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Original research

Effect of feeding frequency on total bilirubin reduction and body temperature changes among neonates with jaundice receiving blue led phototherapy at Marthen Indey TNI-AD Hospital, Jayapura

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ABSTRACT

Background: Hyperbilirubinemia in neonates requires prompt intervention to prevent neurological complications. Blue LED phototherapy is a primary treatment, yet its effectiveness relies on hydration and feeding frequency to facilitate bilirubin excretion. Phototherapy also carries a risk of altering body temperature, necessitating close monitoring.
Purpose: This study analyzed the effect feeding frequency and blue LED phototherapy with total bilirubin reduction and body temperature changes among neonates with jaundice.
Methods: A quasi-experimental pretest-posttest comparison group study involved 80 neonates selected through purposive sampling. Respondents were divided into high feeding frequency (10 times/24 hours, n=40) and low feeding frequency (6 times/24 hours, n=40) groups. Total bilirubin levels and body temperature were measured before and after 24-hour therapy. Analyses included the Wilcoxon Signed Rank Test and Mann-Whitney U Test.
Results: Neonates had a mean gestational age of 38.79 ± 1.10 weeks, and birth weight of 2749.7 ± 166.3 g. Baseline total bilirubin (15.52 ± 0.31 mg/dL) and body temperature (36.75 ± 0.09°C) were comparable between groups. Both groups showed significant bilirubin reduction ($p < 0.001$). The high-frequency group demonstrated significantly greater reduction (median change 5.95 mg/dL) than the low-frequency group (3.40 mg/dL; $p < 0.001$, $r = 0.62$). Temperature changes within both groups were significant ($p < 0.001$) but remained clinically normal, with no between-group difference ($p = 0.176$, $r = 0.14$).
Conclusion: Higher feeding frequency was associated with greater bilirubin reduction without adverse temperature effects. However, the quasi-experimental design limits causal inference. Clinical protocols should emphasize frequent feeding and temperature monitoring for safe, optimal treatment.

1. Background

Neonatal jaundice, or hyperbilirubinemia, is a critical clinical condition in the early stages of life that requires prompt and precise intervention. If left untreated, excessive levels of unconjugated bilirubin can cross the blood-brain barrier, leading to severe neurological complications such as kernicterus or permanent brain damage [1]. Therefore, identifying effective management strategies to accelerate bilirubin reduction while maintaining physiological stability is essential in neonatal intensive care units [2].

Globally, neonatal jaundice remains one of the leading causes of hospital readmission during the first week of life [3]. In Indonesia, the high prevalence of hyperbilirubinemia poses a significant challenge to reducing neonatal mortality rates. Inadequate management of jaundice has been associated with long-term developmental delays, emphasizing the importance of optimizing hospital-based interventions to improve neonatal health outcomes [4].

Blue LED phototherapy has been identified as the gold standard and most effective primary treatment for neonatal jaundice. This technology works by converting bilirubin into water-soluble isomers that can be excreted through bile and urine without requiring hepatic conjugation. Previous studies indicate that LED-based systems are more efficient than conventional phototherapy due to their specific wavelength and lower heat emission, yet they still require supportive clinical factors to achieve optimal results [5].

In this context, feeding frequency becomes a direct nursing intervention because it is regulated through daily nursing care activities, including feeding schedules, breastfeeding assistance, and monitoring of intake adequacy. Nurses play a central role in ensuring that neonates receive adequate and timely feeding during phototherapy, especially when infants are separated from mothers or experience weak suckling reflex. Feeding management is therefore not a passive factor, but an active component of nursing care that can be modified to improve bilirubin elimination outcomes [1], [6].

The relationship between feeding frequency and the rate of bilirubin reduction can be explained through the mechanism of enterohepatic circulation. Adequate feeding whether through breastfeeding or formula stimulates bowel movements and facilitates the excretion of bilirubin through stool [7]. Higher feeding frequency is believed to minimize the reabsorption of bilirubin in the intestines, thereby accelerating the overall reduction of total serum bilirubin levels during phototherapy [8].

Despite its benefits, phototherapy carries the risk of altering neonatal thermoregulation. Exposure to light sources and the requirement of minimal clothing during therapy can lead to fluctuations in body temperature, such as hyperthermia or increased insensible water loss. Maintaining a stable body temperature is crucial for neonates, as thermal stress can compromise their metabolic recovery and overall clinical stability [9].

Although previous studies have examined the effects of phototherapy, limited evidence exists regarding the specific association between feeding frequency and the rate of bilirubin reduction using Blue LED technology in the context of Jayapura, Papua. Most existing research focuses on conventional phototherapy or general hydration, with limited attention to specific feeding intervals in a controlled hospital setting. This gap highlights the need for further research in local healthcare facilities [10].

Hospital of TNI-AD Marthen Indey Jayapura is a significant setting for this study as it serves a diverse population in the Papua region, where neonatal jaundice is frequently managed in its neonatal ward. Preliminary observations at the hospital indicate variations in feeding practices among jaundiced neonates, which may influence the duration of therapy and the stability of the infants' body temperature [10]. However, comprehensive evidence regarding how feeding frequency interacts with Blue LED phototherapy in this specific facility remains limited.

Previous studies have shown that intensive feeding protocols and optimized phototherapy can significantly shorten hospital stays and reduce the risk of complications [11]. However, challenges in balancing high-frequency feeding with nursing workloads and neonatal tolerance remain, particularly in busy clinical environments [12].

Therefore, this study aims to analyze the association of Blue LED phototherapy and feeding frequency with the rate of total bilirubin reduction and changes in body temperature among neonates with jaundice at Marthen Indey TNI-AD Hospital, Jayapura. The findings are expected to provide evidence-based insights for neonatal nurses and pediatricians in developing more effective clinical protocols to improve the quality of care and outcomes for jaundiced neonates.

2. Methods

2.1 Research design

This study used a quasi-experimental design with a pretest-post-test comparison group to evaluate the association between feeding frequency during Blue LED phototherapy and clinical outcomes. The study compared two different feeding protocols: a high-frequency feeding group (10 times per 24 hours) and a low-frequency feeding group (6 times per 24 hours) to examine their association with total bilirubin levels and body temperature stability in neonates with jaundice. This design was chosen because randomization was not feasible; participants were allocated to groups based on the predetermined clinical care protocol implemented during the study period.

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2.2 Setting and sample

The study was conducted at the Neonatal Care Unit of Marthen Indey TNI-AD Hospital, Jayapura. The participants were 80 neonates with hyperbilirubinemia who met the inclusion criteria, including a diagnosis of neonatal jaundice, term or late preterm gestational age (≥35 weeks), appropriate birth weight for gestational age (≥2000 g), and clinical stability (normal vital signs, no respiratory distress, no sepsis). Neonates with hemolytic disease, major congenital anomalies, or contraindications to breastfeeding were excluded. The severity of jaundice was assessed clinically and by total serum bilirubin levels before enrollment.

Participants were recruited using purposive sampling and allocated to either the high feeding frequency group (10 feedings/24 hours) or the low feeding frequency group (6 feedings/24 hours) according to the predetermined clinical care protocol implemented during the study period rather than by randomization. Each group consisted of 40 neonates. A sample size of 40 per group was determined based on pragmatic considerations of available participants during the study period and comparable sample sizes from similar quasi-experimental studies [8], [12].

2.3 Intervention

The intervention consisted of Blue LED phototherapy combined with two different feeding frequency protocols. All neonates received phototherapy according to the hospital's standard neonatal jaundice management protocol, while the feeding frequency differed between groups.

Blue LED phototherapy was administered using a neonatal LED phototherapy unit with a peak wavelength of 460–490 nm, which corresponds to the optimal absorption spectrum of bilirubin. The irradiance was maintained at approximately 30–35 μW/cm²/nm, measured at the infant's skin level, and the distance between the LED light source and the infant was standardized at 30–40 cm throughout the treatment period. During phototherapy, neonates wore protective eye shields, and only diapers were used to maximize skin exposure. Body position was changed every 2–3 hours according to the unit protocol to ensure uniform light exposure. Phototherapy was administered continuously for 24 hours, with brief interruptions only for feeding, routine nursing care, and clinical assessment.

Participants were allocated to one of two feeding frequency protocols according to the predetermined clinical care protocol. The high feeding frequency group received breast milk or formula 10 times within 24 hours, whereas the low feeding frequency group received feeding 6 times within 24 hours. Feeding adherence was monitored and documented by neonatal nurses throughout the intervention period. Total serum bilirubin concentration and body temperature were measured immediately before the initiation of phototherapy (pre-test) and again after completion of the 24-hour intervention (post-test). Throughout the intervention, neonates were continuously monitored for thermal stability and other adverse events to ensure patient safety.

2.4 Instruments and data collection

Data were collected using laboratory measurements of total serum bilirubin (mg/dL) and medical-grade thermometers for body temperature (°C). Feeding frequency was recorded using structured observation sheets over a 24-hour treatment period.

The feeding intervention was standardized into two protocols. The high feeding frequency group received feeding approximately 10 times per 24 hours, while the low feeding frequency group received feeding approximately 6 times per 24 hours. Feeding was primarily breast milk, provided through direct breastfeeding when possible. In cases where direct breastfeeding was not feasible, expressed breast milk was administered using cup feeding or bottle feeding according to neonatal condition and maternal availability. The volume of each feeding was adjusted based on neonatal age, weight, and clinical tolerance following neonatal feeding guidelines (approximately 60–90 mL/kg/day divided across feeding episodes).

Nursing staff played an active role in implementing and documenting feeding schedules. Nurses assisted mothers in breastfeeding initiation, ensured feeding adherence according to the assigned frequency, and monitored feeding adequacy and tolerance. All feeding events were documented in real time to ensure compliance with the intervention protocol.

Measurements of bilirubin levels and body temperature were conducted twice, at baseline before initiation of Blue LED phototherapy (pretest) and after completion of the phototherapy period (posttest). Laboratory technicians measuring bilirubin levels were blinded to group allocation to minimize detection bias. Data analysis was performed using the Wilcoxon Signed Rank Test for within-group comparisons and the Mann-Whitney

U Test for between-group differences, with statistical significance set at $p < 0.05$.

2.5 Data analysis

Descriptive and inferential statistics were employed to analyze the data. Frequencies, percentages, means, medians, and standard deviations were used to summarize neonatal characteristics including gestational age, birth weight, clinical severity of jaundice, and eligibility for breastfeeding, as well as total bilirubin levels and body temperature before and after the intervention.

Bivariate analysis was performed to examine differences within and between the high feeding frequency group and the low feeding frequency group. The Wilcoxon Signed Rank Test was used to assess pretest and post-test differences within each group, while the Mann-Whitney U Test was applied to compare changes in total bilirubin levels and body temperature between groups. Effect sizes (r) were calculated for all non-parametric tests to indicate practical significance. A significance level of $p < 0.05$ was considered statistically significant. All statistical analyses were conducted using Statistical Product and Service Solutions (SPSS) software version 27.

2.6 Research ethics

Ethical approval was obtained from the Health Research Ethics Committee with reference number 514/KEPK/2024. Prior to data collection, informed consent was obtained from parents or legal guardians of all neonates included in the study. Participation was voluntary, and confidentiality and anonymity of respondents were strictly maintained throughout the study. Parents had the right to withdraw their neonates from the study at any time without affecting the standard of care.

3. Results

The implementation of this study was conducted in the Neonatal Care Unit of Marthen Indey TNI-AD Hospital, Jayapura. The research process began with the identification of neonates diagnosed with hyperbilirubinemia who met the inclusion criteria. A total of 80 neonates were involved and divided into two intervention groups: the high feeding frequency group (receiving breast milk or formula 10 times per 24 hours) and the low feeding frequency group (6 times per 24 hours). All 80 neonates completed the study with no attrition. Before the Blue LED phototherapy was initiated, initial measurements (pre-test) of total serum bilirubin and body temperature were recorded. During the 24-hour phototherapy session, nurses and the research team monitored feeding adherence and thermal stability. After the intervention period, repeated measurements (post-test) were conducted to evaluate the rate of bilirubin reduction and any changes in body temperature. The study followed ethical protocols, ensuring neonatal safety and coordination with the hospital's medical staff throughout the data collection process.

Table 1. Frequency Distribution of Respondents' Characteristics

Variable	Statistics	High Frequency (n=40)	Low Frequency (n=40)	Total (n=80)
Gender	Male, n (%)	18 (45.0%)	19 (47.5%)	37 (46.2%)
	Female, n (%)	22 (55.0%)	21 (52.5%)	43 (53.8%)
Birth Weight (g)	Mean ± SD	2795.5 ± 149.7	2704.0 ± 171.2	2749.7 ± 166.3
Gestational Age (wk)	Mean ± SD	38.90 ± 1.30	38.67 ± 0.86	38.79 ± 1.10
Initial Bilirubin (mg/dL)	Mean ± SD	15.51 ± 0.27	15.53 ± 0.35	15.52 ± 0.31
Initial Temperature (°C)	Mean ± SD	36.75 ± 0.10	36.75 ± 0.08	36.75 ± 0.09

Data analysis based on respondents' characteristics showed that the majority of neonates were female (53.8%). The mean birth weight was 2749.7 grams, and the mean gestational age was 38.79 weeks. Baseline measurements showed a mean total bilirubin of 15.52 mg/dL and a mean body temperature of 36.75°C, indicating that both groups started with comparable clinical conditions. Feeding type distribution was similar between groups, with 67.5% receiving breast milk. Baseline comparability testing using the Mann-Whitney U Test confirmed no significant differences between

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groups for bilirubin (p = 0.784) or temperature (p = 0.923) at baseline.

Table 2. Bivariate Analysis Results (Wilcoxon and Mann-Whitney U Test)

Variables & Groups	Pre-test Median (IQR)	Post-test Median (IQR)	Median Delta (Change)	*p-value* (Within Group)[1]	*p-value* (Between Group)[2]
Total Bilirubin (mg/dL)					
High Frequency (10x/day)	15.50 (15.3–15.8)	9.65 (9.5–9.8)	5.95	< 0.001	< 0.001
Low Frequency (6x/day)	15.60 (15.4–15.8)	12.25 (12.1–12.4)	3.4	< 0.001	
Body Temperature (°C)					
High Frequency (10x/day)	36.70 (36.7–36.8)	36.60 (36.5–36.7)	0.1	< 0.001	0.176
Low Frequency (6x/day)	36.80 (36.7–36.8)	36.50 (36.5–36.7)	0.1	< 0.001	

Note: [1]Wilcoxon Signed Rank Test; [2]Mann-Whitney U Test. Effect size for bilirubin between-group comparison: r = 0.62 (large effect). Effect size for temperature between-group comparison: r = 0.14 (small effect).

Based on the bivariate analysis in Table 2, the results demonstrate that blue LED phototherapy was significantly associated with reduced total bilirubin levels in both research groups (p < 0.001). Although both groups showed a positive response to treatment, there was a distinct difference in effectiveness based on feeding frequency. The high feeding frequency group (10 times/24 hours) demonstrated a substantially greater bilirubin reduction with a Median Delta of 5.95 mg/dL, compared to the low frequency group (6 times/24 hours), which achieved a reduction of 3.40 mg/dL. The inter-group comparison using the Mann-Whitney U Test confirmed this finding with a p-value of < 0.001 (r = 0.62, large effect), suggesting that increased feeding frequency is associated with accelerated bilirubin reduction by enhancing excretion through stool and urine, thereby minimizing enterohepatic circulation.

Regarding body temperature, statistical tests revealed significant changes in both groups during phototherapy (p < 0.001). However, from a clinical perspective, these changes were minimal, with a Median Delta of 0.10°C in the high-frequency group and 0.30°C in the low-frequency group, and the neonates' body temperatures remained consistently within the normal range (36.5°C – 37.5°C). This indicates that blue LED technology is safe for neonatal thermoregulation due to its low heat emission. Furthermore, the inter-group comparison yielded a p-value of 0.176 (r = 0.14, small effect), suggesting no significant association between feeding frequency and body temperature fluctuations. Overall, these findings indicate that an increased feeding frequency of 10 times per day is associated with improved phototherapy efficacy without posing a risk of thermal instability in neonates with jaundice.

4. Discussion

4.1 Feeding Frequency and Bilirubin Reduction

The findings of this study demonstrate that feeding frequency is significantly associated with the rate of total bilirubin reduction among neonates undergoing blue LED phototherapy. Neonates who received a higher feeding frequency (10 times/24 hours) experienced a significantly greater reduction in bilirubin levels compared to those in the low-frequency group (6 times/24 hours). These findings are consistent with the physiological principle that frequent enteral intake stimulates bowel motility, facilitates the elimination of stool, and minimizes the enterohepatic circulation of bilirubin [7], [13].

While these results support the association between high-frequency feeding and greater bilirubin reduction, it is important to critically evaluate these findings against conflicting evidence in neonatal literature. Some researchers argue that total enteral volume and caloric intake are more

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significant predictors of bilirubin clearance than the frequency of feeding episodes alone [14]. For instance, studies suggest that as long as the total daily requirement (mL/kg/day) is met, the specific number of feeding intervals may have a diminishing return on bilirubin reduction. Furthermore, the type of nutrition provided remains a controversial variable. Formula-fed neonates often experience a more rapid decline in bilirubin levels than exclusively breastfed neonates, regardless of frequency, due to the presence of certain pregnanes and enzymes in breastmilk that can occasionally inhibit conjugation or promote reabsorption [15]. By focusing solely on frequency, clinicians must be careful not to overlook the qualitative aspects of enteral intake.

4.2 Confounding Factors and Methodological Considerations

Several confounding factors may have influenced the outcomes of this study and warrant critical consideration. First, the etiology of the jaundice (hemolytic vs. physiological) was not fully controlled. Neonates with ABO or Rh incompatibility typically present with more aggressive bilirubin production, which may be less responsive to feeding interventions alone compared to those with non-hemolytic jaundice.

Second, the initial serum bilirubin level at the start of treatment is a known confounder; neonates with higher baseline levels often show a more dramatic absolute reduction during the first 24 hours of phototherapy. Third, a significant consideration exists regarding the "time on" phototherapy. Feeding a neonate 10 times in 24 hours necessitates more frequent removal from the light source and increased handling, which theoretically reduces the cumulative irradiance received. However, our findings suggest that the physiological benefits of enteral stimulation (increased excretion) outweigh the minor loss of light exposure time. This suggests that interrupted phototherapy for the purpose of frequent feeding is not only safe but may be therapeutically preferable to continuous phototherapy with infrequent feeding.

4.3 Temperature Stability and Phototherapy Safety

The metabolic pathway of bilirubin clearance during phototherapy relies heavily on hydration to support the renal excretion of lumirubin, a water-soluble byproduct [16]. High-frequency feeding ensures a steady state of hydration, reducing the risk of weight loss and promoting clinical stability. Furthermore, this study confirms the safety of blue LED technology. Despite increased handling for 10 feedings, the neonates maintained stable thermoregulation with a median delta of only 0.10°C in the high-frequency group and 0.30°C in the low-frequency group. This reinforces the superior safety profile of LEDs over conventional halogen lamps, which often caused hyperthermia and insensible water loss when infants were handled frequently [5], [9].

4.4 Nursing Practice Implications

From a neonatal nursing perspective, these findings emphasize that nutritional management is not merely supportive but is a core component of jaundice treatment. Nurses at Marthen Indey TNI-AD Hospital should integrate breastfeeding support and scheduled feeding intervals (minimum 10 times/day) into standard phototherapy care plans [1], [17]. Standardizing these protocols can reduce parental anxiety and provide a holistic environment where feeding and medical treatment are prioritized equally [18].

However, it is essential to acknowledge the limitations of this study. The quasi-experimental design without randomization limits the ability to account for all maternal and neonatal confounders, such as maternal medication use or subtle variations in neonatal metabolic rates. The 24-hour observation period also fails to capture the potential for bilirubin rebound after phototherapy is discontinued. Furthermore, the study was conducted in a single military hospital in Jayapura, which serves a specific population; generalizability to civilian hospitals or other regions in Indonesia may be limited.

4.5 Limitations and Future Research

This study has several limitations that must be acknowledged. First, the quasi-experimental design with non-random allocation introduces the potential for selection bias, as groups were determined by existing clinical protocols rather than random assignment. Second, the 24-hour observation period is insufficient to assess bilirubin rebound after phototherapy cessation or long-term neurodevelopmental outcomes. Third, while

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feeding frequency was controlled, the exact volume and caloric intake per feeding were not standardized, which may have influenced bilirubin clearance independent of frequency. Fourth, the single-center design in a military hospital limits generalizability to other settings and populations.

Future research should employ randomized controlled trials with stricter stratification for feeding types (breastmilk vs. formula) and jaundice etiology to further isolate the effect of frequency from other clinical variables. Longitudinal studies with longer follow-up periods are needed to assess bilirubin rebound and neurodevelopmental outcomes. Multi-site studies across different regions of Indonesia would enhance generalizability.

5. Conclusion

This study demonstrates a significant association between higher feeding frequency and greater total bilirubin reduction among neonates undergoing blue LED phototherapy. Neonates who received feeding 10 times per 24 hours achieved a significantly greater reduction in bilirubin levels compared to those fed 6 times per 24 hours. In contrast, lower feeding frequency was associated with slower bilirubin reduction. Furthermore, while phototherapy was associated with minor statistical changes in body temperature, these fluctuations remained within normal clinical limits, and no significant association was found between feeding frequency and thermal instability.

These findings highlight the importance of optimized enteral intake and the safety of blue LED technology in promoting neonatal recovery. However, the quasi-experimental design without randomization limits causal inference, and the single-center setting restricts generalizability.

Healthcare facilities such as Marthen Indey TNI-AD Hospital play an important role in supporting neonatal well-being through standardized clinical protocols, including intensive feeding schedules and consistent physiological monitoring. Nurses in neonatal settings should incorporate routine feeding assessments, lactation support, and family-centered education into their care plans for jaundiced neonates. Clinical providers are also encouraged to strengthen monitoring systems to ensure that high-frequency feeding is maintained alongside phototherapy to optimize treatment efficacy while ensuring thermal safety. Future randomized controlled trials with longer follow-up periods are recommended to confirm these findings and establish evidence-based feeding protocols for neonatal jaundice management.

6. Acknowledgment

none

7. References

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