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Comparison of 2 Methods of Light Reduction on Preterm Infants' Sleep Pattern in NICU: A Randomized Controlled Trial

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Abstract

Objective: Growth and development of preterm infants may be negatively affected by constant bright light in neonatal intensive care units (NICUs). It may also contribute to sleep pattern disorders commonly seen in in this group of infants. Reducing exposure to light by covering the incubators is recommended by guidelines of the Neonatal Individualized Developmental Care and Assessment Program (NIDCAP).

Materials and Methods: This randomized clinical trial study was performed on 60 preterm infants with gestational age of 28-32 weeks admitted at NICU of Al-Zahra Teaching Hospital of Tabriz University of Medical Sciences in 2014. Preterm infants were divided randomly in 2 groups: In the first group (intervention), incubators were covered with a thick cover and the face was covered with a cloth (face cover). In the second group (observation), incubators were covered with a thick cover but the face was not covered. We darkened the environment of NICU by closing the curtain and turning off additional florescent lights from 19:30 PM till 7:30 AM in both groups, then we compared sleep pattern in 2 groups of infants by using sleep diagram.

Results: In the intervention group (face cover), the mean frequency of sleep during the 6 days increased by 2.96 times/ observations and the mean amount of sleep increased by 59 minutes.

Conclusion: This study showed that light reduction with incubator covers and eye shield, increases the frequency and sleep duration in premature infants.

Keywords: Preterm Infant, Sleep, Light reduction, Face cover

Introduction

Recent medical advances in neonatal care have led to an increase in survival rate of preterm infants and an increase in the length of stay in neonatal intensive care units (NICUs) (1). Sleep deprivation in fetal and neonatal periods seriously affects the nervous system and development in hospitalized infants (2). NICUs are usually inappropriate environments for infants to sleep due to brightness of overhead lights and excessive noise. In addition repeated painful medical and nursing procedures disturb sleep of infants during hospitalization (3).

Many studies have shown that disturbance in sleep-wake patterns of premature infants lead to complications such as: reduction in brain weight (4), decreased pain threshold (5), increased susceptibility to diseases (6), disruption in the early development of the senses, consciousness disorders, cognitive deficits, physiological disorders (7), and even sudden infant death syndrome (8). Exposure to irregular extra uterine light in the nursery may contribute to disturbances in body temperature and sleep patterns that are commonly experienced by preterm infants (9).

In most nurseries, preterm infants receive care in an environment that has no planned light-dark cycles. Infants are exposed to continuous bright light (CBL), continuous near darkness (ND) or an unstructured combination of both. Recommended ambient light in NICU is 100 to 200 lux during day and at night is lower than 50 based on ICU design guideline. In very preterm infants, there has been no demonstrable benefit of exposure to light. After 28 week of gestation, evidence suggests that diurnal cycled light (CL) has potential benefit for the infants (9). Caregivers may have some challenges from reducing levels of ambient light in performing tasks and maintaining wakefulness. There are different methods of reducing ambient light and decreasing exposure of infants to bright light in the units (9). Neonatal Individualized Developmental Care and Assessment Program (NIDCAP) guidelines recommend that most infants should be kept nearly in complete darkness during sleep. During alert periods, and/or when infants are held, controlled indirect lighting provides

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an overall muted or semi-dark environment. Evidence supports CL versus CBL shortens length of stay, as does CL versus ND. There is no research to evaluate ND by covering overhead of infants inside the covered incubators and evaluate its effect on sleep pattern in preterm infants. The aim of this study was to determine the effect of 2 methods of light reduction on preterm infants sleep pattern in a neonatal intensive care unit.

Published guidelines of NIDCAP on reducing exposure to light by covering the incubators, have not shown any significant improvement, short- or long-term outcomes (10). Creating more barriers for light inside the incubator (by covering the face) and inducing ND may help increase the sleep duration by reducing the light more effectively.

Materials and Methods

Subject Recruitment and Study Design

The present study was a randomized clinical trial. It was performed on 60 inborn premature infants with 28-32 weeks gestational age with birth weight ranging between 1716.5 ± 939.29 g (Mean and SD in intervention group: 1263 ± 324.31 and in control group: 1340 ± 376.5). The infants were admitted in the neonatal intensive care unit (NICU) of Al-Zahra teaching hospital of Tabriz, Iran from January 2014 to May 2014. Parents were asked to sign an informed consent. Exclusion criteria included congenital anomalies, need of phototherapy during observation days, mechanical ventilation and use of sleep affecting drugs in mother or infants (Tables 1and 2).

Sample and Size

Sample size was extracted from Mann study having mean and SD of 24.42 ± 1.32 for control group and 24.00 ± 1.45 for intervention group. We considered $\alpha = 0.05$ as error level and $\beta = 0.80$ as the statistical power. The sample size was 25 infants for each group that we considered 30 for probable loss of patients during the study. Randomization was performed by using the Rand list software.

Data Collection Instruments

We used a questionnaire consisting of demographic characteristics of infants like, gestational age, birth weight, Apgar score, gender and the risk factors of pregnancy including type of delivery, pre-eclampsia, and multiple pregnancies. A sleep diagram was implemented in order to record sleep-wake states of the infants during observations. Six levels of observable states are used based on the Brazelton Neonatal Behavioral Assessment Scale (BNBAS) (11). In order to determine sleep stage in our study, stages 1 , 2 and 3 of alertness were evaluated as sleep and marked in the sleep diagram.

Content validity of the questionnaire was determined by ten professors of the Nursing and Midwifery Faculty of Tabriz University of Medical Sciences. Moreover, the reliability of the scale was confirmed by a Cronbach alpha of 0.87. We provided a unit with a dim light for both groups by closing the curtains and turning off additional florescent lights from 19:30 PM to 7:30 AM. The incubators were covered by a thick cover. In the intervention group, we covered the face of the infants loosely with a second thin cover as an eye shield which dampened the light more effectively. We ensured that no aggressive interventions had been performed at least one hour before the observation. State of sleep and wakefulness, along with crying and feeding were observed and recorded in a sleep diagram by the researchers. Observers recorded daily activities such as sleeping, waking, eating or feeding during the 6 days for both groups on a checklist: in 20-minute intervals. On the first and sixth days, observation time was 12 hours and 6 hours from the second to the fifth day (2-7 AM). The period of the sleep/wake rhythm was calculated for each infant according to the data. The expert panel, with the participation of neonatologists and Head nurses of unit, agreed on the time of observations; as minimum activity

Table 1. Demographic Characteristic in 2 Groups of Preterm Infants[a]

Variables	Without Covering the Face		Covering Face Group		P
	Mean-SD	Max-Min	Mean-SD	Max-Min	
Gestational age (wk)	30-5.33	32-28	1.3529.68-	32-28	0.18
Birth weight (g)	1340-376.5	2000-1000	1263.6-324.31	2060-1020	0.19
Birth height (cm)	4-4.12	49-31	38.98-3.98	49-32	0.15
First minute Apgar	7-1.54	9-4	7.12-1.78	9-1	0.22

[a] Intervention group (covered face) and control (without the covering face).

Table 2. Demographic Characteristic in 2 Groups of Preterm Infants[a]

Variables	Without Covering the Face		Covering Face Group		P
	No.	Percent	No.	Percent	
Girl	18	53.40	17	62.20	0.11
Boy	12	46.60	13	37.8	0.11
NVD	4	15.20	3	8.90	0.12
CS	26	84.80	27	91.10	0.12

[a] Intervention group (covered face) and control (without the covering face).

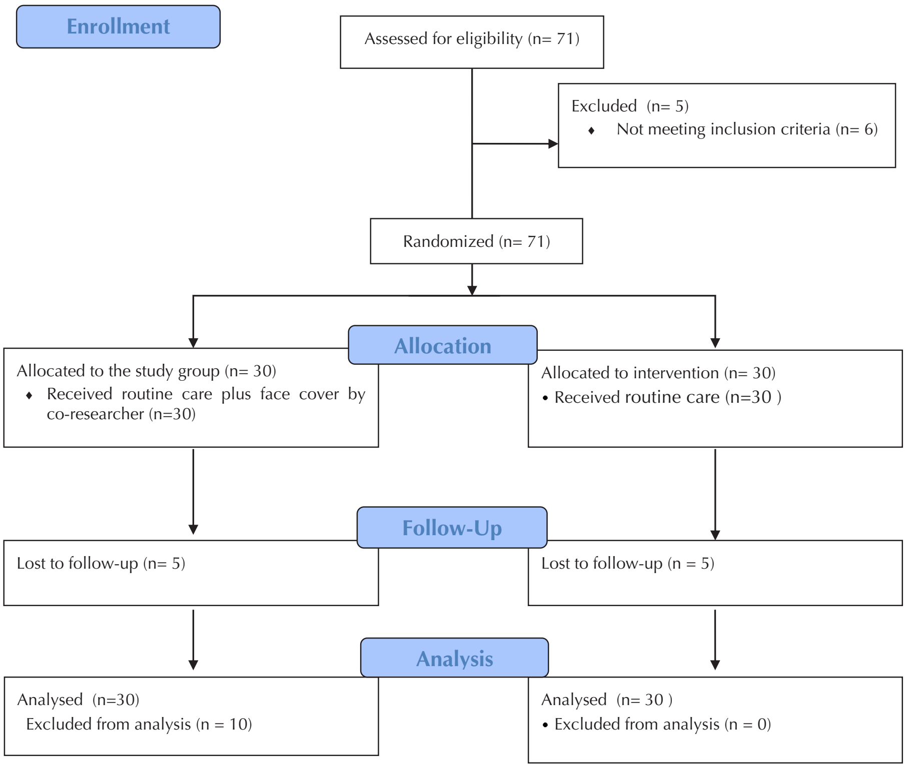

Figure 1. Flow Diagram of 2 Groups of Preterm Infants.

and interventions occurred during early morning hours. The observers were 2 experienced nursing staff who were trained by a certified trainer on the evaluation of alertness of infants according to the NIDCAP guidelines.

As a pilot study, the mean time of sleep of 10 infants was recorded separately by 2 observers. By using Cohen's kappa coefficient, inter-rater agreement between 2 nurses was found to be 81%. Noise was measured and recorded on the checklist by using 2 sound level meter model RS-232 as a mean made by Lutron Company placed in the middle of 2 parts of a rectangular shape unit and reported with decibel (dB, and light was measured with a lux meter model EXTECH401027 made by Lutron Company and placed near infants' faces inside the incubator. During the study, the amount of ambient light and noise were measured twice a day and it was attempted to maintain noise level at an acceptable level of less than 50 decibels (dB). In order to control the sound level in the NICU, we used noise reduction protocol according to the previous conducted study in our unit (12).

Statistical Analysis

Data were analyzed by using SPSS-13 software and descriptive statistical methods, and frequency and duration of sleep were analyzed using inferential statistics with independent t-test. The P value less than 0.05 was statistically significant. The repeated measures analysis of variance (ANOVA) compared means across variables that were based on repeated observations. Significant differences were followed by Sidak post hoc test. Sphericity assumption of correlations were assessed and confirmed by Mauchly test.

Results

We could not find statistically significant differences in birth weight, gestational age or severity of illness as assessed by the Clinical Risk Index for Babies (CRIB). The age of infants during observation was 2 weeks after delivery or more, when they did not receive respiratory support. Sixty infants finished the study and 11 infants had loss of follow up: six infants from intervention group and 5 from observation group. The main reason for exclusion were transfer to another NICU because of family convenience (4 infants in each group), 1 infant in intervention and 2 in observation group were referred to Children's hospital because of suspected necrotizing enterocolitis for sophisticated observation by pediatric surgeon team (Figure 1).

The mean frequency of sleep periods in the infants on the first day of intervention in the intervention group was 2.96 ± 2.12 compared to 3.21 ± 2.39 times/observations in control group, that changed to 31.46 on the sixth day in the covered face group as compared to 19.96 times/observations in the group without the face being covered. There was a significant difference between both groups in terms of the mean frequency of sleep periods from the first to the sixth days and in the entire 6 days of the study ($P = 0.0001$). This difference on the first and sixth day of intervention was 5.33 and 11.5 times, respectively; the frequency of sleep increased 2.17-fold (Table 3). The trend of changes in the means frequency of sleep periods in both

Table 3. The Mean Sleep Periods (times/observations) in Intervention (Covered Face) and Control (Without Covering Face) Groups During 6 Days of Observation

Study Days	Covering Face Group (n=30)	Without Covering the Face (n=30)	*P*
First day	28.53 ± 3.55	23.17 ± 3.61	0.001
Second day	17.90 ± 1.22	12.32 ± 2.25	0.005
Third day	17.01 ± 0.99	12.00 ± 1.60	0.016
Fourth day	16.01 ± 1.21	12.33 ± 1.70	0.033
Fifth day	18.12 ± 0.77	12.43 ± 1.81	0.001
Sixth day	31.46 ± 3.50	19.96 ± 3.50	0.001
Difference between 1st and 6th day in each group	2.96 ± 2.12	3.21 ± 2.39	0.0001
P value	$P<0.001$	$P<0.001$	

Table 4. Total Time of Sleep Periods (hours) in Premature Infants in Intervention (Covered Face) and Control Groups During 6 Days of Observation

Study Days	Covering Face Group (n = 30)	Without Covering the Face (n = 30)	*P*
First day	9.50 ± 3.5	7.71 ± 3.20	0.001
Second day	5.96 ± 1.28	4.10 ± 2.25	0.005
Third day	5.60 ± 0.98	4.00 ± 1.60	0.016
Fourth day	5.23 ± 1.21	4.10 ± 1.76	0.033
Fifth day	6.03 ± 0.76	4.20 ± 1.11	0.001
Sixth day	10.48 ± 3.2	6.60 ± 3.26	0.001
Difference between 1st and 6th day in each group	1.83 ± 0.98	2.31 ± 1.11	0.0001
P value	$P<0.001$	$P<0.001$	

groups also showed a significant difference from the first to the sixth day.

Table 4 presents the total time of sleep periods (hours) in premature infants in intervention (covered face) and control groups during the 6 days of observations.

The mean sleep duration in infants was 570 minutes on the first day in the intervention group compared to 463 minutes in control group, and changed to 629 minutes on the sixth day in the intervention group (ND) compared to 396 minutes in control group. We found a significant difference between the 2 groups in the mean amount of sleep from the first to the sixth day of intervention (p=0.0001). The mean duration of sleep in the covered-face group increased 59 minutes on the sixth day compared to the first day, but the mean amount of sleep in the group without facial cover decreased 67 minutes on the sixth day compared to the first day. The difference between 2 groups was around 107 minutes on the first day and around 233 minutes on the sixth day of intervention; there was a 2.17-fold increase in the difference (Table 3). The trend of changes in the mean amount of sleep in both groups from the first to the sixth day of the intervention also shows a significant difference.

During the 6-day observations, the mean of light measured inside the incubator in the intervention group (covered face) was 2.55 ± 2.23 (range 0- 5 lux) and 8.11 ± 1.39 (5 to 12 lux) in the control group ($P = 0.0001$) which reflects the effectiveness of the intervention in reducing the amount of ambient light received by the infants and making ND. Mean of noise level in the ward during observation days was 47-56 dB for both groups. The mean and standard deviation of the noise level in 2 points of unit were 52.76 ± 6.96 and 53.83 ± 3.29 dB that was not statistically significant. As noise is one of the major causes of sleep disorder, it can be concluded that noise was well controlled in both groups, and the effect of this confounding variable on infants' sleep was eliminated ($P < 0.001$).

Discussion

There is a trend to use lower lighting levels in NICUs. Supporting the sleep pattern of preterm infants is one of the goals in developmental care of preterm infants (10). Most of the experts agreed that newborn infants are more stable and consume less energy in low light conditions. Monitoring systems helps nursing staff to work in the units with lower level of light. On the other hand, evidence suggests that natural light (NL) have good effect on human health and welfare.

Creating more barriers for light inside the incubator (by covering the face) and creating ND may help in increasing the sleep duration by reducing the light more effectively. Some nurseries define ND as 5 to 10 lux. Morag and Ohlsson in 2016 in a Cochrane systematic review assessed CL in the intensive care unit for preterm and low birth weight infants (cycled light: approximately 12 hours of light on and 12 hours of light off). They concluded that CL versus CBL shortens length of stay, as does CL versus ND. We could not find any research in making ND by covering the face of infants inside the covered incubators and evaluate its effect on sleep pattern of preterm infants. In previous studies, light reduction was just limited to coverage of incubators (9).

Our study showed that the mean duration and the frequency of sleep periods in the infants whose faces were covered and had ND during 6 days of intervention increased as compared to control group. In control group, duration of sleep and number of sleep periods decreased on the sixth day in comparison to the first day. Several studies showed that a covering over the infant's incubator increased sleep time in these infants from 4.5 hours to approximately 9.5 hours 3 months after discharge (13,14). Our results are in line with Hailstorm et al study that showed dimming the environment was effective in improving sleep time in premature infants with gestational age of 28-32 weeks (15), as it created a resting environment similar to maternal womb.

Dreyfus-Brisac shows that rhythmic cycling periods of activity and quiescence can be identified in the human fetus between 28 and 32 weeks of gestation. Neither quiet (NREM, non-rapid eye movement) nor active (REM, rapid eye movement) sleep can be identified in premature babies between 24 and 26 weeks of gestations (16). Although sleep begins to consolidate and establish its relation to the light /dark cycle by sixth week after birth, the longest wake period is still randomly distributed in 3 months (17).

In general, the results of this study showed that modulation of environmental factors such as reducing the level of light, along with pulling a shield on the face of infants could increase sleep amount in premature infants in NICU, and this revealed the effectiveness of the intervention (18).

One of the strengths of this study was the long observation time (48 hours during the 6 days) which increased the validity of the findings, while most studies on sleep control in newborns has been only for 24 hours.

The present study showed covering of the face will be useful in improving sleep in premature infants in NICU. Therefore, it is recommended that all methods implemented in this study including covering the incubators, closing the curtains in the ward, reducing lights and noise in the ward, and covering infants' faces in NICU would increase sleep periods and time. However, further research is needed to investigate whether covering the face has a long-term effect on duration of sleep or not.

In this study, we only assessed infant sleep pattern for 6 days. However, we suggest the conductance of studies with longer periods of time. We could not record electrical activities of brain during sleep, so we recommend arranging a research by polysomnography or amplitude-integrated electroencephalography (aEEG) monitoring for further studies.

Conflict of Interests

The authors declared no conflict of interest.

Ethical Issues

The study was approved by the ethics committee of Tabriz University of Medical Sciences (No. 93129). The goal of our study was explained to the parents and they signed a written informed consent. The study was registered in IRCT (Iranian Randomized Clinical Trials; http://irct.ir/) with IRCT201409114613N13 code.

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