RESEARCH PAPER

A Comparative Study of Thigh Circumference With Other Antropometric Measurements as a Measure of Low Birth Weight

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ABSTRACT

Introduction: Low birth weight (LBW) remains a major public health concern and is associated with increased neonatal morbidity and mortality. In resource-limited settings, simple anthropometric measurements may serve as useful surrogate markers for identifying LBW neonates when weighing facilities are unavailable. Thigh circumference has emerged as a promising indicator because of its simplicity and strong correlation with birth weight. The present study aimed to compare thigh circumference with other anthropometric measurements as a predictor of low birth weight and to evaluate its sensitivity, specificity, and predictive validity among newborns.

Materials and Methods: This hospital-based observational study was conducted at Adichunchanagiri Institute of Medical Sciences from May 2024 to December 2025 among 500 live-born neonates. Anthropometric measurements including thigh circumference, chest circumference, mid-upper arm circumference (MUAC), calf circumference, and head circumference were recorded within 24–48 hours of birth using standardized techniques. Correlation analysis and Receiver Operating Characteristic (ROC) curve analysis were performed to evaluate the diagnostic performance of anthropometric parameters in detecting LBW neonates.

Results: Among 500 neonates, 12 (2.4%) were low birth weight. The mean thigh circumference was 16.71 ± 1.84 cm. Thigh circumference demonstrated a strong positive correlation with birth weight ($r = 0.947$, $p < 0.001$), as well as with MUAC ($r = 0.987$), calf circumference ($r = 0.986$), and chest circumference ($r = 0.978$). LBW neonates had significantly lower thigh circumference compared to non-LBW neonates (12.17 ± 0.35 cm vs 16.74 ± 1.81 cm; $p < 0.001$). ROC analysis showed excellent diagnostic performance of thigh circumference with an AUC of 0.999. A cut-off value of <12.45 cm demonstrated 99.8% sensitivity and 100% specificity for identifying LBW neonates.

Conclusion: Thigh circumference is a simple, reliable, and highly accurate anthropometric parameter for identifying low birth weight neonates. Its excellent sensitivity, specificity, and ease of measurement make it a practical screening tool, particularly in peripheral and resource-limited healthcare settings.

Keywords: Low birth weight; Thigh circumference; Anthropometry; Neonates; Receiver operating characteristic curve

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INTRODUCTION

Low birth weight (LBW), defined by the World Health Organization as a birth weight of less than 2500 g irrespective of gestational age, remains a major global public health concern [1]. LBW is commonly associated with prematurity and intrauterine growth restriction (IUGR), both of which contribute significantly to neonatal morbidity and mortality [2]. Globally, nearly 15–20% of all births are estimated to be low birth weight, with the highest burden reported in South Asia [3]. Infants born with LBW are at increased risk of infections, impaired growth and development, long-term neurological deficits, and higher infant mortality rates [4]. Birth weight is also considered an important indicator of maternal nutritional status, socioeconomic conditions, quality of antenatal care, and overall fetal wellbeing [5].

Anthropometry is a simple, non-invasive, inexpensive, and practical method for assessing body size and proportions, particularly in neonates [6]. In resource-limited settings where calibrated weighing scales may not always be available, alternative anthropometric measurements can serve as surrogate markers for identifying LBW infants [7]. Measurements such as chest circumference, mid-upper arm circumference (MUAC), calf circumference, and head circumference have been studied extensively for their association with birth weight [8]. These methods are especially valuable in rural and peripheral healthcare settings because they are easy to perform, reproducible, and require minimal training and equipment.

Among the various anthropometric parameters, thigh circumference has emerged as one of the most reliable indicators for predicting birth weight [9]. Previous studies have demonstrated a strong positive correlation between thigh circumference and birth weight, with reported correlation coefficients ranging from 0.776 to 0.95 [10]. Several investigators have proposed different cutoff values for identifying LBW neonates using thigh circumference measurements [9]. In addition, recent studies have shown high sensitivity, specificity, and area under the receiver operating characteristic (ROC) curve for thigh circumference in detecting LBW infants, indicating excellent diagnostic performance [11]. Compared with other anthropometric parameters, thigh circumference offers the advantage of simplicity, rapid assessment, and minimal interobserver variability, making it particularly suitable for community-based neonatal screening programs [11].

Despite encouraging evidence from previous studies, variations in anthropometric measurements and cutoff values across different populations necessitate region-specific evaluation to establish reliable standards for local neonatal populations. Furthermore, limited data are available comparing thigh circumference with other anthropometric indicators such as chest circumference, MUAC, calf circumference, and head circumference in the detection of low-birth-weight neonates. Therefore, the present study was undertaken to compare thigh circumference with other anthropometric measurements as a predictor of low birth weight and to evaluate its sensitivity, specificity, and predictive validity among newborns delivered at a tertiary care center.

MATERIALS AND METHODS

This hospital-based observational study was conducted in the Department of Pediatrics at Adichunchanagiri Institute of Medical Sciences from May 2024 to December 2025. The study population comprised live-born neonates delivered at the institute during the study period. All live-born normal neonates, irrespective of gestational age, were eligible for inclusion. Anthropometric measurements were performed within 24–48 hours of birth to minimize the influence of early postnatal physiological weight loss. Neonates from multiple pregnancies, newborns with gross congenital anomalies or malformations, and infants born to mothers with conditions known to affect fetal growth such as hypertensive disorders of pregnancy, gestational diabetes mellitus, chronic infections, or systemic illnesses were excluded. Newborns with uncertain gestational age, defined as a discrepancy greater than two weeks between obstetric and clinical gestational age assessment, were also excluded from the study.

The sample size was calculated based on the findings of Takasandhe et al., considering a standard deviation (SD) of 1, combined Z value of 2.76, and allowable error (d) of 0.123, the estimated sample size was 500 newborns. A purposive sampling technique was employed, and all eligible neonates meeting the inclusion criteria during the study period were enrolled consecutively.

Anthropometric measurements were obtained by the principal investigator using standardized techniques to minimize interpersonal variation. All measurements were performed with the newborn in a supine position. Birth weight was measured using a calibrated neonatal weighing scale. Thigh circumference, chest circumference, mid-upper arm circumference (MUAC), calf circumference, and head circumference were measured using a flexible non-stretchable measuring tape and recorded to the nearest 0.1 cm. Thigh circumference was measured at the midpoint of the thigh, chest circumference at the level of the nipples during quiet respiration, MUAC at the midpoint between the acromion and olecranon process, calf circumference at the maximum circumference of the calf, and head circumference at the maximum occipitofrontal diameter.

All collected data were entered into Microsoft Excel and analyzed using SPSS Statistics version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Karl Pearson's correlation coefficient was used to determine the association between birth weight and various anthropometric measurements. Receiver Operating Characteristic (ROC) curve analysis was performed to assess the diagnostic accuracy of anthropometric parameters and to identify optimal cut-off values for detecting low birth weight neonates. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for each parameter. A p-value of <0.05 was considered statistically significant.

RESULTS

The majority of mothers belonged to the 25–29 years age group [188 (37.6%)], followed by 30–34 years [135 (27.0%)] and 20–24 years [127 (25.4%)]. Most participants were nulliparous [333 (66.6%)]. Nearly half of the deliveries occurred at full term between 38 and 39 weeks [241 (48.2%)], while 120 (24.0%) were late term. Vaginal delivery was the predominant mode of delivery [383 (76.6%)]. The sex distribution of newborns was almost equal, with 251 (50.2%) males and 249 (49.8%) females. Low birth weight was observed in 12 (2.4%) neonates. (Table 1)

Table 1. Maternal and Neonatal Baseline Characteristics

Variable	Category	n (%)
Maternal age (years)	≤19	42 (8.4)
	20–24	127 (25.4)
	25–29	188 (37.6)
	30–34	135 (27.0)
	≥35	8 (1.6)
Parity	0	333 (66.6)
	1	144 (28.8)
	2	22 (4.4)
	≥3	1 (0.2)
Gestational age	Preterm (33–36 weeks)	30 (6.0)
	Early term (37 weeks)	96 (19.2)
	Full term (38–39 weeks)	241 (48.2)
	Late term (40–41 weeks)	120 (24.0)
	Post-term (42 weeks)	13 (2.6)
Delivery type	Vaginal delivery	383 (76.6)
	Cesarean section	117 (23.4)
Sex of newborn	Male	251 (50.2)
	Female	249 (49.8)
Low birth weight status	LBW	12 (2.4)
	Non-LBW	488 (97.6)

The mean maternal pre-pregnancy weight was 58.43 ± 7.71 kg, while the average maternal weight gain during pregnancy was 11.56 ± 2.99 kg. Among neonatal anthropometric parameters, chest circumference demonstrated the highest mean value (30.73 ± 1.87 cm), followed by head circumference (33.46 ± 1.14 cm). The mean thigh circumference was 16.71 ± 1.84 cm. (Table 2)

Table 2. Maternal Weight and Neonatal Anthropometric Measurements

Variable	**Mean ± SD**
Maternal pre-pregnancy weight (kg)	58.43 ± 7.71
Maternal weight gain during pregnancy (kg)	11.56 ± 2.99
Thigh circumference (cm)	16.71 ± 1.84
Chest circumference (cm)	30.73 ± 1.87
Mid-upper arm circumference (MUAC) (cm)	10.18 ± 1.84
Calf circumference (cm)	11.42 ± 1.86
Head circumference (cm)	33.46 ± 1.14

Thigh circumference demonstrated a very strong positive correlation with birth weight ($r = 0.947$, $p < 0.001$). Strong correlations were also observed with MUAC ($r = 0.987$), calf circumference ($r = 0.986$), and chest circumference ($r = 0.978$). Head circumference showed a comparatively moderate correlation ($r = 0.470$), although statistically significant. These findings suggest that thigh circumference closely parallels other neonatal anthropometric parameters and may serve as a reliable surrogate marker for identifying low birth weight neonates. (Table 3)

Table 3. Correlation of Thigh Circumference with Birth Weight and Other Anthropometric Measurements

Variable	**Pearson correlation coefficient (r)**	**p-value**
Birth weight (kg)	0.947	<0.001
Chest circumference (cm)	0.978	<0.001
MUAC (cm)	0.987	<0.001
Calf circumference (cm)	0.986	<0.001
Head circumference (cm)	0.470	<0.001

Statistically significant differences were observed between LBW and non-LBW neonates for thigh circumference, chest circumference, MUAC, and calf circumference ($p < 0.001$ for all). LBW neonates had markedly lower mean anthropometric measurements compared to non-LBW neonates. However, head circumference did not differ significantly between the two groups ($p = 0.172$). (Table 4)

Table 4. Comparison of Anthropometric Measurements According to Low Birth Weight Status

Variable	**LBW (n = 12) Mean ± SD**	**Non-LBW (n = 488) Mean ± SD**	**p-value**
Thigh circumference (cm)	12.17 ± 0.35	16.74 ± 1.81	<0.001
Chest circumference (cm)	25.20 ± 0.44	30.75 ± 1.85	<0.001
MUAC (cm)	8.47 ± 0.31	10.21 ± 1.81	<0.001
Calf circumference (cm)	10.33 ± 0.21	11.45 ± 1.83	<0.001
Head circumference	32.57 ± 1.03	33.47 ± 1.14	0.172

(cm)			

Mean thigh circumference progressively increased with advancing gestational age. Preterm neonates had the lowest mean thigh circumference (14.97 ± 1.37 cm), whereas post-term neonates demonstrated the highest mean value (18.35 ± 1.39 cm), indicating a positive relationship between gestational maturity and neonatal anthropometric growth. (Table 5)

Table 5. Mean Thigh Circumference According to Gestational Age

Gestational age group	Mean thigh circumference (cm) ± SD
Preterm (35–36 weeks)	14.97 ± 1.37
Early term (37 weeks)	16.42 ± 1.77
Full term (38–39 weeks)	16.52 ± 1.65
Late term (40–41 weeks)	17.54 ± 1.83
Post-term (42 weeks)	18.35 ± 1.39
Overall	16.71 ± 1.84

ROC analysis demonstrated excellent diagnostic performance of thigh circumference, MUAC, and calf circumference for identifying LBW neonates, each with an AUC of 0.999. Chest circumference also showed excellent discriminatory ability with an AUC of 0.995. In contrast, head circumference demonstrated only moderate predictive performance with an AUC of 0.736 and was not statistically significant. (Table 6)

Table 6. Receiver Operating Characteristic (ROC) Analysis of Anthropometric Measurements for Detection of Low Birth Weight

Variable	AUC	Standard error	p-value	95% CI
Thigh circumference (cm)	0.999	0.001	0.003	0.997–1.000
Chest circumference (cm)	0.995	0.003	0.003	0.988–1.000
MUAC (cm)	0.999	0.001	0.003	0.997–1.000
Calf circumference (cm)	0.999	0.001	0.003	0.996–1.000
Head circumference (cm)	0.736	0.130	0.159	0.480–0.991

Thigh circumference demonstrated near-perfect sensitivity (99.8%) and specificity (100%) at a cut-off value of <12.45 cm for detecting LBW neonates. Similar diagnostic performance was observed for MUAC and calf circumference. Chest circumference also showed excellent predictive ability, whereas head circumference demonstrated poor sensitivity despite maintaining high specificity. (Table 7)

Table 7. Optimal Cut-off Values of Anthropometric Measurements for Identification of Low Birth Weight

Parameter	Optimal cut-off	Sensitivity	Specificity
Thigh circumference	<12.45 cm	99.8%	100%
Chest circumference	<27.55 cm	99.2%	100%
MUAC	<8.85 cm	99.8%	100%
Calf circumference	<10.95 cm	99.8%	100%
Head circumference	<32.75 cm	40.6%	100%

DISCUSSION

Low birth weight remains an important determinant of neonatal morbidity and mortality, particularly in developing countries where access to advanced neonatal care and accurate weighing facilities may be limited. In the present study, the majority of neonates were delivered at full term, with 48.2% born between 38–39 weeks of gestation, indicating a predominantly healthy study population. The prevalence of LBW in our study was relatively low at 2.4%, which is considerably lower than that reported by Jyothi S and colleagues and Doddamani DR et al., both of whom observed an LBW prevalence of 52.4% [12,13]. Similarly, Srivastava R et al. reported a comparatively lower prevalence of 6.8%, while Huque F et al. documented LBW in 41% of neonates [14,15]. These differences may be attributed to variations in maternal nutritional status, socioeconomic conditions, antenatal care utilization, and regional demographic characteristics. The sex distribution in our study was nearly equal, similar to findings reported in several previous studies, suggesting the absence of significant sex-based sampling bias.

The anthropometric measurements observed in our study were generally higher compared to several previous studies, reflecting better overall neonatal growth and nutritional status. The mean thigh circumference in our study was 16.71 ± 1.84 cm, which was higher than values reported by Kokku PK et al. (15.9 cm), Srivastava R et al. (15.40 cm), and Dasgupta S et al. (14.66 cm) [14,16,17]. Similar trends were observed for MUAC and calf circumference measurements. In addition, our study demonstrated a strong positive correlation between thigh circumference and birth weight ($r = 0.947$, $p < 0.001$), which was higher than the correlations reported by Doddamani DR et al. ($r = 0.776$) and Huque F et al. ($r = 0.845$) [13,15]. Strong correlations were also observed between thigh circumference and MUAC, chest circumference, and calf circumference, emphasizing that thigh circumference closely reflects overall neonatal anthropometric growth. Similar observations were reported by Vinitha G et al. and Yigzaw HK et al., who also demonstrated significant positive associations between thigh circumference, birth weight, and gestational age [18,19].

An important finding of the present study was the progressive increase in thigh circumference with advancing gestational age. Mean thigh circumference increased from 14.97 cm in preterm neonates to 18.35 cm in post-term neonates, indicating that thigh circumference reflects fetal growth and maturity. Comparable findings were reported by Yigzaw HK et al., who demonstrated a strong association between mid-thigh circumference and gestational age, with excellent diagnostic performance for identifying preterm neonates (AUC = 0.960) [19]. Similarly, Hirudayakanth K et al. reported a significant linear relationship between thigh circumference, gestational age, and birth weight [20]. These observations support the concept that thigh circumference may serve not only as a surrogate marker for birth weight but also as an indicator of fetal maturity and intrauterine growth.

The present study further demonstrated that LBW neonates had significantly lower anthropometric measurements compared to normal birth weight infants. The mean thigh circumference among LBW neonates was 12.17 cm compared to 16.74 cm among non-LBW neonates ($p < 0.001$). ROC analysis revealed excellent diagnostic performance of thigh circumference, MUAC, and calf circumference, each with an AUC of 0.999. A thigh circumference cut-off value of <12.45 cm demonstrated 99.8% sensitivity and 100% specificity for identifying LBW neonates. These findings are consistent with studies by Jyothi S et al., who reported a sensitivity of 97.5% and specificity of 80.9% at a cut-off of 15 cm corresponding to a birth weight of 2.5 kg [12]. Vinitha G et al. also demonstrated high sensitivity and specificity of thigh circumference in both male and female neonates, while Yigzaw HK et al. reported progressive increases in thigh circumference across different birth weight categories [19]. Although chest circumference showed comparable predictive ability in some studies, thigh circumference offers the advantage of easy accessibility, rapid measurement, and minimal interference during neonatal examination. These findings collectively support the utility of thigh circumference as a simple, reliable, and cost-effective anthropometric screening tool for early identification of low-birth-weight neonates, particularly in resource-limited healthcare settings.

CONCLUSION

The present study demonstrated that thigh circumference is a simple, reliable, and highly accurate anthropometric parameter for identifying low birth weight neonates. Thigh circumference showed a strong positive correlation with birth weight and other anthropometric measurements, along with excellent diagnostic performance on ROC analysis. Among the evaluated parameters, thigh circumference performed comparably to other established anthropometric indicators such as MUAC and calf circumference, while offering the advantages of ease of measurement, rapid assessment, and minimal equipment requirement. The progressive increase in thigh circumference with advancing gestational age further supports its usefulness as an indicator of fetal growth and maturity. Therefore, thigh circumference can serve as an effective screening tool for early identification of low-birth-weight neonates, particularly in peripheral and resource-limited healthcare settings where access to accurate weighing facilities may be limited.

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