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Comparative assessment of the accuracy of anthropometry and can score to evaluate fetal malnutrition in preterm neonates

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Abstract

Background: Fetal malnutrition may occur in preterm neonates despite appropriate weight for gestational age and may not be adequately identified by conventional anthropometric assessment alone.

The Clinical Assessment of Nutritional Status (CANS) score provides a simple clinical assessment of subcutaneous fat and muscle depletion, while the ponderal index (PI) evaluates neonatal body proportionality. This study compared the diagnostic performance of the CANS score and PI for identifying fetal malnutrition in preterm neonates.

Objectives: To compare the accuracy of CANS score and ponderal index in assessing fetal malnutrition among preterm neonates and to evaluate their relationship with neonatal anthropometric parameters and maternal/ peri natal risk factors.

Methods: A prospective observational study was conducted among 225 preterm neonates of 28 to 36+6 weeks' gestation at Karnataka Medical College and Research Institute, Hubballi, from March 2024 to December 2025. CANS scoring and anthropometric measurements were performed within 48 hours of birth. A CANS score <25 and PI <2.2 were considered indicative of fetal malnutrition. Weight-for-gestational-age classification was used as the reference standard. Diagnostic performance was assessed using sensitivity, specificity, predictive values, accuracy and ROC analysis.

Results: Among 225 neonates, 183 (81.3%) were AGA, 37 (16.4%) SGA and 5 (2.2%) LGA. CANS identified fetal malnutrition in 88 (39.1%), compared with 15 (6.7%) by PI. CANS demonstrated higher sensitivity than PI (89.2% vs. 5.4%) and higher negative predictive value (97.1% vs. 83.3%). PI showed greater specificity (93.1% vs. 72.3%) and slightly higher accuracy (78.7% vs. 75.1%). The AUC was 0.86 for CANS and 0.41 for PI. CANS score showed significant positive correlations with birth weight (r=0.623), length (r=0.398), head circumference (r=0.287) and chest circumference (r=0.268), all p<0.001.

Conclusion: CANS score demonstrated better sensitivity and discriminatory ability than ponderal index for identifying fetal malnutrition in preterm neonates when weight-for-gestational-age was used as the reference standard. CANS is a simple, bedside screening tool that can complement conventional anthropometric assessment.

Keywords: Fetal Malnutrition, Preterm Neonate, CANS Score, Ponderal Index, Anthropometry, Small for Gestational Age.

Introduction

Fetal malnutrition (FM) is a clinical condition resulting from inadequate accumulation of subcutaneous fat and muscle tissue during intrauterine life. It represents an abnormal nutritional state of the fetus and is distinct from small-for-gestational-age (SGA) status. An infant may be classified as SGA on the basis of birth weight but may not show clinical evidence of malnutrition, while an infant with an appropriate birth weight for gestational age may still have reduced subcutaneous fat and muscle mass. Thus, fetal malnutrition may occur across a broad range of birth weights and cannot be identified solely by conventional weight-for-gestational-age classification. [1]

Assessment of fetal nutritional status at birth is important because fetal malnutrition has been associated with increased neonatal morbidity and may have consequences for subsequent growth and development. Conventional neonatal assessment commonly relies on birth weight, length, head circumference and their relationship with gestational age. Although these parameters are useful for assessing fetal growth, they primarily describe body size and may not adequately reflect body composition or the degree of depletion of subcutaneous tissue. [1,2]

Weight-for-gestational-age classification is widely used to categories neonates as SGA, appropriate-for-gestational-age (AGA), or large-for-gestational-age (LGA). However, this approach is based on population-based growth standards and does not directly assess the amount of fat and muscle tissue present in an individual neonate. Therefore, additional clinical or anthropometric methods may be required to identify fetal malnutrition that is not apparent from birth weight alone. [1,3]

Anthropometric measurements such as birth weight, length, head circumference and chest circumference provide objective information about neonatal size. Proportionality indices, particularly the ponderal index (PI), have also been used to identify disproportionate fetal growth. The ponderal index is calculated from birth weight and length and may indicate relative thinness or wasting when the body weight is low in relation to length. It is therefore a potentially useful simple bedside measure of fetal nutritional status. [2,4]

The Clinical Assessment of Nutritional Status (CANS) score was developed by Metcoff as a clinical method for detecting fetal malnutrition at birth. Unlike weight-based classification, CANS evaluates physical evidence of depletion of subcutaneous fat and muscle tissue. The assessment consists of nine clinical signs involving the hair, cheeks, chin and neck, arms, legs, back, buttocks, chest and abdomen. Each parameter is scored from 1 to 4, producing a total score ranging from 9 to 36. A score below 25 is conventionally considered indicative of fetal malnutrition. [1,5]

The principal advantage of the CANS score is its simplicity. It can be performed at the bedside without sophisticated equipment and requires only a systematic clinical examination. Mehta et al. evaluated CANS in 637 newborns and demonstrated that CANS identified a proportion of neonates with fetal malnutrition that was not completely captured by conventional measures of intrauterine growth. They suggested that CANS may be useful as a simple clinical index for identifying fetal malnutrition. [5]

Rao et al. subsequently evaluated the suitability of Canscore in 372 newborns and demonstrated significant relationships between Canscore and neonatal anthropometric measurements, including weight, length and body mass index. Their findings supported the relationship between clinical evidence of nutritional depletion and conventional anthropometric characteristics, although they also proposed modified scoring thresholds. [6]

Other studies have demonstrated that CANS and anthropometric indices do not necessarily identify the same neonates as malnourished. Sankhyan et al., in a study of 529 term neonates, found that CANS identified fetal malnutrition in a proportion of infants who were classified as AGA, while some neonates classified as SGA were clinically well nourished. These findings further support the concept that fetal malnutrition and SGA are related but distinct entities.[7]

The comparison between CANS and anthropometric indices is particularly important in preterm neonates. Prematurity is associated with substantial variation in body composition according to gestational age, and the accumulation of subcutaneous fat increases during late gestation. Consequently, a clinical score based partly on the appearance and palpability of subcutaneous tissue may perform differently in early and late preterm infants compared with term neonates. [1,8]

Evidence from studies specifically involving preterm neonates remains limited and is not entirely consistent. Ezenwa and Ezeaka evaluated neonates between 28 and 36 completed weeks of gestation using body mass index, ponderal index and CANSCORE.

They reported fetal malnutrition in 40.0% using BMI, 34.3% using CANSCORE and 30.0% using PI. When BMI was used as the reference standard, PI demonstrated better sensitivity than CANSCORE. These findings indicate that the diagnostic performance of CANS may differ in preterm infants and that anthropometric indices may provide important complementary information. [8]

Similarly, comparative studies in term neonates have demonstrated that CANS, PI and other proportionality indices may identify different proportions of infants with fetal malnutrition. Ezenwa et al. reported that CANS identified 14.5% of term neonates as malnourished, while PI identified 10.3%, and concluded that CANS could be useful when combined with anthropometric assessment rather than being considered a replacement for anthropometry.[9]

Maternal and antenatal factors also contribute to impaired fetal growth and nutritional depletion. Hypertensive disorders of pregnancy, pre-eclampsia, placental insufficiency, premature rupture of membranes and multiple pregnancy may adversely affect fetal growth and nutrient delivery. In preterm neonates, Korkmaz et al. reported an important burden of fetal malnutrition and demonstrated associations with maternal and neonatal factors, highlighting the clinical importance of recognising fetal malnutrition in this population. [10]

Despite the availability of several methods, there is no universally accepted single gold standard for diagnosing fetal malnutrition. CANS evaluates clinical body composition, PI evaluates proportionality, and weight-for-gestational-age evaluates fetal size relative to gestational maturity. Comparison of these approaches may therefore provide useful information regarding their respective diagnostic characteristics.

The present study was undertaken to comparatively assess the accuracy of anthropometry and CANS score for evaluating fetal malnutrition among preterm neonates. Specifically, the study compared CANS score and ponderal index using weight – for - gestational-age classification as the reference standard and evaluated their sensitivity, specificity, predictive values, accuracy and discriminatory performance.

The study also assessed the relationship of CANS score and ponderal index with neonatal anthropometric parameters and maternal and perinatal risk factors.

Materials and Methods

Study Design and Setting

The present study was designed as a hospital-based prospective observational cross-sectional study conducted in the Neonatal Intensive Care Unit (NICU) and postnatal wards of Karnataka Medical College and Research Institute, Hubballi, Karnataka, India. The study aimed to evaluate the diagnostic performance of the Clinical Assessment of Nutritional Status (CANS) score and ponderal index in identifying fetal malnutrition among preterm neonates at birth, with weight-for-gestational age used as the reference standard.

The study was conducted over a period of 22 months, from March 2024 to December 2025. Eligible preterm neonates delivered at or admitted to the study centre during the study period were enrolled consecutively until the required sample size was achieved.

Study Population

The study population comprised live-born preterm neonates with a gestational age of 28 completed weeks to 36 weeks + 6 days, based on antenatal ultrasound-derived expected date of delivery (EDD), who were admitted to the NICU.

Inclusion Criteria

The following neonates were included:

- Singleton or multiple live-born preterm neonates.
- Gestational age between 28 completed weeks and 36 weeks + 6 days.
- Neonates admitted to the NICU of Karnataka Medical College and Research Institute, Hubballi.
- Parents or legal guardians willing to provide written informed consent.

Exclusion Criteria

Neonates were excluded if they had:

- Unknown or unreliable gestational age.

- Major congenital anomalies.
- Intrauterine death or stillbirth.
- Other conditions precluding reliable anthropometric or clinical nutritional assessment.

Mothers with significant pregnancy-related conditions such as gestational diabetes mellitus or cardiovascular disease were excluded according to the predefined study protocol.

Sampling Technique

A consecutive sampling technique was used. All eligible preterm neonates fulfilling the inclusion criteria during the study period were enrolled consecutively until the calculated sample size was attained.

Sample Size

The sample size was calculated based on the reported sensitivity of the CANS score for detection of fetal malnutrition. A sensitivity of 83.1% reported by Chelli et al. was considered for sample-size estimation.

The formula used was:

$$n = Z^2 \times Sn \times (1 - Sn) / (d^2 \times p)$$

Where:

- **Z** = Standard normal deviate at 99% confidence level = 2.58
- **Sn** = Expected sensitivity = 0.831
- **1 − Sn** = 0.169
- **d** = Desired absolute precision = 0.01
- **p** = Expected prevalence of fetal malnutrition among preterm neonates = 41.5%

Based on the above assumptions, the required sample size was calculated as 225 preterm neonates. Therefore, a total of 225 eligible preterm neonates were planned for inclusion in the study.

Study Variables and Parameters

The following parameters were recorded using a predesigned and pretested data collection proforma:

Maternal parameters

- Maternal age
- Antenatal care status
- Antenatal complications
- Maternal anaemia
- Pregnancy-induced hypertension
- Diabetes mellitus
- Other relevant maternal risk factors

Neonatal parameters

- Sex
- Gestational age
- Birth weight
- Birth length
- Head circumference
- Chest circumference
- Body mass index, where applicable
- Ponderal index
- Clinical Assessment of Nutritional Status (CANS) score
- Weight-for-gestational-age classification
- Clinical evidence of fetal malnutrition

Assessment of Gestational Age

Gestational age was primarily determined from the antenatal ultrasound scan and expected date of delivery (EDD). Where required, clinical assessment using the New Ballard Score was used to support assessment of gestational maturity.

Clinical Assessment of Nutritional Status

The Clinical Assessment of Nutritional Status (CANS) score, described by Metcoff et al., was used for clinical assessment of fetal malnutrition. The assessment was performed within 48 hours of birth by trained investigators using systematic clinical examination.

The CANS assessment evaluates nine superficial physical signs indicative of loss of subcutaneous tissue and muscle mass:

1. Hair
2. Cheeks
3. Chin and neck
4. Arms
5. Legs
6. Back
7. Buttocks
8. Chest
9. Abdomen

Each parameter was assigned a score from 1 to 4, depending on the degree of preservation or loss of subcutaneous tissue and muscle mass. A score of 4 represented the best nutritional status, whereas a score of 1 represented the most marked evidence of malnutrition.

The individual scores were summed to obtain the total CANS score, with a maximum possible score of 36. A CANS score <25 was considered indicative of fetal malnutrition.

Anthropometric Assessment

Anthropometric measurements were performed within 48 hours of birth using standardised techniques and calibrated instruments.

Birth Weight

Birth weight was measured with the neonate without clothing using a calibrated infant weighing scale. Weight was recorded to the nearest 10 g.

Based on the Fenton preterm growth chart, birth weight was classified according to gestational age:

- Small for gestational age (SGA): birth weight <10th percentile
- Appropriate for gestational age (AGA): birth weight between the 10th and 90th percentiles
- Large for gestational age (LGA): birth weight >90th percentile

Length

Recumbent length was measured using a standardised infantometer, with the neonate positioned appropriately according to standard anthropometric technique.

Head and Chest Circumference

Head circumference and chest circumference were measured using a non-stretchable measuring tape at standardised anatomical landmarks. Measurements were recorded in centimetres.

Ponderal Index

The ponderal index (PI) was calculated using the following formula:

Ponderal Index = [Birth weight (g) / Length^3 (cm)] × 100

A ponderal index <2.2 was considered suggestive of fetal malnutrition according to the predefined study criteria.

Data Collection Procedure

After initial stabilization following delivery, eligible neonates underwent clinical and anthropometric assessment within the first 48 hours of life. Maternal and antenatal details were obtained from the medical records and maternal interview wherever appropriate.

Anthropometric measurements were performed using calibrated instruments under standardized conditions. CANS scoring was performed through systematic head-to-toe examination by trained investigators. The neonates were assessed in a warm environment to minimize heat loss and measurement-related variability.

All observations were recorded contemporaneously in a predesigned and pretested proforma. The collected data were subsequently entered into a computerized database for statistical analysis.

Study Outcomes

Primary outcome

The primary outcome was the diagnostic accuracy of the CANS score in comparison with ponderal index and weight-for-gestational-age classification for identification of fetal malnutrition among preterm neonates.

Secondary outcome

The secondary outcome was to evaluate the association of maternal and antenatal risk factors with fetal malnutrition among preterm neonates.

Statistical Analysis

Data were entered into a computerised database and analysed using Statistical Package for the Social Sciences (SPSS) software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were summarised as frequencies and percentages.

The association between categorical variables was assessed using the Chi-square test or Fisher's exact test, as appropriate. Comparison of continuous variables between two groups was performed using the independent samples t-test. For comparison among three groups, namely SGA, AGA, and LGA, one-way analysis of variance (ANOVA) was used.

The relationship between continuous variables was assessed using Pearson's correlation coefficient where appropriate. Diagnostic performance of the CANS score and ponderal index was assessed using receiver operating characteristic (ROC) curve analysis, with weight-for-gestational-age classification serving as the reference standard.

Diagnostic parameters including sensitivity, specificity, positive predictive value, negative predictive value, accuracy, and area under the ROC curve (AUC) were calculated. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was commenced only after obtaining approval from the Institutional Ethics Committee of the concerned institution. Written informed consent was obtained from the parents or legal guardians of all participating neonates.

Patient confidentiality was maintained throughout the study, and data were used exclusively for research purposes. The study involved only routine clinical examination and anthropometric measurements, with no additional invasive procedures performed solely for research purposes. The study was conducted in accordance with accepted ethical principles for research involving human participants.

Results and Observations

A total of 225 preterm neonates fulfilling the predefined eligibility criteria were included in the study. The demographic, maternal, neonatal, anthropometric and nutritional parameters were analysed. The diagnostic performance of the Clinical Assessment of Nutritional Status (CANS) score and ponderal index was evaluated using weight-for-gestational-age classification as the reference standard.

Table 1: Sociodemographic, Maternal and Neonatal Characteristics of the Study Population (n = 225)

Variable	Category	n	%
Maternal age (years)	≤20	21	9.3
	21–25	111	49.3
	26–30	64	28.4
	31–35	16	7.1
	>35	13	5.8
Parity	Primigravida	109	48.4
	G2A1	21	9.3

	G2P1L1	39	17.3
	Others	56	24.9
Maternal risk factors	No risk factor	98	43.6
	Severe pre-eclampsia	41	18.2
	PPROM	20	8.9
	Gestational hypertension	9	4.0
	PROM	8	3.6
	Twin gestation	8	3.6
	Others	41	18.2
Gestational age (weeks)	<30	24	10.7
	30–32	69	30.7
	32–35	107	47.6
	>35	25	11.1
Mode of delivery	PTVD	126	56.0
	LSCS	97	43.1
	Other/assisted	2	0.9
Sex	Male	130	57.8
	Female	95	42.2
Indication for NICU admission	RDS	121	53.8
	Low birth weight	37	16.4
	TTNB	18	8.0
	Birth asphyxia	14	6.2
	VLBW	12	5.3
	Others	23	10.2

The mean maternal age was 25.79 ± 5.12 years, with almost half of the mothers (49.3%) belonging to the 21–25-year age group. Primigravida mothers constituted 48.4% of the study population. Maternal risk factors were present in 56.4% of pregnancies, with severe pre-eclampsia being the most frequently documented individual risk factor (18.2%). Most neonates were born between 32 and 35 weeks of gestation (47.6%). Vaginal delivery was more common than LSCS (56.0% vs. 43.1%). Male neonates constituted 57.8% of the study population. RDS was the commonest indication for NICU admission (53.8%).

Table 2: Distribution According to Weight-for-Gestational-Age Classification

Growth status	n	%
AGA	183	81.3
SGA	37	16.4
LGA	5	2.2
Total	225	100.0

The majority of neonates were appropriate for gestational age (AGA), accounting for 81.3% of the study population. SGA neonates constituted 16.4%, while LGA neonates represented only 2.2%.

Table 3: Distribution of Fetal Malnutrition According to Ponderal Index

Fetal malnutrition by ponderal index	N	%
Present (PI <2.2)	15	6.7
Absent (PI ≥2.2)	210	93.3
Total	225	100.0

Using a ponderal index cut-off of <2.2, fetal malnutrition was identified in 15 (6.7%) neonates, whereas 210 (93.3%) were classified as having no fetal malnutrition by this criterion.

Table 4: Distribution of Fetal Malnutrition According to CANS Score

Fetal malnutrition by CANS score	N	%
Present (CANS <25)	88	39.1
Absent (CANS ≥25)	137	60.9
Total	225	100.0

According to the CANS score, 88 (39.1%) neonates had evidence of fetal malnutrition, while 137 (60.9%) did not. Thus, the CANS score identified a substantially greater proportion of neonates with fetal malnutrition than the ponderal index.

Table 5: Descriptive Statistics of Maternal and Neonatal Parameters (n = 225)

Parameter	Mean ± SD
Maternal age (years)	25.79 ± 5.124
Maternal haemoglobin (g/dL)	10.426 ± 0.921
Age at examination (hours)	20.33 ± 9.085
Birth weight (kg)	1.620 ± 0.431
Length (cm)	38.480 ± 2.321
Head circumference (cm)	30.222 ± 2.035
Chest circumference (cm)	26.611 ± 2.120
CANS score	25.33 ± 3.406
Ponderal index	2.654 ± 0.448

The mean birth weight of the neonates was 1.62 ± 0.43 kg. The mean CANS score was 25.33 ± 3.41, while the mean ponderal index was 2.65 ± 0.45. The anthropometric measurements reflected the expected variation associated with the preterm study population.

Primary Outcome

Table 6: Diagnostic Performance of Ponderal Index and CANS Score Using Weight-for-Gestational-Age Classification as Reference Standard

Diagnostic parameter	Ponderal Index (%)	CANS Score (%)
Sensitivity	5.4	89.2
Specificity	93.1	72.3
Positive predictive value	13.3	38.8
Negative predictive value	83.3	97.1
Accuracy	78.7	75.1

The CANS score demonstrated markedly higher sensitivity (89.2%) compared with the ponderal index (5.4%). The CANS score also showed a higher negative predictive value (97.1% vs. 83.3%), indicating good ability to identify neonates unlikely to have fetal malnutrition according to the reference classification.

In contrast, the ponderal index demonstrated higher specificity (93.1%) and marginally higher overall accuracy (78.7%) compared with the CANS score (75.1%). Thus, the CANS score demonstrated superior sensitivity, whereas the ponderal index demonstrated greater specificity.

ROC Analysis

ROC curve analysis demonstrated an AUC of 0.86 for the CANS score, indicating good discriminatory ability for detection of fetal malnutrition. The ponderal index showed an AUC of 0.41, indicating poor discriminatory performance in comparison with the reference standard. Overall, the findings suggest that CANS score had better screening potential for identifying fetal malnutrition among preterm neonates.

Table 7: Correlation of CANS Score and Ponderal Index with Maternal and Neonatal Parameters

Variable	CANS score r	p-value	Ponderal index r	p-value
CANS score	1.000	—	0.295	<0.01
Maternal age	-0.099	0.139	0.004	0.956
Maternal haemoglobin	-0.017	0.803	-0.149	0.026
Age at examination	-0.130	0.052	-0.098	0.142
Birth weight	0.623	<0.001	0.405	<0.001
Length	0.398	<0.001	-0.167	0.012
Head circumference	0.287	<0.001	-0.079	0.236
Chest circumference	0.268	<0.001	-0.039	0.557

CANS score showed a strong positive correlation with birth weight (r = 0.623, p <0.001) and moderate positive correlations with length (r = 0.398), head circumference (r = 0.287), and chest circumference (r = 0.268), all statistically significant.

Ponderal index also demonstrated a significant positive correlation with birth weight (r = 0.405, p <0.001). A weak negative correlation was observed between maternal haemoglobin and ponderal index (r = −0.149, p = 0.026). Maternal age and age at examination were not significantly correlated with either CANS score or ponderal index.

Table 8: Comparison of Mean CANS Score and Ponderal Index According to Growth Status

Parameter	Growth status	N	Mean ± SD	p-value
CANS score	AGA	183	25.80 ± 2.862	<0.001
	SGA	37	21.86 ± 2.551	
	LGA	5	33.80 ± 2.683	
	Total	225	25.33 ± 3.406	
Ponderal index	AGA	183	2.613 ± 0.395	<0.001
	SGA	37	2.768 ± 0.531	
	LGA	5	3.324 ± 0.916	
	Total	225	2.654 ± 0.448	

There was a statistically significant difference in mean CANS score across AGA, SGA and LGA groups (p <0.001). SGA neonates had the lowest mean CANS score (21.86 ± 2.55), whereas LGA neonates had the highest score (33.80 ± 2.68).

The mean ponderal index also differed significantly across growth-status groups (p <0.001), with the highest value among LGA neonates. These findings demonstrate a significant relationship between growth classification and neonatal nutritional assessment parameters.

Table 9: Comparison of Fetal Malnutrition Identified by Different Assessment Methods

Assessment method	Malnutrition present, n (%)	Malnutrition absent, n (%)
CANS score <25	88 (39.1)	137 (60.9)
Ponderal index <2.2	15 (6.7)	210 (93.3)
SGA by weight-for-gestational age	37 (16.4)	188 (83.6)

The CANS score identified fetal malnutrition in 39.1% of neonates, compared with 6.7% identified by the ponderal index and 16.4% classified as SGA by weight-for-gestational-age. Thus, CANS assessment identified a substantially larger proportion of neonates with clinical evidence of fetal malnutrition.

Secondary Outcome

Table 10: Association Between Maternal Risk Factors and Fetal Malnutrition

Maternal risk factor	Malnutrition absent, n	Malnutrition present, n	Total	p-value
No risk factors	69	29	98	0.010
Hypertensive disorders	26	33	59	
PROM/PPROM	20	8	28	
Twin gestation	6	3	9	
Oligohydramnis	3	2	5	
Others	13	13	26	
Total	137	88	225	

Table 11: Association of Clinical and Perinatal Variables with Fetal Malnutrition

Variable	Category	Absent, n	Present, n	Total	p-value
Gestational age	<30 weeks	15	9	24	0.300
	30–32 weeks	39	30	69	
	32–35 weeks	71	36	107	
	>35 weeks	12	13	25	
Mode of delivery	LSCS	58	39	97	0.512
	PTVD	78	48	126	
	NVD/assisted	1	1	2	
LSCS indication	Not applicable	63	37	100	0.134
	Severe pre-eclampsia	21	17	38	
	PROM/PPROM	17	12	29	
	Previous LSCS	14	5	19	
	Breech	1	2	3	
	Others	21	15	36	
Sex	Female	57	38	95	0.815
	Male	80	50	130	

Admission indication	RDS	76	45	121	0.009
	Low birth weight	23	14	37	
	TTNB	15	3	18	
	Birth asphyxia	7	7	14	
	VLBW	5	7	12	
	Others	11	12	23	

Discussion

The present study compared the diagnostic performance of the Clinical Assessment of Nutritional Status (CANS) score and ponderal index (PI) for identifying fetal malnutrition among 225 preterm neonates. Weight-for-gestational-age classification was used as the reference standard. The principal findings were that CANS identified fetal malnutrition in 39.1% of neonates, whereas PI identified 6.7%. CANS demonstrated substantially higher sensitivity and negative predictive value, while PI demonstrated higher specificity. ROC analysis also showed better discriminatory performance for CANS than PI in the present study.

The study population consisted predominantly of AGA neonates, with 183 (81.3%) classified as AGA, 37 (16.4%) as SGA and 5 (2.2%) as LGA. In contrast, 88 (39.1%) neonates had a CANS score below 25. This difference is important because it demonstrates that clinical evidence of fetal nutritional depletion was present in a substantial proportion of neonates who were not classified as SGA. Metcoff emphasised that fetal malnutrition and SGA are not synonymous and that fetal malnutrition may occur at almost any birth weight.[1] This concept forms the basis for using clinical nutritional assessment in addition to conventional growth classification.

The present finding is comparable with the observations of Mehta et al., who evaluated 637 newborns and found that CANS classified approximately 40% as malnourished, whereas weight-for-age and ponderal index classified smaller proportions. Their study concluded that CANS could identify fetal malnutrition that may not be recognised by conventional methods.[5] However, the present study differs from their population because the current study was restricted to preterm neonates, whereas the earlier study included newborns more broadly.

Sankhyan et al. also demonstrated that CANS could identify fetal malnutrition among AGA neonates. In their study of 529 term newborns, 4% of AGA neonates were considered malnourished by CANS, while 42.9% of SGA neonates were found to be well nourished according to the CANS assessment.[7] These observations support the interpretation that birth weight classification and clinical nutritional status measure related but different aspects of fetal growth.

In the present study, the mean CANS score was 25.33 ± 3.41. There was a statistically significant difference in mean CANS score across AGA, SGA and LGA groups. SGA neonates had the lowest mean CANS score of 21.86 ± 2.55.

whereas LGA neonates had the highest mean score of 33.80 ± 2.68. AGA neonates had an intermediate mean score of 25.80 ± 2.86. This progressive pattern indicates that CANS score was significantly related to conventional growth classification.

The relationship between CANS and anthropometric characteristics was further demonstrated by correlation analysis. CANS score showed a strong positive correlation with birth weight ($r = 0.623$, $p < 0.001$). Significant positive correlations were also observed with length ($r = 0.398$, $p < 0.001$), head circumference ($r = 0.287$, $p < 0.001$) and chest circumference ($r = 0.268$, $p < 0.001$). These findings suggest that better preservation of subcutaneous tissue and muscle mass was associated with greater neonatal body size.

The findings are consistent with the study by Rao et al., who demonstrated significant relationships between CANSCORE and neonatal weight, length and BMI. Their findings indicated that increasing anthropometric retardation was associated with an increased prevalence of clinical evidence of fetal malnutrition.[6] Thus, although CANS is a clinical score, its relationship with objective anthropometric measurements supports its biological relevance.

The mean ponderal index in the present study was 2.654 ± 0.448. Using the predefined PI cut-off of <2.2, only 15 (6.7%) neonates were classified as having fetal malnutrition. This was considerably lower than the 39.1% identified using CANS. The difference suggests that CANS and PI may detect different aspects of fetal nutritional status.

The low prevalence identified by PI in the present study should not necessarily be interpreted as evidence that PI is clinically unimportant. PI is a measure of body proportionality and may be particularly useful for identifying neonates who are disproportionately thin for their length. However, it may not identify all neonates who demonstrate clinical depletion of subcutaneous fat and muscle tissue. In the present study, therefore, PI appeared to have greater specificity but substantially lower sensitivity than CANS.

The diagnostic analysis demonstrated a sensitivity of 89.2% for CANS compared with 5.4% for PI when weight-for-gestational-age classification was used as the reference standard. The difference was substantial and indicates that CANS was much more sensitive for identifying neonates classified as having fetal malnutrition according to the selected reference standard.

The negative predictive value was also higher for CANS than PI (97.1% versus 83.3%). This suggests that neonates with a CANS score ≥25 were unlikely to be classified as malnourished by the reference method. Therefore, within the present study population, CANS demonstrated characteristics favourable for screening.

However, the present findings must be interpreted in relation to the reference standard used. Weight-for-gestational-age primarily identifies fetal size rather than direct depletion of body fat and muscle. Because fetal malnutrition and SGA are not synonymous, using weight-for-gestational-age as the reference standard may underestimate or misclassify some cases of true fetal malnutrition.[1]

Consequently, the sensitivity and specificity reported in this study represent agreement with the selected reference classification rather than performance against an absolute gold standard.

This issue is particularly important when comparing the present results with the study by Ezenwa and Ezeaka. Their study specifically included preterm neonates between 28 and 36 completed weeks and evaluated BMI, PI and CANSCORE.

They reported FM in 40.0%, 34.3% and 30.0% using BMI, CANSCORE and PI, respectively. When BMI was used as the reference, PI had better sensitivity than CANSCORE.[8] The difference from the present findings is likely related, at least in part, to the different reference standard. In the present study, weight-for-gestational-age was used as the reference, whereas BMI was used as the standard in the Ezenwa and Ezeaka study.

The present study therefore does not establish that CANS is inherently superior to PI in all preterm neonates. Rather, it demonstrates that CANS performed better than PI when weight-for-gestational-age classification was used as the reference standard in this particular study population. This distinction is important and strengthens the scientific interpretation of the findings.

The ROC findings were consistent with the diagnostic results. The AUC for CANS was 0.86, indicating good discriminatory ability, whereas the PI AUC was 0.41, indicating poor discriminatory performance against the selected reference classification. Thus, in the present cohort, CANS provided better discrimination between neonates classified according to the reference standard.

The higher specificity of PI compared with CANS is also noteworthy. PI showed a specificity of 93.1%, whereas CANS had a specificity of 72.3%. This means that although PI missed many neonates identified by the reference classification, those classified as malnourished by PI were relatively more likely to belong to the reference-defined group.

This pattern is consistent with the general principle that a highly specific measure may be more useful for confirmation, whereas a highly sensitive measure may be more useful for screening.

The correlation analysis showed that PI had a significant positive correlation with birth weight ($r = 0.405$, $p < 0.001$). A weak negative correlation was observed between maternal haemoglobin and PI ($r = -0.149$, $p = 0.026$). No significant correlations were observed between PI and head circumference or chest circumference. These findings demonstrate that PI reflects a different aspect of neonatal anthropometry compared with CANS.

The mean PI also differed significantly among AGA, SGA and LGA neonates. The highest mean PI was observed among LGA neonates, while the lowest mean PI was observed among AGA neonates in the present dataset. The statistically significant difference suggests that proportionality varied according to growth classification, although PI alone did not identify fetal malnutrition in as many neonates as CANS.

The significant association between maternal risk factors and fetal malnutrition observed in the present study is clinically relevant. Maternal risk factors were present in 56.4% of pregnancies, and hypertensive disorders represented an important proportion. Maternal hypertension and pre-eclampsia can impair uteroplacental perfusion and fetal nutrient delivery and are therefore biologically plausible contributors to fetal growth restriction and nutritional depletion. Korkmaz et al. reported a high burden of fetal malnutrition among preterm infants and identified maternal hypertensive disorders among important associated factors. [10]

In the present study, gestational age was not significantly associated with fetal malnutrition ($p = 0.300$). This finding should be interpreted cautiously because all participants were preterm and the study population was distributed within a relatively restricted gestational-age range. In addition, fetal malnutrition reflects nutritional depletion rather than gestational maturity alone.

Similarly, mode of delivery and sex were not significantly associated with fetal malnutrition. These findings suggest that the nutritional status identified by CANS was not substantially influenced by whether delivery occurred by LSCS or vaginally or by neonatal sex in this cohort.

The indication for NICU admission showed a statistically significant association with fetal malnutrition ($p = 0.009$). Respiratory distress syndrome was the most common admission indication, accounting for 53.8% of neonates. However, this association should be interpreted with caution because admission diagnoses in preterm neonates are strongly influenced by gestational age, birth weight and other clinical factors that may themselves be related to fetal nutritional status.

An important strength of the present study is that both a clinical nutritional assessment and an anthropometric proportionality measure were evaluated within the same preterm population.

The sample included 225 neonates, and assessment was performed within the first 48 hours after birth using standardised clinical and anthropometric procedures. Diagnostic performance was assessed using sensitivity, specificity, predictive values, accuracy and ROC analysis, allowing a more comprehensive comparison of the two approaches.

The study also has limitations. First, weight-for-gestational-age was selected as the reference standard, although it is not an independent gold standard for fetal malnutrition. Second, CANS contains a subjective clinical component and may be influenced by examiner experience.

Appropriate training and standardisation are therefore necessary to improve reproducibility. Third, the study was conducted at a single centre, which may limit generalisation to other neonatal populations. Finally, the observational nature of the study prevents determination of causal relationships between maternal risk factors and fetal malnutrition.

Despite these limitations, the findings demonstrate that clinical and anthropometric methods provide complementary information regarding fetal nutritional status. CANS identified substantially more neonates with fetal malnutrition than PI and demonstrated higher sensitivity and better ROC discrimination against the selected reference standard. PI, on the other hand, demonstrated higher specificity. Therefore, CANS may be useful as a screening tool, while PI and weight-for-gestational-age can provide complementary objective information.

Conclusion

CANS score identify a substantially higher proportion of fetal malnutrition than ponderal index among preterm neonates. It demonstrated higher sensitivity (89.2%), negative predictive value (97.1%), and better discriminatory ability (AUC 0.86), whereas ponderal index showed higher specificity (93.1%). CANS score was significantly correlated with birth weight and other anthropometric parameters.

Thus, CANS is a useful bedside screening tool for detecting fetal malnutrition in preterm neonates and may complement conventional anthropometric assessment.

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