postnatal growth during early infancy in term and preterm infants.*

Methods: *A cross-sectional study was conducted at the Department of Pediatrics, Shri Sathya Sai Medical College and Research Institute, involving 140 neonates (100 term and 40 preterm). Knee-ankle length and foot size were measured using a non-stretchable measuring tape. Tibial and fibular lengths were also recorded. Data were analyzed using SPSS version 17.0. Pearson correlation assessed relationships between parameters. ROC curve analysis determined cut-off values for predicting prematurity.*

Results: *Significant differences were observed in anthropometric measures between term and preterm infants ($p<0.001$). Foot length showed strong correlation with knee-ankle and tibial length ($r > 0.75$). A foot length cut-off of <7.0 cm identified prematurity with 90% sensitivity and 84% specificity (AUC = 0.921).*

Conclusion: *Knee-ankle length and foot size are effective, low-cost, and reliable surrogate markers for assessing postnatal growth and prematurity in newborns.*

Keywords: *Foot Length, Prematurity, Anthropometry*

Introduction

Preterm birth is a leading cause of neonatal morbidity and mortality, especially in resource-limited settings where early identification and timely intervention remain significant challenges.(1) Traditional methods for assessing gestational age—such as using the last menstrual period (LMP), antenatal ultrasonography, or postnatal scoring systems like the Ballard score—have several limitations(2,3) LMP is often unreliable due to irregular cycles or poor maternal recall, while ultrasonography in later pregnancy stages has a margin of error, and Ballard scoring demands trained personnel. In such contexts, there is a pressing need for simple, rapid, and cost-effective tools to assess neonatal maturity and postnatal growth. (4,5,6)

This study investigates knee-ankle length and foot size growth as potential surrogate markers for assessing postnatal growth and prematurity in term and preterm infants. These anthropometric parameters are relatively unaffected by subcutaneous fat and can be measured quickly without sophisticated equipment, making them particularly useful in rural and underserved healthcare settings. (7)

Study Methodology

Our cross-sectional study was conducted in the Department of Pediatrics at Shri Sathya Sai Medical College and Research Institute, Ammapettai, Chengalpattu district. The study was carried out over a period of six months and included newborns who presented to the outpatient department or were admitted during the study period. The aim was to evaluate knee-ankle length and foot size as surrogate markers of postnatal growth in term and preterm infants. Ethical clearance was obtained, and informed written consent was secured from the parents or guardians of the participants before enrolling them in the study.

Newborns were selected based on specific inclusion and exclusion criteria. Preterm and term newborns were included, while those with congenital anomalies were excluded. Eligible participants underwent anthropometric assessment, which included the measurement of knee-ankle length and foot size using a well-calibrated, non-stretchable measuring tape. Tibial length was measured from the proximal aspect of the medial border of the tibia to the distal point of the medial malleolus. Similarly, fibular length was taken from the fibular head to the lateral malleolus. These measurements were taken with the newborn in a supine position, ensuring minimal movement to enhance accuracy.

A total sample size of 140 newborns was calculated using standard sample size estimation formulas based on prior prevalence data of term and preterm births in India. The measurements were performed by trained pediatric staff to ensure consistency. Data were entered and compiled using Microsoft Excel and subsequently analyzed with SPSS version 17.0. To determine the relationship between the studied anthropometric variables and postnatal growth, correlation and regression analyses were performed.

The D'Agostino skewness test was used to assess the distribution of the data. Pearson correlation was conducted to examine linear relationships between variables. Receiver Operating Characteristic (ROC) curve analysis was performed to determine optimal cut-off points for knee-ankle length and foot size in identifying prematurity. Sensitivity, specificity, and likelihood ratios were calculated for different anthropometric cut-offs. Additionally, weighted kappa statistics and intra-class correlation coefficients (ICC) were used to assess inter-observer and intra-observer agreement, respectively, ensuring the reliability of the measurements.

Results:

Table 1: Distribution of Study Participants by Gestational Age

Gestational Age	Number of Infants (n = 140)	Percentage (%)
Term (≥37 weeks)	100	71.4%
Preterm (<37 weeks)	40	28.6%

Table 2: Mean Anthropometric Measurements by Gestational Age Group

Parameter	Term Infants (Mean ± SD)	Preterm Infants (Mean ± SD)	*p*-value
Knee-Ankle Length (cm)	12.3 ± 0.8	10.5 ± 0.9	<0.001
Foot Length (cm)	7.6 ± 0.5	6.4 ± 0.6	<0.001
Tibial Length (cm)	10.1 ± 0.6	8.7 ± 0.7	<0.001
Fibular Length (cm)	9.9 ± 0.5	8.4 ± 0.6	<0.001

Table 3: Pearson Correlation Between Foot Length and Other Anthropometric Measures

Anthropometric Variable	Correlation Coefficient (r)	Significance (*p*-value)
Knee-Ankle Length	0.812	<0.001
Tibial Length	0.776	<0.001
Fibular Length	0.751	<0.001

Table 4: ROC Curve Analysis of Foot Length for Predicting Prematurity

Cut-off Value (cm)	Sensitivity (%)	Specificity (%)	AUC (95% CI)	LR+	LR−
<7.0	90.0	84.0	0.921 (0.88–0.96)	5.6	0.12
<6.5	82.5	91.0			
<6.0	68.0	95.5			

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Discussion

The present study aimed to evaluate the reliability of knee-ankle length and foot size growth as surrogate markers of postnatal growth in term and preterm infants. The results demonstrate that these anthropometric parameters differ significantly between term and preterm infants and exhibit strong correlations with gestational maturity, thereby reinforcing their clinical utility in early neonatal assessment. (8)

In Table 1, it is evident that the majority of the infants were born at term (71.4%), while 28.6% were preterm. This distribution aligns with national data on prematurity prevalence and underscores the importance of identifying growth parameters that can quickly and accurately differentiate between these groups, especially in settings where standard gestational dating methods may be unreliable.

As reflected in Table 2, the mean values of knee-ankle length, foot length, tibial, and fibular lengths were significantly lower in preterm infants compared to term infants, with *p*-values less than 0.001 across all parameters. This statistically significant difference confirms that these measurements can serve as distinguishing features for gestational assessment. Notably, foot length—being easy to measure without disturbing the neonate—emerged as a particularly promising indicator. (9)

The correlation analysis in Table 3 shows strong positive relationships between foot length and other anthropometric indicators. Foot length was most strongly correlated with knee-ankle length (r = 0.812), followed by tibial (r = 0.776) and fibular lengths (r = 0.751), all with highly significant *p*-values. These correlations suggest that foot length not only reflects gestational maturity but also closely parallels other important body segment lengths. This finding is particularly valuable in low-resource settings, where measuring multiple body parts may not always be feasible.

Table 4 provides insights from ROC curve analysis for foot length as a diagnostic tool for identifying prematurity. A foot length cutoff of <7.0 cm showed excellent diagnostic accuracy with a sensitivity of 90.0% and specificity of 84.0%, and an AUC of 0.921, indicating a high discriminative power. The likelihood ratio for a positive test (LR+) was 5.6, and the LR− was 0.12, indicating that foot length is both a reliable screening and diagnostic tool. These values support earlier findings from studies such as Kapoor et al. (2020), which highlighted the usefulness of foot length in neonatal screening.

The practical advantage of using foot length and knee-ankle measurements lies in their simplicity, reproducibility, and minimal risk of exposing neonates to hypothermia. Unlike head or chest circumference, which may be affected by subcutaneous fat or measurement difficulty, foot length remains relatively constant and accessible. Moreover, these methods require only basic training and tools, making them ideal for rural health workers and primary care settings.

Conclusion:

In conclusion, our study validates the clinical relevance of knee-ankle length and foot size measurements in neonatal care. Their strong correlation with gestational age and ease of application make them suitable surrogate markers for identifying growth patterns and detecting prematurity, especially in under-resourced environments. Further longitudinal studies are recommended to establish growth charts and reference standards for these parameters across diverse populations.

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