

Comparing the Effects of Continuous and Cyclical Lightings on Weight Gain and Length of Hospital Stay Among Preterm Neonates

Mahdi Esmaeilzadeh,¹ Mohsen Shoja,² Esmaeil Shoja,³ Mohamad Shoja,⁴ Hossein Nejat,⁵ and Davood Oudi^{6,*}

¹Department of Physiology, Esfarayen Faculty of Medical Sciences, Esfarayen, Iran

²Department of Epidemiology, Esfarayen Faculty of Medical Sciences, Esfarayen, Iran

³Department of Occupational Health, Faculty of Health, North Khorasan University of Medical Sciences, Bojnurd, Iran

⁴Department of Pediatrics, Faculty of Medicine, North Khorasan University of Medical Sciences, Bojnurd, Iran

⁵Nurse Staff, Vali Asr Hospital Open Heart Unit, Birjand University of Medical Sciences, Birjand, Iran

⁶Department of Nursing, Faculty of Nursing and Midwifery, Birjand University of Medical Sciences, Birjand, Iran

*Corresponding author: Davood Oudi, Instructor of Nursing, Department of Nursing, Faculty of Nursing and Midwifery, Birjand University of Medical Sciences, Birjand, Iran. Tel: +98-09365643539, E-mail: davoodoudi@yahoo.com

Received 2015 May 30; Revised 2015 October 25; Accepted 2015 October 31.

Abstract

Background: Hospitalization in neonatal intensive care units predisposes preterm neonates to negative stimuli such as continuous 24-hour lighting.

Objectives: The present study was done to evaluate the effects of a cyclical lighting model on weight gain and length of hospital stay among preterm neonates.

Methods: This clinical trial was performed during year 2012 on 60 preterm neonates, who were hospitalized in the neonatal intensive care unit of Bentolhoda hospital, Bojnord, Iran. The neonates were conveniently recruited and randomly allocated to a control and an experimental group through permuted block randomization. The neonates in these groups were exposed to continuous and cyclical lighting, respectively. Their weight and sleeping time were measured both before and after the intervention. Moreover, the length of their hospital stay was documented. The data were analyzed through doing the independent-sample t and the Mann-Whitney U tests by using the SPSS software (v. 18.0) at a significance level of less than 0.05.

Results: Before the study intervention, the groups did not differ significantly regarding the neonates' birth weight, Apgar score, height and sleeping time ($P > 0.05$). Compared with baseline values, the neonates' weight in the control and the experimental groups increased significantly during the study by 263 ± 52 and 232 ± 48 grams, respectively ($P = 0.02$). Moreover, the means of hospital stay in the groups were 10.6 ± 1.5 and 9.1 ± 1.4 days ($P = 0.03$) while the means of sleeping time were 17.03 ± 2 and 18.3 ± 2 hours/day ($P = 0.02$), respectively.

Conclusions: Using cyclical lighting in the same way as usual day/night-based lighting is recommended for neonates, who are hospitalized at neonatal intensive care units.

Keywords: Lighting, Darkness, Preterm Neonates, Weight Gain

1. Background

Neonatal mortality is among the main criteria for evaluating care quality and comparing healthcare systems of different communities (1). Currently, preterm delivery is one of the most common causes of neonatal mortality. It is usually associated with complications such as low birth weight, respiratory and digestive problems, and poor sensorimotor development, all of which can increase neonatal mortality (2). The prevalence of preterm delivery in our country, Iran, is around 9% (3-5), highlighting the need for closer attention to preterm neonates.

Although modern approaches to neonatal care have significantly improved preterm neonates' health conditions, preterm delivery is still a major cause of mortality,

neurologic complications and disability among neonates, who have no congenital defects and imposes heavy financial burden on healthcare systems (6, 7). In 2000, the cost of providing neonatal care in the United States was more than ten billion dollars from which, 60% was related to the neonates, who had a gestational age of less than 37 weeks and 12% to those with a gestational age of 24 to 26 weeks (8, 9). Although the rate of other causes of neonatal morbidity and mortality has decreased, preterm delivery has still remained a major neonatal health problem (10).

Compared with full-term neonatal care, preterm neonatal care is more important and difficult. Preterm neonatal care significantly improves preterm neonates' growth and development and reduces neonatal mortality rate. Therefore, creating a healthy condition is absolutely

necessary for improving preterm neonates' physical and neural growth and minimizing the risk of developing serious complications. Care services for enhancing the quality of preterm neonates' nutrition and sleep are of grave importance to their health. One of the strategies that can enhance the quality of nutrition, sleep and growth and reduce mortality rate among preterm neonates, is the regulation of their sleep-wake cycle through artificial cyclical lighting (11). However, our literature search yielded only a few human studies in this area, most of which dealt with evaluating the effects of cyclical or continuous lighting on neonatal outcomes such as weight gain, sleeping time, mechanical ventilation time, breastfeeding rate and length of hospital stay (12-14).

2. Objectives

The findings of these studies are conflicting and hence, the present study was performed to evaluate the effects of a day/night-based simulated lighting model on weight gain and length of hospital stay among preterm neonates, who were hospitalized at the neonatal intensive care unit (NICU) of Bentolhoda hospital, Bojnord, Iran.

3. Methods

This pretest-posttest controlled clinical trial was performed during year 2012 at the neonatal intensive care unit (NICU) of Bentolhoda hospital, Bojnord, Iran. Newborn preterm neonates were recruited in the study after their vital signs (including blood pressure and heart and respiratory rates) became stable. Neonates were excluded if they had a gestational age of more than 37 weeks, suffered from serious health conditions, or needed medical treatment or mechanical ventilation. Consequently, 60 neonates were conveniently recruited and randomly allocated to a control and an experimental group through permuted block randomization. In the experimental group, neonates were exposed to cyclical lighting while their counterparts in the control group were treated with normal lighting of the study setting, which involved non-cyclical lighting.

The neonates in the experimental group were hospitalized in a room, where the lighting and the sound could be controlled easily. In order to ensure that the levels of lighting and sound in the room were as low as a natural night, a lux meter (EC1-X, Hagner, Sweden) and a sound meter (TES, Taiwan) were used, respectively. The levels of lighting and sound were kept respectively at 3 - 7 lux and 45 decibels (15). Moreover, we opened the windows of the room during the day and exposed the neonates in the experimental group to natural daylight. In case of inadequate daylight,

artificial lighting at 200 - 300 lux was used to provide the neonates with adequate light (15).

The weight of the neonates in both study groups was measured using a weighing scale (BY20, Beurer Inc., Germany) both one-day before and one-day after the intervention. Weight measurements were performed for all participants, two hours after their meal and at the same time during the day. Moreover, the amount of their sleeping time was measured and documented by the staff nurses in each working shift. Accordingly, the amount of sleeping time was calculated through summing the sleeping times of all shifts of a day. All neonates in both groups were fed by the same feeding protocol, so that neonates, who were not adequately breastfed were bottle-fed with a standard infant formula. The length of hospital stay was determined through referring to the neonates' medical records. Data collection was performed by a research assistant, who was blind to the groups.

This study was registered in the Iranian registry of clinical trials with the following code IRCT2015060722583N1. The data were analyzed via the SPSS software (v. 18.0). The measures of central tendency and dispersion were used for data description while the independent-sample t and the Mann-Whitney U tests were run for between-group comparisons of body weight, length of hospital stay and amount of sleeping time. P values of less than 0.05 were considered significant.

4. Results

The study groups did not differ significantly from each other regarding the neonates' birth weight, gestational age, Apgar score, the amount of time receiving mechanical ventilation, and baseline weight ($P > 0.05$; Table 1). After the study intervention, the mean values of the neonates' weight and sleeping time in the experimental group were significantly higher while the length of their hospital stay was significantly shorter than their counterparts in the control group.

5. Discussion

The results of the study illustrated that compared with the neonates, who were exposed to continuous lighting; the neonates treated with the simulated cyclical lighting model had greater weight gain, shorter hospital stay and longer sleeping time. Cyclical lighting, meaning natural day/night-based lighting, conforms to circadian rhythm of the body and thus, provides better condition for a deep sleep. Moreover, it can increase the production of growth-related factors, facilitate weight gain and improve health status among neonates.

Table 1. Comparing the Study Groups Regarding the Neonates' Characteristics Before the Study Intervention

| Variable Group | Apgar Score | Mechanical Ventilation Time Before the Study (Hours) | Birth Weight (Gram) | Gestational Age (Weeks) | Hospital Stay Before the Study (Days) |
|---------------------|-------------|--|---------------------|-------------------------|---------------------------------------|
| Experimental | 7 (0.7) | 2.9 (0.5) | 1460 (345) | 33 (2) | 16.2 (3) |
| Control | 6.5 (0.6) | 3.4 (0.6) | 1440 (340) | 31 (2) | 15.5 (2.5) |
| P value | 0.43 | 0.13 | 0.16 | 0.64 | 0.33 |

Table 2. Comparing the Groups Regarding the Primary Outcomes of the Study

| Variables Groups | Weight Gain(Gram) | Hospital Stay (Days) | Sleeping Time A Day (Hours) |
|---------------------|-------------------|----------------------|-----------------------------|
| Experimental | 263 (52) | 9.1 (1.4) | 18.3 (2) |
| Control | 232 (48) | 10.6 (1.5) | 17.03 (2) |
| P value | 0.02 | 0.03 | 0.02 |

Miller et al. (1995) (16) also allocated 41 preterm neonates hospitalized in an NICU to a continuous and a cyclical lighting group. They matched the groups in terms of the neonates' birth weight, gestational age and Apgar score. In line with our findings, they found that compared with neonates, who were treated with continuous lighting, neonates in the cyclical lighting group had faster weight gain, faster breastfeeding onset, less need for phototherapy or mechanical ventilation, and better motor coordination.

Mann et al. (1986) (12) also investigated the effects of day/night-based lighting simulation on preterm neonates, who had a gestational age of less than 36 weeks. They allocated the neonates to either a cyclical lighting (20 ones) or a continuous lighting group (21 ones). The neonates in these groups were treated with cyclical day/night-based lighting and continuous 24-hour lighting, respectively. Their results illustrated that there were no significant differences between the groups in terms of the neonates' weight gain, oxygen therapy time and breastfeeding time. However, sleeping time in the cyclical lighting group was significantly longer than the continuous lighting group, i.e. after hospital discharge, the amount of sleeping time in the first group was two hours more than the second group. Moreover, post-discharge weight gain was significantly higher in the cyclical lighting group. In line with these findings, we also found that in the cyclical lighting group, sleeping time was significantly longer.

Taheri et al. (2005) (17) also recruited 66 preterm neonates from the NICU of Al-Zahra hospital (Isfahan, Iran), and allocated them to two 33-case groups. In one group, the neonates were exposed to cyclical lighting. Accordingly, they reduced the amount of luminance in the

NICU from 180 - 200 to 5 - 10 lux from 19:30 to 07:30. On the other hand, the neonates in their control group were exposed to continuous 24-hour lighting at a luminance of 180 - 200 lux. They measured their participants' weight both before and after the intervention and found that the mean weight variations in the cyclical lighting group were greater than the control group. This finding is in agreement with our findings.

Brandon et al. (2002) (14) also examined the effects of cyclical lighting and continuous near darkness on neonates with a gestational age of 31 weeks or less. They compared neonates, who had been exposed to cyclical lighting since birth with neonates, who had been treated with continuous near darkness since the same time. Their findings revealed that the neonates in the cyclical lighting group had faster weight gain compared with their counterparts in the continuous near darkness group. However, the groups did not significantly differ from each other concerning the length of hospital stay and the amount of time receiving mechanical ventilation. Our findings also revealed that cyclical lighting significantly improved the neonates' weight gain.

Boo et al. (2002) (18) also evaluated the effects of light exposure on weight gain among preterm neonates hospitalized at the NICU. They recruited 96 preterm neonates, who weighed less than 2000 grams and were aged at least seven days, and allocated them to a 50-person and a 46-person group. The neonates in the first group were exposed to light for twelve hours a day while in the second group; the neonates were placed in an environment with dim lighting until the time of their hospital discharge. Their findings revealed no significant difference between the groups in terms of the neonates' weight gain. This finding contradicts our findings probably due to the differences in the neonates' age, lighting protocol, or feeding protocol in these two studies.

Most studies have confirmed the effectiveness of day/night-based simulated lighting model on preterm neonates' growth. However, there are some conflicting findings, which can be attributed to differences in the methods, samples or contexts of the studies. Conducting large-scale studies to assess primary outcomes with more

precision is recommended.

5.1. Conclusion

The day/night-based simulated lighting model can improve preterm neonates' weight gain, decrease the length of their hospital stay and increase their sleeping time.

Acknowledgments

This study was approved and supported by the research administration and the ethics council of northern Khorasan University of Medical Sciences, Bojnord, Iran (approval code: 91.60.2321). Hereby, we thank the NICU staff of Bentolhoda hospital as well as all participants of the study.

References

- Yousefi Z, Khajeh Karamoddin M, Vahedian M, Ahmadian H. Prevalence of vaginal infections during pregnancy and its association with preterm birth [in Persian]. *J Shaheed Sadoughi Univ Med Sci*. 2002;10(3):65-9.
- Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Rouse DJ, Spong CY. *Williams Obstetrics*. Tehran, Iran: Arjmand Press; 2010. pp. 420-42.
- Davari Tanha F, Valadan M, Kaveh M, Bagherzadeh Jalilvand S, Hassan-zade M. Risk factors for recurrent preterm delivery in three university hospitals [in Persian]. *Tehran Univ Med J*. 2007;62(2):24-9.
- Sohrabi D, Ghanbari Gorgani M. A survey on Risk factors and outcomes of women with preterm labor admitted to Valiasr hospital in Zanjan [in Persian]. *J Urmia Nurs Midwifery Fac*. 2011;9(2):84-9.
- Lotfalizadeh M, Mohammadzadeh A, Kamandi S, Bagheri S. Incidence and risk factors of preterm birth in Imam Reza hospital-2000-2001 [in Persian]. 2005;8:93-100.
- Dyson DC, Danbe KH, Bamber JA, Crites YM, Field DR, Maier JA, et al. Monitoring women at risk for preterm labor. *N Engl J Med*. 1998;338(1):15-9. doi: [10.1056/NEJM199801013380103](https://doi.org/10.1056/NEJM199801013380103). [PubMed: 9414326].
- Yost NP, Cox SM. Infection and preterm labor. *Clin Obstet Gynecol*. 2000;43(4):759-67. [PubMed: 11100293].
- Adams KM, Eschenbach DA. The genetic contribution towards preterm delivery. *Semin Fetal Neonatal Med*. 2004;9(6):445-52. doi: [10.1016/j.siny.2004.04.001](https://doi.org/10.1016/j.siny.2004.04.001). [PubMed: 15691782].
- Ancel PY. [Preterm labor: pathophysiology, risk factors and outcomes]. *J Gynecol Obstet Biol Reprod (Paris)*. 2002;31(7 Suppl):510-21. [PubMed: 12454622].
- Creasy RK, Rensik R, Lams JD. *Creasy and Resniks Maternal - fetal medicine: principle and practice*. 7 ed. Philadelphia: Saunders/Elsevier; 2009.
- Hao H, Rivkees SA. The biological clock of very premature primate infants is responsive to light. *Proc Natl Acad Sci USA*. 1999;96(5):2426-9. [PubMed: 10051658].
- Mann NP, Haddow R, Stokes I, Goodley S, Rutter N. Effect of night and day on preterm infants in a newborn nursery: randomised trial. *Br Med J (Clin Res Ed)*. 1986;293(6557):1265-7. [PubMed: 3096460].
- Morag I, Ohlsson A. Cycled light in the intensive care unit for preterm and low birth weight infants. *Cochrane Database Syst Rev*. 2011(1):006982. doi: [10.1002/14651858.CD006982.pub2](https://doi.org/10.1002/14651858.CD006982.pub2). [PubMed: 21249685].
- Brandon DH, Holditch-Davis D, Belyea M. Preterm infants born at less than 31 weeks' gestation have improved growth in cycled light compared with continuous near darkness. *J Pediatr*. 2002;140(2):192-9. doi: [10.1067/mpd.2002.121932](https://doi.org/10.1067/mpd.2002.121932). [PubMed: 11865270].
- Omidianidost A, Ghasemkhani M, Kakooei H, Shahtaheri SJ, Ghanbari M. Risk Assessment of Occupational Exposure to Crystalline Silica in Small Foundries in Pakdasht, Iran. *Iran J Public Health*. 2016;45(1):70-5. [PubMed: 27057524].
- Miller CM, White R, Whitman TL, Ocallaghan MF, Maxwell SE. The effects of cycled versus noncycled lighting on growth and development in preterm infants. *Infant Behav Dev*. 1995;18(1):87-95.
- Taheri P, Dehghan D, Ghazavi Z, Hagh Shenas I. Effect of cycled light on weight gain of preterm infants in Isfahan in 2005 [in Persian]. *Iran J Nurs Midwifery Res*. 2005;10(1).
- Boo NY, Chee SC, Rohana J. Randomized controlled study of the effects of different durations of light exposure on weight gain by preterm infants in a neonatal intensive care unit. *Acta Paediatr*. 2002;91(6):674-9.