



Impact of Feeding Time and Gastroesophageal Reflux Disease (GERD) in Children with Cerebral Palsy on Nutritional Status

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ABSTRACT:

Background: Children with cerebral palsy (CP) frequently experience feeding difficulties and gastroesophageal reflux disease (GERD), both of which contribute to poor nutritional status. The timing of feeding may influence the severity of GERD and associated nutritional outcomes, but this relationship remains underexplored.

Objective: To assess the feeding time and the severity of GERD in children with CP, and to evaluate the relationship between feeding time, GERD severity, and the nutritional status in this population.

Methods: This was a prospective observational study conducted in the outpatient department and/or inpatient wards of the Department of Paediatrics over a period of 3 months (January to March 2025).

Results: In this study, 68 children with CP were equally divided into three groups based on predominant feeding time: Morning (n=23), Midday (n=22), and Evening/Night feeders (n=23). The mean ages were comparable across groups (Morning: 6.9 ± 3.1 years, Midday: 7.0 ± 3.6 years, Evening/Night: 6.5 ± 3.4 years; $p=0.812$), with no significant differences in gender distribution, CP subtype, or feeding method. However, significant differences were noted in GERD severity and nutritional outcomes. Mild GERD was observed in 60.9% of Morning feeders and 54.5% of Midday feeders, but only in 26.1% of Evening/Night feeders. In contrast, moderate GERD was found in 56.5% and severe GERD in 17.4% of Evening/Night feeders, compared to much lower proportions in the other groups ($p=0.022$). Regarding nutritional status, the mean weight-for-age z-scores were -1.4 ± 0.9 for Morning feeders, -1.6 ± 1.0 for Midday feeders, and significantly lower at -2.1 ± 1.1 for Evening/Night feeders ($p=0.042$). Similarly, BMI-for-age z-scores were lowest in the Evening/Night group (-2.0 ± 1.2), compared to -1.1 ± 1.0 and -1.3 ± 1.1 in the Morning and Midday groups, respectively ($p=0.030$). Univariate analysis revealed that evening/night feeding was associated with higher odds of moderate-to-severe GERD (OR: 2.8; 95% CI: 1.2–6.5; $p=0.011$), and multivariate analysis confirmed it as an independent predictor of both GERD severity (adjusted OR: 2.5; $p=0.032$) and lower BMI-for-age ($\beta = -0.7$; $p=0.02$). Other factors, including CP subtype, gender, and feeding method, did not significantly affect GERD severity or nutritional status.



Conclusion: Predominant evening or night-time feeding in children with CP is associated with increased GERD severity and poorer nutritional status. Optimizing feeding schedules may serve as a simple and effective strategy to improve gastrointestinal and nutritional outcomes in this population.

Introduction

Cerebral palsy (CP) is a group of permanent disorders affecting the development of movement and posture, causing activity limitations, and is attributed to non-progressive disturbances in the developing fetal or infant brain.(1) Globally, CP remains the most common motor disability in childhood, with an estimated prevalence of 2 to 3 per 1,000 live births.(2) Beyond motor dysfunction, children with CP often face a myriad of associated impairments, including feeding difficulties, gastroesophageal reflux disease (GERD), and growth and nutritional deficits, all of which can significantly impact quality of life and long-term health outcomes.(3)

Feeding problems are the most frequent challenges encountered in children with CP, affecting up to 85% of this population.(4) These difficulties range from oromotor dysfunction and swallowing incoordination to gastrointestinal dysmotility, each of which can predispose to GERD. GERD, characterized by the retrograde flow of gastric contents into the esophagus, is highly prevalent in children with CP, with estimates suggesting that up to 75% of severely affected children experience significant reflux symptoms.(5) The pathophysiology of GERD in CP is multifactorial, involving impaired lower esophageal sphincter function, delayed gastric emptying, scoliosis-related postural issues, and neurological impairments that hinder protective reflexes.(6)

Malnutrition is another major concern in children with CP, resulting from inadequate energy intake, increased energy expenditure, feeding inefficiency, and chronic gastrointestinal symptoms such as reflux, vomiting, and dysphagia.(7) Children with CP are particularly vulnerable to failure to thrive and poor growth, and malnutrition in this population is associated with increased morbidity, diminished immune function, and impaired cognitive development.(8) Emerging evidence suggests that GERD not only exacerbates feeding aversion and nutrient loss but also contributes to chronic undernutrition, highlighting the interconnected nature of feeding problems, reflux and nutritional status in CP.(9)

While the clinical burden of GERD and malnutrition in children with CP is well recognized, relatively little attention has been directed toward the role of feeding patterns, particularly the timing of food intake, in modulating these outcomes. Circadian physiology suggests that gastric motility and esophageal clearance vary throughout the day, with nocturnal periods being more susceptible to reflux events due to decreased swallowing frequency, prolonged supine positioning, and reduced esophageal peristalsis.(10) Feeding late in the evening or at night may thus amplify GERD severity and, by extension, adversely impact nutritional status. However, empirical data specifically exploring the relationship between feeding time, GERD severity, and nutritional outcomes in children with CP remain sparse.

Given these gaps in knowledge, the aim of the present study was to assess the feeding time and the severity of gastroesophageal reflux disease in children with cerebral palsy, and to evaluate the relationship between feeding time, GERD severity, and the nutritional status in this population.

Materials and Methods

This was a prospective observational study conducted in the outpatient department and/or inpatient wards of the Department of Paediatrics over a period of 3 months (January to March 2025). The research protocol was reviewed and approved by the Institutional Human Ethics Committee (IHEC) under proposal ID IHEC-I/3449/25 dated 20/01/2025, and informed consent was obtained from the parents or legal guardians of all participating children through a Participant Information Sheet (PIS) and consent form. Children aged between 1 and 18 years diagnosed with cerebral palsy (any subtype: spastic, dyskinetic, ataxic, or mixed) and with gastroesophageal reflux disease (GERD) confirmed by the Paediatric GERD Symptom Questionnaire (PGSQ) were included in the study. Participants were required to be on oral or enteral feeding. Children with significant medical conditions that could independently affect nutrition or GERD (such as congenital anomalies or severe cardiac disease) and those receiving medications



or interventions that could influence GERD symptoms (e.g., proton pump inhibitors) were excluded. Based on power analysis to detect meaningful differences with appropriate effect size and significance levels while accounting for potential attrition, the estimated sample size was 68 children.

Data collection involved recording baseline demographic details, clinical characteristics, and feeding practices. Predominant feeding time was operationally defined as the time of day when the child consumed the majority (>50%) of their daily caloric intake. Based on this, participants were equally divided into three groups: Morning feeders (predominant intake between 6:00 AM and 10:00 AM), Midday feeders (predominant intake between 11:00 AM and 3:00 PM), and Evening/Night feeders (predominant intake between 6:00 PM and 10:00 PM). GERD severity was assessed using the PGSQ and categorized as mild, moderate, or severe. Nutritional status was evaluated through anthropometric measurements, including weight, height, and body mass index (BMI), complemented by dietary intake assessments using a 24-hour dietary recall and a food frequency questionnaire.

Comparisons of GERD severity and nutritional parameters among the three feeding time groups were performed. Statistical analysis was conducted using appropriate tests; categorical variables were analysed using the Chi-square test or Fisher's exact test as applicable, and continuous variables were compared

using Analysis of Variance (ANOVA) or Kruskal-Wallis test depending on data distribution. Multivariable regression analysis was performed to adjust for potential confounders such as age, gender, type of cerebral palsy, and mode of feeding. A p-value of <0.05 was considered statistically significant.

Results

A total of 68 children with cerebral palsy were equally distributed into three groups based on their predominant feeding time: Morning group (n=23), Midday group (n=22), and Evening/Night group (n=23). The mean age across the groups was comparable, with no significant difference observed (Morning: 6.9 ± 3.1 years, Midday: 7.0 ± 3.6 years, Evening/Night: 6.5 ± 3.4 years; $p=0.812$). The gender distribution was also similar, with males comprising 56.5% in the Morning group, 59.1% in the Midday group, and 60.9% in the Evening/Night group ($p=0.942$). Regarding the type of cerebral palsy, spastic CP was the most common subtype across all groups (60.9%, 63.6%, and 56.5% respectively), followed by mixed, dyskinetic, and ataxic forms, with no statistically significant difference between groups ($p=0.895$). In terms of feeding method, the majority of children in all groups were on oral feeding (78.3% in Morning, 72.7% in Midday, and 69.6% in Evening/Night), while enteral feeding (nasogastric or gastrostomy) was required for 21.7%, 27.3%, and 30.4% respectively, again without significant difference ($p=0.772$).

Table 1: Baseline characteristics of the feeding groups

		Morning group N = 23	Midday group N = 22	Evening/Night group N = 23	P value
		n (%)	n (%)	n (%)	
Age (in years), Mean (SD)		6.9 (3.1)	7.0 (3.6)	6.5 (3.4)	0.812
Gender	Male	13 (56.5)	13 (59.1)	14 (60.9)	0.942
	Female	10 (43.5)	9 (40.9)	9 (39.1)	
Type of cerebral palsy	Spastic	14 (60.9)	14 (63.6)	13 (56.5)	0.895
	Dyskinetic	3 (13.0)	3 (13.6)	3 (13.0)	
	Ataxic	1 (4.3)	1 (4.5)	2 (8.7)	
	Mixed	5 (21.7)	4 (18.2)	5 (21.7)	
Feeding method	Oral	18 (78.3)	16 (72.7)	16 (69.6)	0.772
	Enteral	5 (21.7)	6 (27.3)	7 (30.4)	

*Statistically significant at $p<0.05$



SD, Standard deviation

The clinical characteristics, including GERD severity and nutritional status, differed significantly among the three feeding groups. A higher proportion of children in the Morning and Midday groups had mild GERD (60.9% and 54.5%, respectively) compared to only 26.1% in the Evening/Night group. Conversely, moderate and severe GERD were more prevalent among Evening/Night feeders (56.5% moderate and 17.4% severe), with a statistically significant difference in GERD severity across the groups ($p=0.022$). Regarding nutritional status, the Evening/Night group had lower mean weight-

for-age z-scores (-2.1 ± 1.1) compared to the Morning (-1.4 ± 0.9) and Midday (-1.6 ± 1.0) groups, with the difference being statistically significant ($p=0.042$). Similarly, BMI-for-age z-scores were lowest in the Evening/Night group (-2.0 ± 1.2), compared to the Morning (-1.1 ± 1.0) and Midday (-1.3 ± 1.1) groups, also reaching statistical significance ($p=0.030$). These findings suggest that children predominantly fed during the evening or night exhibited more severe GERD symptoms and poorer nutritional indicators.

Table 2: Comparison of feeding groups by GERD severity and nutritional status

		Morning group N = 23	Midday group N = 22	Evening/Night group N = 23	P value
		n (%)	n (%)	n (%)	
GERD severity	Mild	14 (60.9)	12 (54.5)	6 (26.1)	0.022*
	Moderate	7 (30.4)	8 (36.4)	13 (56.5)	
	Severe	2 (8.7)	2 (9.1)	4 (17.4)	
Weight-for-age z-score, Mean (SD)		-1.4 (0.9)	-1.6 (1.0)	-2.1 (1.1)	0.042*
BMI-for-age z-score, Mean (SD)		-1.1 (1.0)	-1.3 (1.1)	-2.0 (1.2)	0.030*

*Statistically significant at $p<0.05$
SD, Standard deviation; GERD, Gastroesophageal reflux disease; BMI, Body mass index

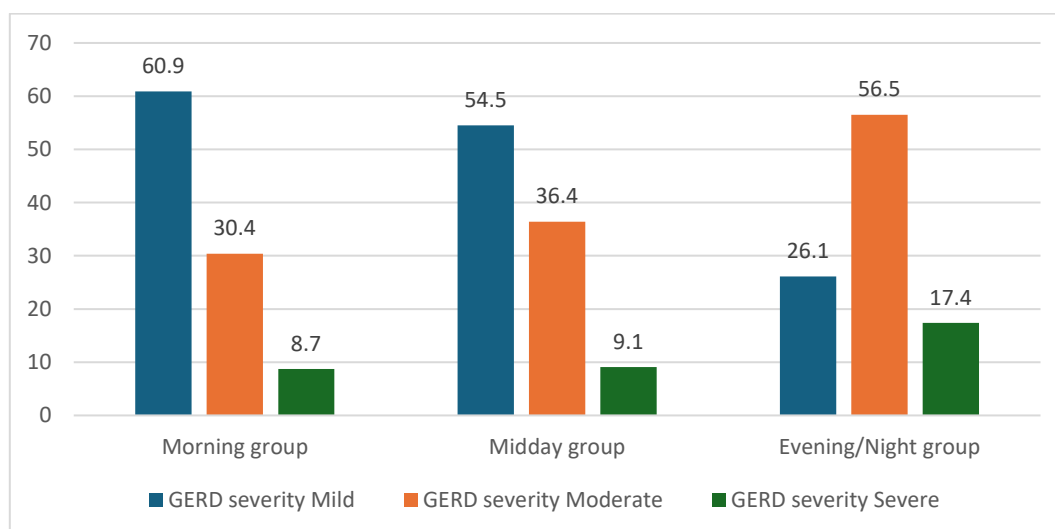


Figure 1: Comparison of feeding groups by GERD severity

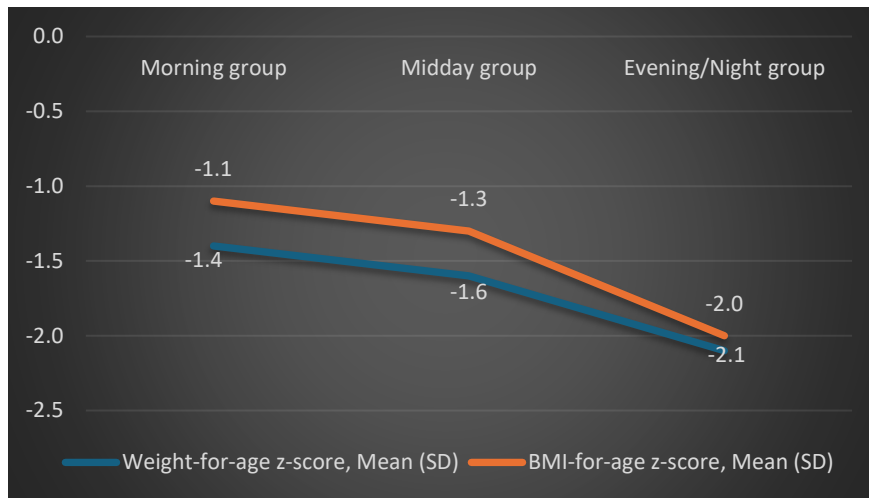


Figure 2: Comparison of feeding groups by nutritional status

On univariate analysis, predominant evening/night feeding was significantly associated with higher GERD severity, with children in the evening/night feeding group having greater odds of moderate-to-severe GERD

compared to those in the morning group (Odds Ratio [OR]: 2.8; 95% Confidence Interval [CI]: 1.2–6.5; p=0.011).

Table 3: Multivariate logistic regression model adjusting for age, gender, CP type, and feeding method

Predictor	Adjusted coefficient	OR/ β -	95% CI	P value
Evening/Night Feeding (vs Morning)	OR 2.5		1.1–5.9	0.032*
Midday Feeding (vs Morning)	OR 1.4		0.6–3.4	0.428
Age	$\beta = -0.03$		-0.09–0.03	0.318
Male (vs Female)	OR 0.9		0.4–2.1	0.812
Enteral Feeding (vs Oral)	OR 1.6		0.6–4.5	0.355

*Statistically significant at p<0.05
OR, Odds ratio; CI, Confidence interval

In multivariate logistic regression adjusting for potential confounders such as age, gender, type of cerebral palsy, and feeding method, evening/night feeding remained an independent predictor of moderate-to-severe GERD (adjusted OR: 2.5; 95% CI: 1.1–5.9; p=0.032). Furthermore, in multivariate linear regression, evening/night feeding was independently associated with lower BMI-for-age z-scores (β coefficient = -0.7, p=0.02). Other covariates, including CP subtype, gender, and feeding method, did not show a statistically significant independent association with either GERD severity or nutritional status in the adjusted models.

Discussion

This prospective observational study examined the relationship between predominant feeding time, gastroesophageal reflux disease severity, and nutritional status in children with cerebral palsy. Our findings reveal that children predominantly fed during the evening or night experienced significantly more severe GERD symptoms and poorer nutritional outcomes compared to those fed earlier in the day. The baseline demographic and clinical characteristics, including age, gender, type of CP, and feeding method, were comparable across the three groups. Spastic CP was the most prevalent subtype,



aligning with existing literature, where spastic forms account for approximately 70–80% of CP cases globally.(11, 12) This uniform distribution across groups minimizes confounding from subtype variation on GERD severity or nutritional outcomes. Importantly, GERD severity varied significantly with feeding time. Children who were predominantly evening/night feeders showed higher rates of moderate-to-severe GERD compared to morning or midday feeders. These findings are consistent with physiological evidence suggesting that supine posture during sleep exacerbates reflux due to gravity-dependent reduction in esophageal clearance and lower esophageal sphincter (LES) relaxation.(10) In children with CP, where neuromuscular incoordination and delayed gastric emptying are common, feeding closer to sleep time likely compounds the risk of GERD.(13)

GERD in children with cerebral palsy results from a combination of anatomical, neurological, and functional abnormalities that predispose them to frequent and severe reflux episodes. Neuromuscular dysfunction plays a central role, as impaired control of the LES due to spasticity or hypotonia leads to increased episodes of transient LES relaxation, allowing gastric contents to reflux into the esophagus.(14) Additionally, children with CP often have delayed gastric emptying, poor esophageal motility, and abnormal swallowing coordination, which further exacerbate reflux by impairing clearance of gastric contents and increasing esophageal exposure to acid.(15) Postural abnormalities, such as scoliosis and prolonged supine positioning, common in children with severe motor impairment, also contribute to the pathogenesis of GERD by reducing the protective effects of gravity on esophageal emptying.(6) Furthermore, the use of certain medications, such as anticholinergics and muscle relaxants, can further weaken LES tone, compounding the risk.

Our study further demonstrated that predominant evening/night feeding was an independent predictor of moderate-to-severe GERD after adjusting for potential confounders. This underscores the critical role of feeding timing, beyond intrinsic patient factors such as CP subtype or feeding modality. These findings support recommendations to avoid feeding close to bedtime in children vulnerable to reflux.(14)

Nutritional status was similarly impacted by feeding patterns. Evening/night feeders exhibited significantly lower weight-for-age and BMI-for-age z-scores, indicating higher rates of malnutrition. Malnutrition in CP is multifactorial, influenced by motor impairments, oromotor dysfunction, and GERD-related feeding difficulties.(7) Our findings suggest that GERD severity, likely worsened by late feeding, contributes further to inadequate nutritional intake or poor nutrient absorption. In multivariate analysis, evening/night feeding remained independently associated with lower BMI-for-age z-scores, reinforcing the significance of feeding timing as a modifiable factor to improve nutritional outcomes. Previous research has reported that GERD in CP is associated with failure to thrive and increased nutritional morbidity.(7, 16) Our results extend this knowledge by highlighting feeding time as a specific behavioral factor influencing both GERD severity and nutritional status.

Children with CP often suffer from oromotor dysfunction, including impaired chewing and swallowing coordination, which reduces effective oral intake and increases the risk of aspiration.(7) These difficulties are compounded by underlying GERD, a common comorbidity in CP, which leads to feeding aversion, vomiting, and reduced nutrient retention.(17) Predominantly feeding during the evening or night may further exacerbate these issues. Late feeding increases the risk of severe GERD episodes during sleep due to supine posture, impaired esophageal clearance, and prolonged acid exposure, resulting in discomfort, disrupted sleep, and subsequent reduced appetite and intake during subsequent meals.(14) Moreover, children fed later in the day may experience a diminished overall caloric intake because fatigue and somnolence can impair feeding efficiency. Night-time GERD symptoms such as regurgitation and nocturnal coughing can also contribute to nutrient loss and poor digestion. Additionally, children with CP often exhibit increased energy expenditure due to spasticity and involuntary movements, but their actual energy intake is reduced, creating a caloric deficit that is intensified in those with severe feeding difficulties and late feeding schedules.(18) Over time, these factors synergistically result in significant weight loss, reduced body mass index, and stunting, thereby perpetuating a cycle of malnutrition, impaired immune function, and developmental delay.



Interestingly, other covariates, such as CP subtype, gender, and feeding method (oral vs. enteral), did not independently predict GERD severity or nutritional outcomes in our cohort. This finding contrasts with earlier studies that reported higher GERD prevalence in dyskinetic CP or among gastrostomy-fed children.⁽¹⁹⁾ The discrepancy may be attributed to the relatively small sample size or the exclusion of children on proton pump inhibitors, which may have attenuated GERD symptoms regardless of feeding method.

The present study has several limitations that should be acknowledged. First, the diagnosis and assessment of GERD were based on a symptom questionnaire (PGSQ) without confirmation through objective diagnostic modalities such as pH monitoring, impedance studies, or endoscopy, which may have introduced diagnostic inaccuracies. Second, the single-center design may limit the generalizability of the findings to broader populations of children with cerebral palsy. Additionally, the study did not extensively evaluate dietary composition, meal size, or calorie density, all of which could independently influence GERD symptoms and nutritional status. Other potential confounders, such as variations in physical activity, sleep patterns, and caregiver feeding practices, were not systematically assessed. Despite adjusting for several variables, the possibility of residual confounding cannot be completely excluded. Finally, since the study relied on caregiver-reported feeding times and dietary intake, recall bias may have influenced the accuracy of the collected data.

Conclusion

In conclusion, this study demonstrates that the timing of predominant feeding plays a significant role in influencing gastroesophageal reflux disease severity and nutritional status in children with cerebral palsy. Children predominantly fed during the evening or night exhibited higher rates of moderate-to-severe GERD and poorer nutritional indicators compared to those fed earlier in the day. Predominant evening or night-time feeding remained an independent predictor of both increased GERD severity and lower BMI-for-age z-scores, even after adjusting for potential confounders. These findings highlight the importance of optimizing feeding schedules as a potentially modifiable factor in the comprehensive management of GERD and nutritional challenges in this vulnerable population.

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