

Impact of phototherapy on multiple biochemical markers in Jaundiced neonates: A prospective comparative observational Study

Sahar Taheri Sani

Gonabad University of Medical Sciences

Mojtaba Norouzi

Shahrekord University of Medical Sciences

Hashem Fathi

Gonabad University of Medical Sciences

Mostafa Eghbalian

Gonabad University of Medical Sciences

Ali Alemi

Gonabad University of Medical Sciences

Niloofar Dadar

Arak University of Medical Sciences

Jalil Meshari

Hamonfateh@gmail.com

Gonabad University of Medical Sciences

Article

Keywords: phototherapy, neonatal jaundice, hyperbilirubinemia, calcium, biochemical parameters

Posted Date: March 25th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-8903084/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Objective

This study aimed to compare short-term changes in serum bilirubin, total calcium, hemoglobin, creatinine, and urinary calcium-to-creatinine ratio between jaundiced term/late-preterm neonates receiving phototherapy versus controls.

Methods

We performed a prospective comparative observational study at Gonabad University of Medical Sciences, Iran. Eighty term/late-preterm neonates with hyperbilirubinemia were grouped into to phototherapy (n = 40) and control (n = 40) groups. Serum hemoglobin, total calcium, creatinine, and urine calcium–creatinine ratio were assessed at baseline and 48 hours, adjusted via ANCOVA for baseline differences. Phototherapy employed LED/fluorescent devices (10–50 $\mu\text{W}/\text{cm}^2/\text{nm}$) for approximately 20 hours until bilirubin levels normalized.

Results

The mean weight of the infants was 3105.7 ± 493.7 grams, and 57.5% of the babies were boys. Phototherapy reduced bilirubin by 38% (15.37 to 9.59 mg/dL; $p < 0.001$). Contrary to the literature, calcium increased in the phototherapy group (8.78 to 9.38 mg/dL; $p < 0.001$) but decreased in controls. Hemoglobin remained stable with phototherapy but declined substantially in controls (-3.92 g/dL; $p < 0.001$). Serum creatinine converged between groups, reflecting normal neonatal maturation.

Conclusions

Phototherapy appears to be an effective and safe phototherapy exposure for jaundiced neonates, leading to more favorable short-term hematologic and biochemical profiles than standard care. These results suggest that phototherapy not only achieves substantial bilirubin reduction but also helps preserve hemoglobin and calcium status without adversely affecting renal function.

INTRODUCTION

Neonatal Hyperbilirubinemia and phototherapy represent one of the most prevalent clinical challenges encountered during the neonatal period, affecting approximately 60% of term and 80% of preterm infants during the first two weeks of life (1–3). While the majority of cases resolve spontaneously or with minimal therapeutic treatment, severe and inadequately managed hyperbilirubinemia carries potentially catastrophic neurological consequences. If progression is not arrested through timely treatment, a permanent neurological sequela characterized by movement disorders (particularly choreoathetoid

cerebral palsy), auditory dysfunction (sensorineural hearing loss), oculomotor impairment, and varying degrees of intellectual disability (4, 5). The prevention of bilirubin-induced neurological damage remains, therefore, a cornerstone of contemporary neonatal care.

Phototherapy has emerged as the gold standard and most widely adopted non-invasive treatment modality for managing significant neonatal hyperbilirubinemia, substantially reducing the clinical need for exchange transfusion across diverse healthcare settings and populations (6). The therapeutic mechanism of phototherapy operates through photo-isomerization (4, 7–10). The documented efficacy of appropriately dosed phototherapy in achieving clinically meaningful bilirubin reduction, combined with its non-invasive administration and favorable safety profile at therapeutic dose ranges, has established it as the preferred treatment across low-, middle-, and high-resource healthcare settings (6, 11–13).

Among the biochemical derangements documented in the literature, phototherapy-induced hypocalcemia and suppression of melatonin secretion have emerged as an area of particular clinical concern. Melatonin normally exerts a tonic inhibitory effect on cortisol signaling pathways. Elevated cortisol levels enhance calcium uptake and incorporation into bone matrix, thereby reducing serum calcium concentrations and precipitating hypocalcemia (14–16). Less comprehensively characterized in the current literature are the specific effects of phototherapy on renal function parameters and other biochemical markers (17, 18). While phototherapy-associated changes in fluid and electrolyte status have been documented in select studies, the magnitude and clinical significance of alterations in serum creatinine levels and renal hemodynamic stability remain incompletely understood (7, 16, 19, 20). This represents a notable evidence gap in the neonatal phototherapy literature.

This study aimed to evaluate the biochemical effects of phototherapy in jaundiced neonates. Its primary goal is to reduce serum bilirubin to safe levels while monitoring systemic changes during treatment. A prospective comparative observational design compares treated neonates with controls below phototherapy thresholds. The study seeks evidence on potential hypocalcemia, hemolysis-related anemia, and renal changes to refine monitoring and care strategies.

METHODS

Study Design and Setting

A prospective comparative observational study conducted in 2024 at Gonabad University of Medical Sciences, Iran.

Participants

Inclusion: Term and late-preterm neonates (≥ 35 weeks of gestation), aged 24 hours–7 days, with confirmed hyperbilirubinemia, birth weight 2200–4200 grams.

Exclusion: Rh/ABO hemolytic disease (positive Coombs test), neonatal sepsis, major congenital anomalies, G6PD deficiency, prior exchange transfusion, baseline acute kidney injury (creatinine > 2.0 mg/dL), maternal gestational diabetes, or lack of parental consent.

Allocation: Non-randomized assignment based on AAP 2022 phototherapy thresholds(21). Phototherapy group (n = 40, bilirubin $\geq$ threshold) vs. Control group (n = 40, bilirubin <threshold). Covariate-adjusted analysis (ANCOVA) addressed baseline imbalances inherent to prospective comparative observational design.

Data Collection

Baseline variables: Neonatal sex, blood types (ABO/Rh), birth weight, postnatal age, gestational age, delivery mode, maternal complications, and Direct Coombs test results.

Biochemical outcomes

We evaluated blood and urine samples collected at baseline and 48 hours ($\pm$ 2 hours) according to standardized protocols. Serum bilirubin was measured by spectrophotometry at 454 nm (< 5–10 mg/dL). Total serum calcium was assessed via colorimetric assay (8.5–10.5 mg/dL); ionized calcium was not measured. Hemoglobin was determined using an automated hematology analyzer (14–20 g/dL), and serum creatinine was measured enzymatically (Jaffe/IFCC; 0.4–1.2 mg/dL). Urinary calcium-to-creatinine ratio was calculated from spot urine samples (< 0.4 mg/mg). Key supportive care variables, including feeding type (breast, formula, or mixed), feeding frequency, intravenous fluid administration (type, rate, volume), and overall fluid balance, were recorded as potential confounders. Laboratory Quality Assurance

All assays are performed by trained technicians using calibrated instruments and standardized protocols. Blood samples: capillary heel-stick (preferred) or venipuncture; centrifuged within 30 minutes at 3000 rpm; analyzed within 2 hours or frozen at -20°C . Urine samples: collected via diaper or catheterization; stored at 4°C ; analyzed within 2 hours. Hemolyzed samples rejected. Daily calibration and quality control materials run per manufacturer protocols.

Phototherapy treatment

Neonates received either LED phototherapy (peak 460 nm, irradiance 25–50 $\mu\text{W}/\text{cm}^2/\text{nm}$) or conventional fluorescent (peak 420–500 nm, irradiance 10–25 $\mu\text{W}/\text{cm}^2/\text{nm}$). Devices positioned approximately 24–30 cm above the torso; eye shields applied; mean duration 20 hours (range 18–30 hours). Phototherapy was discontinued when the bilirubin fell below the treatment threshold and remained low on reassessment. The control group received supportive care only.

Sample Size:

The sample size was determined as 80 infants, considering an effect size of 0.35, a confidence level of 0.95, and a power of 0.80, using the G-Power3.1.9.2 software for the ANCOVA test sample size calculation formula for the two groups(22), and also considering a possible dropout of 10%.

Statistical Analysis

First, independent t-test and chi-square test were used to provide descriptive statistics and compare demographic factors in the groups (Phototherapy and control). Then, the mean comparison of the clinical factors was performed separately for each group by an independent T-test. A paired t-test was used to examine the mean of the clinical factors before and after 48 hours in the form of a figure. R software version 5.4.1 and the command "grouped_ggwithinstats" were used for data analysis. The significance level in all tests was considered less than 0.05.

Result

According to Table 1, the mean weight of the infants was 3105.7 ± 493.7 grams, and 57.5 percent of the babies were boys. According to independent t-tests and chi-square, all demographic variables were homogeneous in the two groups ($p\text{-value} > 0.05$).

Table 1
Demographic variables in the Phototherapy and control groups

Variables	Mean $\pm$ Sd		Independent T-test	
	Photography	Control	t	P-value
Weight (2200–4200 g)	3105.7 $\pm$ 493.7	3095.5 $\pm$ 316.5	3116.0 $\pm$ 627.1	-0.18 0.854
N (%)		Chi-square test		
	Photography	Control	χ^2	P-value
Sex				
Male	46(57.5)	6(30.0)	14(70.0)	4.65 0.058
Female	34(42.5)	26(59.1)	18(40.9)	
Offspring's blood type				
A	2(4.3)	2(100)	0	1.84 0.604
AB	6(12.8)	3(50.0)	3(50.0)	
B	8(17.0)	4(50.0)	4(50.0)	
O	31(66.0)	16(51.6)	22(46.8)	
Mother's blood type				
A	9(12.0)	6(66.7)	3(33.3)	1.72 0.633
AB	3(4.0)	1(33.3)	2(66.7)	
B	26(34.7)	14(53.8)	12(46.2)	
O	37(49.3)	17(45.9)	20(54.1)	

Table 2 shows difference in the mean of clinical factors in the Phototherapy and Control groups. According to the results of the independent t-test, before the treatment, only the mean Creatinine (mg/dl) in the control group was higher than the Phototherapy group (p-value < 0.001). After the treatment, the mean Hemoglobin (gr/dl) (p-value < 0.001), Calcium (mg/dl) (p-value < 0.001) in the Phototherapy group was higher than the control group. But, after the meditation, the mean Bilirubin (mg/dl) (p-value < 0.001) and Calcium Creatinine (p-value < 0.001) were higher in the control group. After the treatment, the mean creatinine (mg/dl) in the two groups did not differ significantly (p-value = 0.494).

Table 2
Difference in the mean of clinical factors in Phototherapy and Control groups

Factors	Mean $\pm$ Sd		Independent T-test	
	Photography	Control	t	P-value
Hemoglobin(gr/dl)				
Before	18.10 $\pm$ 2.82	18.51 $\pm$ 2.53	-0.69	0.489
After	17.97 $\pm$ 2.88	14.59 $\pm$ 0.54	7.29	< 0.001
Calcium(mg/dl)				
Before	8.78 $\pm$ 1.09	8.81 $\pm$ 1.30	-0.10	0.919
After	9.37 $\pm$ 0.24	8.04 $\pm$ 0.26	23.18	< 0.001
Bilirubin(mg/dl)				
Before	15.36 $\pm$ 3.60	15.08 $\pm$ 3.25	0.36	0.717
After	9.58 $\pm$ 2.43	15.08 $\pm$ 3.25	-8.55	< 0.001
Calcium Creatinine				
Before	0.26 $\pm$ 0.03	0.26 $\pm$ 0.06	0.21	0.832
After	0.25 $\pm$ 0.03	0.48 $\pm$ 0.08	-16.12	< 0.001
Creatinine(mg/dl)				
Before	30.80 $\pm$ 5.34	43.36 $\pm$ 8.24	-8.09	< 0.001
After	19.54 $\pm$ 3.21	20.18 $\pm$ 4.99	-0.68	0.494

Hemoglobin (gr/dl)

The mean hemoglobin (gr/dl) in the Phototherapy group did not differ significantly after the treatment (effect size = 0.03, p-value = 0.820), while in the control group, the mean decreased from 18.52 to 14.60 gr/dl after 48 hours (effect size = 1.52, p-value < 0.001).

Calcium (mg/dl)

The mean calcium (mg/dl) in the Phototherapy group increased from 8.78 to 9.38 **mg/dl** after the treatment (effect size=-0.52, p-value < 0.001) but decreased from 8.81 to 8.04 **mg/dl** in the control group (effect size = 0.54, p-value = 0.001).

Bilirubin (mg/dl)

The mean bilirubin (mg/dl) in the treatment group decreased from 15.37 to 9.59 **mg/dl** (effect size = 1.34, p-value < 0.001) but did not differ significantly in the control group (effect size = 0, p-value = 1).

Calcium creatinine

The mean calcium creatinine did not differ significantly in the Phototherapy group (effect size = 0.16, p-value = 0.300) but increased from 0.26 to 0.47 in the control group (effect size=-2.00, p-value < 0.001).

Creatinine (mg/dl)

The mean creatinine (mg/dl) decreased in both groups after the treatment, but this decrease was greater in the control group (effect size = 1.80, p-value < 0.001) than in the Phototherapy group (effect size = 2.48, p-value < 0.001) (Fig. 1).

DISCUSSION

The present study showed that phototherapy was associated with more favorable short-term laboratory changes in jaundiced neonates compared with controls. Infants receiving phototherapy showed higher post- treatment hemoglobin and calcium levels, alongside a marked reduction in bilirubin, without significant change in the calcium–creatinine ratio. In contrast, controls had a pronounced hemoglobin decline and an increased calcium–creatinine ratio. Renal function, as reflected by creatinine, improved similarly in both groups, indicating that phototherapy had no adverse renal effects.

We found that phototherapy was associated with more favorable short-term laboratory changes in jaundiced neonates compared with controls. This finding is partly consistent with a recent study of Meena et al, where blue-LED phototherapy significantly reduced bilirubin, blood urea, and creatinine while maintaining corrected calcium within the normal range, suggesting an overall beneficial short-term biochemical profile (23). Probably phototherapy rapidly lowers bilirubin, which can improve hepatic and renal function and thus lead to more favorable short-term laboratory trends than in untreated jaundiced neonates.

We found that infants receiving phototherapy had higher post- treatment hemoglobin and calcium levels, along with a marked reduction in bilirubin, compared with controls. This aligns with Can et al findings indicating that effective bilirubin reduction can occur without clinically relevant anemia, and that phototherapy-related changes in red cell indices often reflect transient oxidative adaptation rather than true hemolysis (24). However, several studies report that serum calcium tends to fall rather than rise during phototherapy, with a substantial proportion of neonates developing biochemical hypocalcemia, suggesting that our more favorable calcium profile may not be universally observed (25–27). One plausible explanation is that, in our cohort, careful attention to feeding, hydration, and possibly earlier initiation and shorter duration of LED phototherapy reduced hemolysis and stress responses while limiting calcium loss. Differences in device type, irradiance, distance from the infant, and local protocols for vitamin D or calcium support may also contribute to the discrepancy with studies in which phototherapy is consistently associated with decreased calcium levels.

In contrast, controls had a pronounced hemoglobin decline and an increased calcium–creatinine ratio. This finding is in line with Kassie et al.'s data showing that jaundiced neonates who do not receive timely or adequate phototherapy can experience progressive hemoglobin reduction, likely reflecting ongoing hemolysis and oxidative stress (28). However, most contemporary studies on neonatal jaundice focus on phototherapy-treated infants and report greater concern about hypocalcemia and increased urinary calcium excretion during treatment, while control or baseline groups generally exhibit smaller changes in calcium balance over similar periods (29–31).

Our study demonstrates that phototherapy does not impair renal function. This aligns with Xiong et al.'s findings, indicating that neonatal phototherapy side effects are generally mild and not severe (32). However, certain studies highlight phototherapy's side effects in neonates (33, 34). Thus, as a precaution, neonatal units should not assume phototherapy is entirely renally safe even within guideline thresholds, and should implement routine pre- and post-treatment monitoring of urea and creatinine to identify rare kidney issues and reassure families.

Study Limitations

This study has some limitations. First, non-randomized allocation may have introduced selection bias and residual confounding despite covariate adjustment. Second, the single-center design with a relatively small sample limits generalizability to other populations and care settings. Finally, the study focused on short-term biochemical changes, without a systematic assessment of clinical manifestations of hypercalcemia or long-term renal and skeletal outcomes.

CONCLUSION

Phototherapy emerges as an effective and safe treatment for jaundiced neonates in this Iranian cohort, producing more favorable short-term hematologic and biochemical profiles, including preserved hemoglobin and calcium levels alongside substantial bilirubin reduction, compared to untreated controls who exhibited hemoglobin decline and elevated calcium-creatinine ratios. Renal function confirms no phototherapy-related nephrotoxicity. These findings can challenge the universality of reported phototherapy side effects like hypocalcemia or anemia seen in other populations, highlighting the modulating influence of optimized supportive care (hydration, feeding) and protocol adherence. Clinical practice should therefore incorporate standardized serial monitoring of key markers (hemoglobin, calcium, creatinine, urinary ratios) to maximize benefits and detect rare complications early.

Declarations

Ethical Approval

The ethics committee at Gonabad University of Medical Sciences approved the protocol of this study, which was carried out in accordance with the principles of the Declaration of Helsinki and has the ethics

code [IR.GMU.REC.1403.025]. Written informed consent was obtained from the parents or legal guardians of all participants after they received a full explanation of the study's objectives, methods, benefits, and potential risks. Furthermore, it was emphasized that withdrawal from the study at any stage was possible without any consequences for the treatment process or receipt of medical services.

Competing interests

The authors declare no competing interests.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contribution

S.T.S. contributed to data collection and drafting of the manuscript. M.E. and A.A. were responsible for study methodology and statistical analysis. H.F. contributed to manuscript drafting and critical revision of the article. M.N. contributed to data interpretation and manuscript editing. J.M. conceived and supervised the study and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Acknowledgement

The authors express their gratitude to all individuals who participated in this study. The authors acknowledge the use of the Qwen-3-Max large language model (developed by Alibaba Cloud) for language editing and grammatical refinement of this manuscript. The model was used solely to improve clarity, grammar, and fluency. All scientific content, interpretation, and responsibility for the accuracy of the work rest entirely with the authors.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. No publicly archived datasets were generated.

References

1. Aynalem, S. et al. Hyperbilirubinemia in Preterm Infants Admitted to Neonatal Intensive Care Units in Ethiopia. *Glob Pediatr. Health.* **7**, 2333794X20985809 (2020).

2. Bhutani, V. K., Wong, R. J. & Stevenson, D. K. Hyperbilirubinemia in Preterm Neonates. *Clin. Perinatol.* **43** (2), 215–232 (2016).
3. Ansong-Assoku, B. A. M., Daley, S. & Ankola, P. Neonatal jaundice. StatPearls. (2024).
4. Diala, U. M. et al. Global prevalence of severe neonatal jaundice among hospital admissions: a systematic review and meta-analysis. *J. Clin. Med.* **12** (11), 3738 (2023).
5. Sarathy, L., Chou, J. H., Romano-Clarke, G., Darci, K. A. & Lerou, P. H. Bilirubin Measurement and Phototherapy Use After the AAP 2022 Newborn Hyperbilirubinemia Guideline. *Pediatrics* ;**153**(4). (2024).
6. Qian, S., Kumar, P. & Testai, F. D. Bilirubin encephalopathy. *Curr. Neurol. Neurosci. Rep.* **22** (7), 343–353 (2022).
7. El-Shaarawy, S. A., Abdel Rahman, H. M., Mohammed, A. A. & El-Shal, A. S. Influence of Phototherapy on Urinary Calcium Excretion among Full Term Neonates. *Egypt. J. Hosp. Med.* **89** (1), 5702–5709 (2022).
8. Gurama, K. I. et al. Comparative Assessment of Phototherapy-induced Hypocalcemia Among Neonates With Unconjugated Hyperbilirubinemia. *Res. Reviews Pediatr.* **26** (3), 59–64 (2025).
9. Kemper, A. R. et al. Clinical practice guideline revision: management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics* **150** (3), e2022058859 (2022).
10. Lin, Q. et al. Risk factors for neonatal hyperbilirubinemia: a systematic review and meta-analysis. *Translational Pediatr.* **11** (6), 1001 (2022).
11. Slaughter, J. L., Kemper, A. R. & Newman, T. B. Technical report: diagnosis and management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics*. ;**150**(3):e2022058865. (2022).
12. van der Geest, B. A. et al. Assessment, management, and incidence of neonatal jaundice in healthy neonates cared for in primary care: a prospective cohort study. *Sci. Rep.* **12** (1), 14385 (2022).
13. Westenberg, L. E. et al. Diagnostic accuracy of portable, handheld point-of-care tests vs laboratory-based bilirubin quantification in neonates: a systematic review and meta-analysis. *JAMA Pediatr.* **177** (5), 479–488 (2023).
14. Abdelatty, R. E., Abdelgawad, E. R. & Ramadan, I. A. Effect of Phototherapy on Serum Calcium and Magnesium Levels in Neonates Receiving Phototherapy for Neonatal Jaundice. *Egypt. J. Hosp. Med.* **85** (1), 3402–3406 (2021).
15. Chuang, G. T., Tsai, I. J. & Tsau, Y. K. Establishing a reference range for serum creatinine in the neonatal population and re-defining neonatal acute kidney injury. *Pediatr. Nephrol.* (2026).
16. Levailant, L. et al. Serum Calcium Normal Range in 1,000 Term Newborns. *Horm. Res. Paediatr.* **98** (2), 136–147 (2025).
17. Abohussein, H. A., Fahmy, B. S., Khalil, A. M. & Fahmy, Y. A. Effect of phototherapy on electrolytes, liver and kidney functions during treatment of neonatal hyperbilirubinemia. *Annals Neonatology J.* **4** (2), 170–186 (2022).

18. Pranty, A. I., Shumka, S. & Adjaye, J. Bilirubin-induced neurological damage: current and emerging iPSC-derived brain organoid models. *Cells* **11** (17), 2647 (2022).
19. Gaafar, M. M., Rasheed, E. M., Abdel Halim, S. M. & El Gendi, M. M. Effect of phototherapy on serum level of calcium and magnesium in term and preterm neonates with hyperbilirubinemia. *Egypt. J. Hosp. Med.* **80** (1), 743–747 (2020).
20. Poudel, D. et al. Phototherapy Induced Hypocalcemia in Term and Preterm Neonates with Hyperbilirubinemia: A Cross-Sectional Study. *J. Nepal. Med. Association* ;**63**(290). (2025).
21. Slusher, T. M., Abdulkadir, I. & Owa, J. A. Relevance of the 2022 American Academy of Pediatrics Hyperbilirubinemia Guidelines for an LMIC. *Pediatrics* ;**151**(4). (2023).
22. Faul, F., Erdfelder, E., Buchner, A. & Lang, A. G. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav. Res. Methods.* **41** (4), 1149–1160 (2009).
23. The Effect of Phototherapy on Various Biochemical Parameters in Neonatal Hyperbilirubinemia. *Indian J. Clin. Pract.* ;**36**(7):21–30. (2025).
24. Can, C., Hamilçikan, Ş., Karakurt, Y. & Can, E. Phototherapy modifies hematologic markers without inducing inflammation in neonates: a retrospective observational study. *Eur. J. Pediatr.* **184** (7), 397 (2025).
25. Pervaiz, G. et al. Effect of Phototherapy On the Serum Calcium Level in Term Neonates with Indirect Hyperbilirubinemia: Phototherapy in Term Neonates with Indirect Hyperbilirubinemia. *Pakistan J. Health Sci.* :189–193. (2025).
26. Kadavakollu, N. & Gopal, K. To Evaluate the Effect of Phototherapy On Serum Calcium Levels in Newborns Requiring Phototherapy According to AAP Guidelines. *Int. J. Pediatr. Neonatology.* **5** (1), 15–18 (2023).
27. Bahbah, M., ElNemr, F., ElZayat, R. & Aziz, E. Effect of phototherapy on serum calcium level in neonatal jaundice. *Menoufia Med. J.* **28** (2), 426 (2015).
28. Kassie, A. et al. Hematological parameter changes and associated factors in neonates with hyperbilirubinemia treated with phototherapy. *BMC Pediatr.* **25** (1), 115 (2025).
29. Sohail, H., Halim, A., Aaraj, S. & Mushtaq, N. Effect of Phototherapy on Serum Calcium Level in Neonatal Jaundice. *J. Islamic Int. Med. Coll. (JIIMC).* **20** (1), 49–53 (2025).
30. Eddala, K. & Bushra, R. K. S. Effect of Phototherapy on Serum Calcium Levels in Physiological Neonatal Jaundice. *J. Contemp. Clin. Pract.* **11**, 164–169 (2025).
31. Agarwal, P. Effect of Phototherapy on Serum Levels of Calcium, Magnesium, Phosphorus, and Vitamin D in Infants with Hyperbilirubinemia. *Int. J. Biomedical Sci. Res.* **1** (1), 1–6 (2025).
32. Xiong, T., Qu, Y., Cambier, S. & Mu, D. The side effects of phototherapy for neonatal jaundice: what do we know? What should we do? *Eur. J. Pediatr.* **170** (10), 1247–1255 (2011).
33. Faulhaber, F. R. S., Procianoy, R. S. & Silveira, R. C. Side Effects of Phototherapy on Neonates. *Am. J. Perinatol.* **36** (3), 252–257 (2019).

34. Fan, S. et al. Analysis of the effect of phototherapy on intestinal probiotics and metabolism in newborns with jaundice. *Front. Pediatr.* **10**, 878473 (2022).

Figures

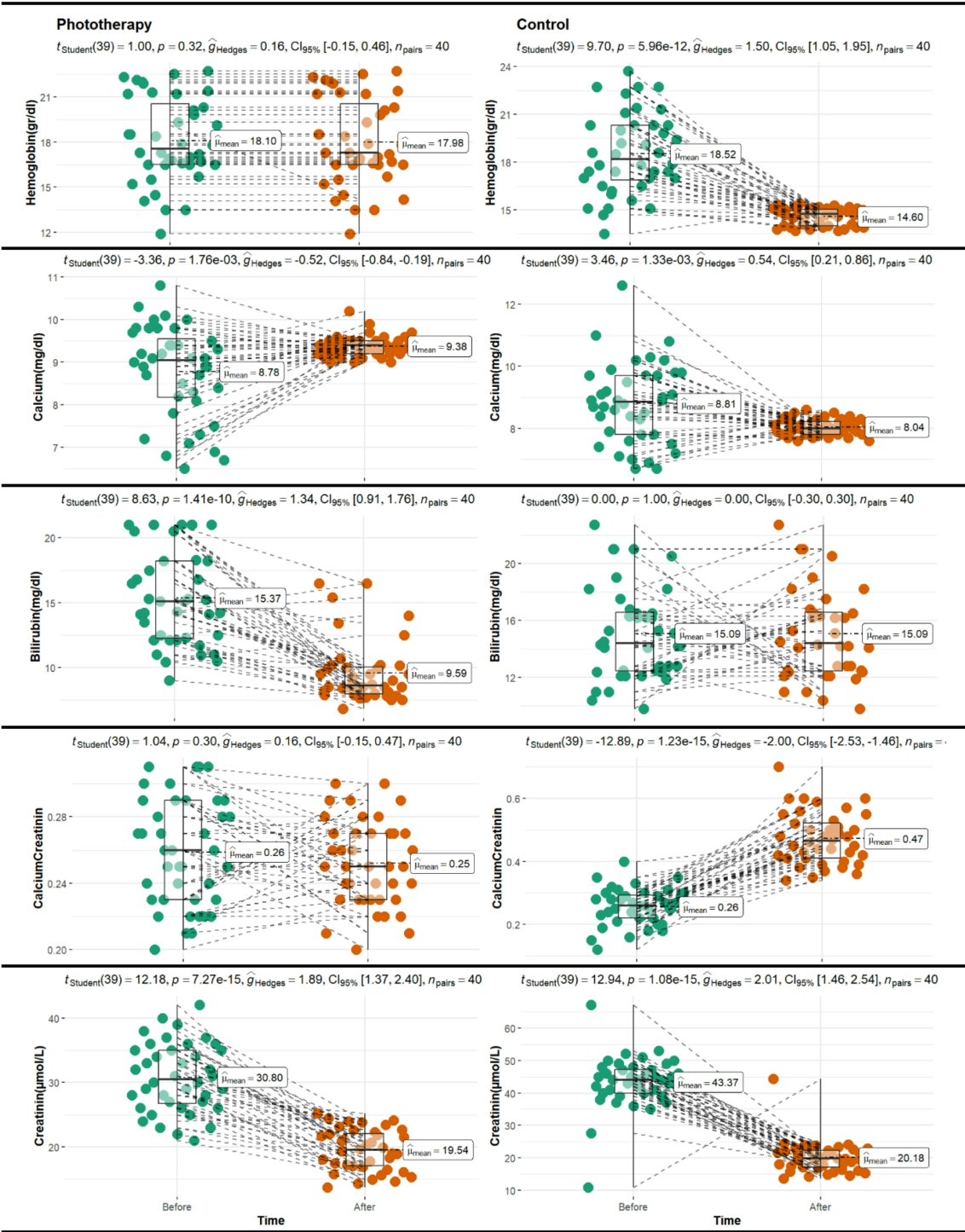


Figure 1

Examining the mean difference in clinical factors before and after invention