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The effect of light and noise reduction on the sleep state of preterm infants

Reducing light and noise

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Abstract
Aim: The aim of this study was to determine the effect of reducing light and noise on the sleep of preterm infants.
Material and Methods: This randomized controlled trial study was conducted on 80 preterm infants. Infants in the study group were observed under a coated oxygen hood to reduce light and noise, and the infants in the control group were observed under a standard oxygen hood, for two hours.
Results: The gestational age of preterm infants in the study group was 32.92±1.17 and in the control group- 33.31±0.90 weeks. There was a significant difference between the study and control groups in terms of the sleep state and activity count ($p< 0.05$).
Discussion: It was concluded that the preterm infants slept longer and the activity count was lower by reducing the light and noise.

Keywords
Infant, Light, Neonatal Intensive Care Unit, Noise, Premature

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Introduction

Nearly 4% of newborns with normal birth weight and 85% of newborns with low birth weight are hospitalized in high-tech Neonatal Intensive Care Units (NICUs) every year [1]. While NICUs can potentially offer remarkably life-saving precautions to such vulnerable infants after birth, they pose a traumatic process for these infants suffering from critical illness due to separation from their mother, pain, social isolation, sleeplessness, and environmental features (stressors), which activate the hypothalamic-hypophysis-adrenal (HPA) axis [2]. The presence of complex, multidimensional (physical, psychosocial, clinical practice), painful and negative stimuli and the lack of developmentally supportive stimuli in the NICUs cause critical and destructive stressors, primarily in these vulnerable infants' brain development as well as in their other systems [3]. Infants respond to stress with bradycardia or tachycardia, changes in oxygen saturation, and abnormal sleep patterns [4].

Due to stressors, preterm infants spend more energy; their healing process, growth, and ability to organize themselves are all negatively affected [5]. The healing environment, which one of the most important components of developmental care, constitutes the most emphasized steps of developmental care present in developmental care models [5,6]. The goal of the healing environment is to support healing by minimizing the negative effect of the extrauterine NICU setting on the developing preterm infant's neurodevelopment [6]. It has been reported that high light levels impair the health of the newborn, therefore the newborn light environment should be individualized [7]. Noise and loud light are recognized as sources of stress that can alter the well-being and development of sensitive preterm infants [8]. Reduction of light and noise in the healing environment is important, especially when it comes to providing preterm infants with supportive developmental care [5,6,9].

By taking these features into consideration, an oxygen hood coated with a transparent film was developed to protect preterm infants from light and noise. The aim of this study was to determine the effect of reducing light and noise on sleep, oxygen saturation and heart rate of preterm infants in NICU.

Material and Methods

Study design

The study was conducted as a randomized controlled trial in the NICU of a university hospital between April 2017 and October 2018. The rooms contained incubators, one sensor door, as well as devices such as ventilator, monitor, and pump based on the patient's condition. Three nurses were working in each ward where the study was conducted. Five physicians, sixteen nurses, four staff members, and four secretaries were on duty between 8:00 am and 4:00 pm every day in the NICU. The physicians, staff members, and secretaries went in and out of the wards.

The NICU, where care was given to high-risk newborns, provides level III and advanced level III intensive care service in terms of its equipment and medical staff. A central bright light was used in the rooms where the study was conducted. The incubators were routinely closed with a cover that just covered the top of the incubators in order to allow the infants to be viewed. In order to determine whether the groups were homogeneous in terms of noise, the researchers took noise measurements outside the incubators of all preterm infants in the study and control groups.

Participants

According to one study [10], it was assumed that the sleep duration of the infants in the study group was longer than those in the control group at the rate of 20%, and the sample size was determined as a total of 74 cases, including minimum 37 cases in each group at the power of 80% at the level of α=0.05. A total of 80 preterm infants were included in the study by considering the possible case losses. The inclusion criteria were determined as follows: 1) Being born at ≤ 34 GW and being within the first 48 hours after delivery [4], 2) Able to receive treatment with an oxygen hood, 3) Having passed ABR (BERA) test.

The exclusion criteria were determined as follows: 1) Suffering from either a congenital anomaly and/or sepsis, 2) Being sedated and being diagnosed with neurological problems, 3) Be intubated, and 4) Receiving CPAP therapy.

The study was conducted using randomization URN method [11]. The colors of the balls used for the study group and the control group were red and white, respectively. When there was an infant who met the inclusion criteria, the balls previously prepared by the researcher were put into a black bag. Any nurse working in the unit at that time was asked to select one of the balls from the bag upon closing her eyes. The infant was assigned to the study group or control group according to the color of the selected ball. In the CONSORT diagram [12], while 39 preterm infants were included in the study group, 41 preterm infants were included in the control group (Figure 1).

Measures

The information form consists of information about the preterm infants' gestational age, inclusion time, birth weight, birth height, sex, and delivery type.

A standard oxygen hood (Natus Medical Inc., San Carlos, CA, USA) was used in the control group. In the study group, the researchers used a standard oxygen hood coated with a transparent, single-layered, and polyester film having a high tensile and breaking strength and low light and ultraviolet transmittance (3MTM, Denmark). A metallurgical and materials engineer covered the outer part of the oxygen hood. The outer part of the oxygen hood was coated with 0.75 mm film. After the oxygen hood was coated, it was left to dry for one month.

The light penetrating standard oxygen hood was determined as 370.2 lx and the light penetrating coated oxygen hood was determined as 214.8 lx in the same environment using a calibrated light meter/photometer (Apollo 1.0, Labino, Sweden). The noise was measured using two calibrated sound level meters (Geratech Sound Level Meter DT-8852/data logger). The noise level in the incubator was 58.1 dBA with the standard oxygen hood and 55.7 dBA with the coated oxygen hood. The coated oxygen hood is registered by the Turkish Patent Institute (Registration no: 2016 19181).

Continuous data monitoring of the oxygen saturation and heart rate was performed using Draeger infinity vista xl medical monitor (Dragerwerk AG & Co.KGaA, Dubai, UAE) and probe (Amydi-med, Nellcor Spo2 Neonate/adult). The data were recorded on the monitor for each one minute between 10:00 am and 12:00 pm.

A sleep-wake activity monitor (Actiwatch 2, Phillips Respironics, USA) was used to measure the sleep-wake status of an infant. In a study conducted in Australia with thirteen term and nine preterm infants, the sleep state of the infants was examined using an Actiwatch and polysomnography devices. It was reported as a result of the study that there was a coherence rate of 89-94% between the Actiwatch and polysomnography device. It was recommended to use the Actiwatch device in infants under six months of age [13,14]. Another study examined the validity of the Actiwatch upon assessing the sleep-wake state of preterm infants in a NICU in Taiwan. In the study, the device was compared with the Anderson Behavioral State Scale (ABSS) and attached to the infants' wrists. The Actiwatch device was assessed as follows: "0" if the infant was asleep and "1" point if the infant was awake. The scale was assessed as follows: the infant was considered asleep for "1 – 4" point(s) and awake for "5 – 12" points. It was found that there was a coherence rate of 68.23 – 81.30% between the Actiwatch device and the ABSS [15]. It was noninvasively attached to the wrist of each preterm infant in the study and control groups. The sleep-wake status of the infant was recorded.

Ethical considerations

The approval from the ethics committee (No: 10840098-604.01.01-E.24329; Date: 16/11/2016), written institutional permission, and necessary ethics committee approval from the national Medicine and Medical Devices Agency (No: 71146310-511.06-E .49431; Date: 2/3/2017) were obtained. Written consent was obtained from the families of the infants to be included in the study.

Procedure

All of the infants were given clustered care at the clinic. The infants were fed either every two hours (≤ 1250 g) or every three hours (≥ 1250 g) based on their weight and clinical condition. In the literature regarding sleep reports a follow-up duration of 2 – 4 hours in order to assess sleep [16]. The follow-up duration in the present study was determined as two hours, as some of the infants were fed every two hours and some others were fed every three hours in the present study. It was reported that the prone position decreased stress behaviors against environmental stressors (noise, light, and touching), therefore meaning that infants slept for a longer time [17]. In the present study, the infants in the study and control groups were not touched for two hours and were laid down in the prone position only. Permission was obtained from the doctor and nurse of the baby in each group included in the study. The nurse responsible for the infants performed the care, feed, and treatment times of the infants in the study group and control group. It was ensured that in the study and control groups, preterm infants took a rest and were not touched for two hours between 10:00 am and 12:00 pm. Both groups were followed up with a sleep-wake activity device and monitor device between these hours and the measurements were recorded. Ambient noise was measured from outside the incubator of each baby.

Statistical analysis

The NCSS 2007 program was used for statistical analyses. Descriptive statistical methods (mean, standard deviation, median, frequency, percentage, minimum, maximum) were used to evaluate the data of the study. Compatibility of the quantitative data to the normal distribution was tested using the Shapiro-Wilk test and graphical examinations. Independent samples t-test and repeated measures test were used in the comparison of normally distributed quantitative variables between two groups; whereas, the Mann-Whitney U test and Friedman Test were used in the comparison of quantitative variables, which did not show normal distribution, between two groups. Pearson chi-square test and Fisher's exact test were used to compare the qualitative data. The $p<0.05$ was accepted as statistical significance.

Results

It was determined that the mean gestational age of the preterm infants in the study and control groups was 32.92±1.17 and 33.31±0.90 weeks, respectively. There was no significant difference between the groups in terms of descriptive characteristics and environmental variables ($p> 0.05$) (Table 1). The ambient noise level was 62,36±1,58 dBA (min: 59,16 dBA; max: 65,73 dBA) and 62,23±1,78 dBA (min: 58,44 dBA; max: 65,32 dBA) in the study and control group, respectively for two hours ($p> 0.05$).

The sleep state of the infants was longer in the study group than in the contol group for a total of two hours and was statistically significant ($p< 0.05$). The total activity count of the preterm infants in the study group for a total of two hours was found to be significantly lower than the control group ($p< 0.05$). There was no significant difference between the groups in terms of oxygen saturation and heart rate of the infants for a total of two hours ($p> 0.05$) (Table 2).

Table 1. Comparison of descriptive characteristics of the preterm infants and environment according to groups (N = 80)

Variables	Study group (n=39)	Control group (n=41)	p
	Mean (SD)	Mean (SD)	
Gestational age, wk.	32.92 (1.17)	33.31 (0.90)	[a]0.159
Time when the preterm infants were included in the study, h	36.10 (12.64)	37.58 (10.97)	[a]0.713
Birth weight, g	2053.59 (405.77)	2084.15 (436.62)	[b]0.747
Birth height, cm	43.33 (2.93)	43.19 (4.51)	[a]0.558
Birth head circumference, cm	31.02 (1.97)	31.06 (2.53)	[a]0.391
Gender (%)			
Female	20 (51.3)	22 (53.7)	[c]0.832
Male	19 (48.7)	19 (46.3)	
Delivery type (%)			
Vaginal	4 (10.3)	3 (7.3)	[d]0.709
Caesarean	35 (89.7)	38 92.7)	

Table 2. Comparison of preterm infants' data according to groups for total 2 hours (N = 80)

Variables (min)	Study group (n=39)	Control group (n=41)	p
	Mean(SD); Min-max	Mean(SD); Min-max	
Oxygen Saturation	97.78(1.68); 91.3-100	97.11(2.01); 89.5-99.8	[a]0,105
Heart rate	136.09(8.89); 113-154	136.07(10.38); 114.25-157	[b]0,992
Sleep time	116.28(4.64); 96.8-120	113.40(6.76); 90.5-120	[a]0.038*
Activity count	589.03(975.72); 0-4787	1284.71(1950.37); 0-9637	[a]0.047*

Abbreviations: SD, standard deviation; [a] Mann-Whitney U test; [b] Independent samples t-test; [c] Pearson Chi square; [d] Fisher's exact test. *p<0.05.

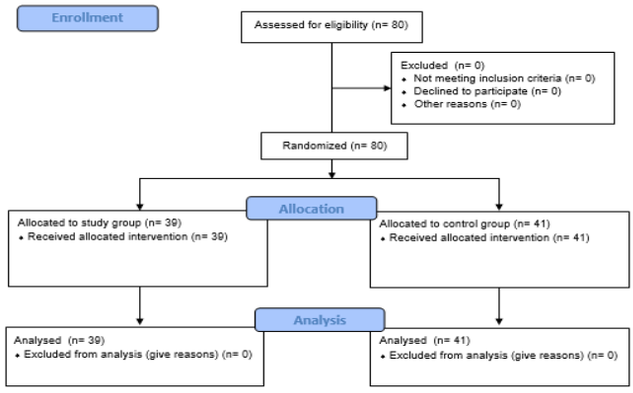

Figure 1. The CONSORT flow diagram

Discussion

Clinical studies that reduce light and noise as components of the healing environment are limited in the literature. In the present study, we used a coated oxygen hood that reduced light and noise and evaluated the sleep state of preterm infants in the NICU. We showed that the preterm infants slept longer and the activity count was lower by reducing the light and noise. There was no difference in terms of oxygen saturation and heart rate values between the groups for total of two hours.

In a similar study, earmuffs were used on preterm infants to decrease the noise and their sleep state, oxygen saturation and heart rate were measured. Thirty-minute records were taken from the infants every two hours within 8 hours during the day for 2 days. It was found that infants' ABSS scores were 1.34±0.3 for with earmuffs and 3.07±1.1 for without earmuffs, which means that those with earmuffs slept significantly longer than the ones without ($p< 0.01$) [10]. Oxygen saturation and heart rate of the infants were comparable ($p> 0.05$) between the groups, similar to our study. In another study using earmuff, the physiological and behavioral findings of the infant were recorded every 2 hours between 8:00 am-4:00 pm. Similarly, ABSS scores were found lower in babies with earmuffs compared to ones without earmuffs, but differently, oxygen saturation values were significantly higher and heart rate values were significantly lower in babies with earmuffs. In that study, the fact that the noise level experienced by the infants with and without earmuffs during the procedure was not measured was emphasized as a limitation [18].

Aita et al. [19] conducted a study using earmuff and eye patch to decrease the light and noise, and they determined that oxygen saturation was the minimum and mean heart rates were the same between groups, except for the higher maximum heart rate. They said that this finding that preterm infants had higher maximum heart rate while they were wearing the earmuff and eye patch should not be an indication that light and noise should not be controlled in the NICU [19].

In a recent study examining the effect of light and noise, no intervention was made to the infants on the first day. It was found that the noise level was 59.4±3.0 dB and the light level was 204±29 lx. On the second day, the infants were given ear plugs and were exposed to a light level of 202±26 lx. The incubator cover was applied on the third day. The noise level was 57±10.6 dB, and the light level was 1.45±0.35 lx. The sleep states of the infants were measured using an electroencephalography (Amplitude-Integrated Electroencephalogram (aEEG)) device for three days. Their NREM sleep scores were higher on the 3rd day (1447±180) compared to the scores determined on the first (1215±129) and second days (1356±162), which means that reducing light and noise increased the infants' NREM sleep states [20].

Conclusion

According to the results of our study compatible with previous studies, reducing light and noise exposure provides longer sleep with fewer movements in preterm infants. It may be suggested to carry out studies that examine other components of the healing environment for future research.

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Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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