CE 1.5 HOURS Continuing Education

Effects of Cycled Lighting Versus Continuous Near Darkness on Physiological Stability and Motor Activity Level in Preterm Infants

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ABSTRACT

Background: Preterm infants generally spend weeks in the neonatal intensive care unit where light intensity can fluctuate as well as be high, leading to physiological instability and increased motor activity in these infants. To date, 2 lighting control methods have been studied: cycled lighting and continuous near darkness. The most appropriate method of lighting is still unknown due to ambivalent results from the studies that have assessed these 2 interventions.

Objective: To compare the effects of cycled lighting versus continuous near darkness on physiological stability and motor activity level in preterm infants born between 28 and 32 weeks of gestation.

Methods: A randomized clinical trial was conducted to compare physiological stability and motor activity level in preterm infants assigned to cycled lighting or continuous near darkness. Thirty-eight participants were recruited and randomly assigned to one of the lighting conditions for 24 hours. Physiological stability was measured using the Stability of the Cardiorespiratory System in Premature Infants (SCRIP) score, the means, and the coefficient of variation of each physiological parameter measured. The level of motor activity was measured with an accelerometer.

Results: There were no significant differences between the 2 groups with regard to physiological stability measured by the SCRIP score, means, and coefficient of variation as well as motor activity level. Participants in both groups were physiologically stable and their motor activity level was comparable.

Implications for Practice and Research: Neither cycled lighting nor continuous near darkness negatively impacted infant's physiologic stability and motor activity level. Further research is required to identify the most appropriate lighting control method for preterm infants born between 28 and 32 weeks of gestation.

Key Words: continuous near darkness, cycled lighting, motor activity level, physiological stability, preterm infant, randomized clinical trial

Lighting in the neonatal intensive care unit (NICU) differs from that of the uterine environment.[1-3] The fetus develops in a light-free environment without visual stimulation,[4] whereas preterm infants in the NICU are exposed to fluctuating and at times high-intensity lighting levels. In fact, in the NICU, lighting can fluctuate from 21.19 to 138.10 lux[2] or 7 to 821 lux[3] over a 24-hour period and can increase to 1200 lux in very little time with procedures involving a lamp.[5] Furthermore, light intensity inside an incubator has fluctuated 259 times from 10 to 50 lux and 73 times from 50 lux and more over a 10-hour period.[6] Exposure to fluctuating or high-intensity lighting triggers signs of stress in preterm infants such as physiological instability[5-10] as well as an increase in motor activity level.[7,9] In the longer term, exposure to high-intensity lighting can impair the retinal, ocular, and visual system functions of preterm infants.[4,11-15] It is, therefore, preferable to control the lighting in the NICU in order to encourage premature infants adaptation to their environment, which is manifested by physiological stability[7,9] and a reduction in motor activity level.[7,9,16]

Thus far 2 methods of lighting control in the NICU have been identified and studied: cycled lighting[7,16-20] and continuous near darkness.[21-27] Some of these studies reported the beneficial effects of cycled lighting, whereas other studies described significant results from continuous near darkness. Furthermore, these studies have methodological limits as well as divergent findings and do not provide a way to identify which method of

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lighting should be used in the NICU.[28] Further studies are required to determine which method of lighting control (cycled lighting or continuous near darkness) better promotes physiological stability and reduced motor activity level in preterm infants in the NICU. No study comparing cyclic lighting and continuous near darkness on physiological stability and motor activity level for 24 hours was identified. The aim of this study was, therefore, to evaluate and compare the effects of cycled lighting versus continuous near darkness on physiological stability and motor activity level in preterm infants born between 28 and 32 weeks of gestation.

LITERATURE REVIEW INSPIRED BY THEORETICAL FRAMEWORKS

According to the synactive theory of development,[29] preterm infants have 5 subsystems, including the autonomic and motor subsystems, which demonstrate stress or adaptation responses when exposed to environmental stimuli such as fluctuating or high-intensity lighting in the NICU.[29] Moreover, according to Roy's adaptation model,[30] nurses should control lighting in the NICU to promote the environmental adaptation of preterm infants and avoid unsuitable responses indicative of stress. In this way, implementing interventions aimed at lighting control would have the effect of promoting preterm infant adaptation, which should manifest itself, according to earlier studies, through improved physiological stability[7,9,31] and reduced motor activity level.[7,9,16,18]

Continuous Near Darkness

Continuous near darkness is defined as light reduction (<20 lux) for a 24-hour period.[28] This lighting control method has been studied mainly in combination with other interventions such as noise reduction, grouping of care, and nonnutritive sucking among others.[21-26] Few studies have examined continuous near darkness as a monointervention.[9,32,33]

Nevertheless, reduced nighttime lighting seems to improve physiological stability and reduce motor activity level in preterm infants. In the cross-over study by Shiroiwa et al,[9] participants were exposed to 10 hours of reduced lighting by wearing light therapy glasses (eye shields) and a hood during the nighttime, which reproduced continuous near darkness. They were then exposed to a period of continuous lighting. The participants' physiological stability and motor activity level were measured during exposure to these 2 lighting periods and then compared. The results showed a reduction in body movements in preterm infants as well as lower frequency and variability in their respiratory rates when exposed to reduced lighting during the nighttime compared with the continuous lighting exposure period.[9] Exposure to a near darkness period seems to have an effect on the physiological stability and motor activity level of preterm infants. However, continuous near darkness has been very little studied as a monointervention and no studies have been identified that evaluate the effects of continuous near darkness on physiological stability and motor activity level in a period lasting more than 10 hours in preterm infants.

What This Study Adds

- Data on physiological stability and motor activity in a randomized controlled trial comparing cycled lighting and continuous near darkness.

Cycled Lighting

Cycled lighting is defined as lighting that follows a day–night cycle[34] to promote the establishment of a circadian rhythm in preterm infants.[16] A number of studies have reported the beneficial effects of this lighting on preterm infants, namely decreased heart beat and motor activity level,[7] the establishment of a faster circadian rhythm,[16] faster weight gain,[17,19,35] fewer hospitalization, and mechanical ventilation days[19] as well as less restlessness, crying, and motor activity at night.[18] These studies compared cycled lighting with continuous near darkness[16-18] or continuous lighting.[7,19,35]

In spite of the numerous studies that examined the effects of cycled lighting, only a few evaluated the effects of this method on physiological stability and motor activity level in preterm infants. In fact, Blackburn and Pattesson[7] reported that preterm infants exposed to cycled lighting over 24 hours presented decreased heart rates and motor activity level at night compared with those exposed to continuous lighting over 24 hours. However, in this study, cycled lighting was compared with continuous undimmed lighting and the participants were not randomized. Furthermore, the duration and light intensity applied during cycled lighting were not clearly defined. Rivkees et al[16] also observed that the group exposed to cycled lighting presented significantly lower motor activity level during the nighttime when compared with the group exposed to continuous near darkness. On the other hand, the main goal of Rivkees et al[16] was to study the establishment of a circadian rhythm evaluated by the number of movements during the daytime and nighttime. Guyer et al[18] reported reduced levels of motor activity during the nighttime in participants at 5 weeks of corrected age exposed to cycled lighting compared with participants exposed to continuous near darkness. Based upon the results of these studies, it therefore seems that exposure to cycled lighting favors physiological stability and reduced motor activity level in preterm infants. However, these 2 studies lasted for a long period (25-34 days) and they were designed to evaluate the establishment of the participants' circadian rhythm, not the physiological stability nor the motor activity level.

Thus far, no study has compared the effects of cycled lighting and continuous near darkness on physiological stability and motor activity level in preterm infants over a 24-hour period during hospitalization. Research questions were:

Q1: What is the difference in physiological stability (heart rate, respiratory rate, and blood oxygen saturation levels) between preterm infants exposed to cycled lighting as compared with continuous near darkness?

Q2: What is the difference in motor activity level (number of periods with movements) between preterm infants exposed to cycled lighting as compared with continuous near darkness?

METHODS

Design

The study design (a randomized comparative clinical trial) makes it possible to evaluate the efficacy of 2 interventions (cycled lighting and continuous near darkness) on preterm infants admitted to the clinical setting of an NICU.[36] The preterm infants were recruited and randomized to 1 of the 2 study arms. Randomization was done by interchanged blocks of 3 and 6. The group assignment, according to computer-generated distribution sequence, was placed in opaque, numbered, and sealed envelopes by a statistician. According to the order indicated by the numbering, one of each participant's parents opened an envelope in the presence of the person in charge of recruiting as soon as the consent form was signed. The research study was approved by the research ethics board and clinical ethics committee of the institution where the study took place. Informed free consent was obtained from one of the parents to recruit each of the participants in the study.

Sample

A total of 38 preterm infants were recruited for this study. Sample size was calculated based on the Lee and Bang study[37] for which physiological stability was evaluated with the Stability of the Cardiorespiratory System in Premature Infants (SCRIP) score in preterm infants at 32 weeks and more of gestational age. The results of Lee and Bang's study[37] indicated that the preterm infants placed in the kangaroo position for 30 minutes presented a significantly higher SCRIP score of 9% when compared with participants in the control group who remained in their incubators. This significant difference of 9% with a standard deviation of 0.3 indicates an effect size of 1.6. In order to perform a conservative calculation of the sample size for the present study, an effect size of 1 was used. Considering $\alpha = 0.05$ and $\beta = 0.20$ (power = 80%), a group size of 16 subjects per group was calculated for a total sample of 32 participants. However, the experimental study by Rivkees et al,[16] which explored cycled lighting in a population that was similar to that of this study, revealed a 17.7% attrition rate. The size of the sample was consequently increased by 18% to a total of 38 participants (19 per group).

The preterm infants were eligible to participate in this research study if they (a) were born between $28^0/_7$ and $31^6/_7$ weeks of gestation, (b) were more than 24 hours' old, (c) were in an incubator at the time the data were collected, and (d) had a parent who was at least 18 years' old and who spoke and read English or French. This gestational age bracket was selected because preterm infants under 28 weeks of gestation show an immature and inadequate response when exposed to continuous intense lighting,[38] whereas those of more than 32 weeks of gestational age had the ability to react in a suitable manner when exposed to inadequate lighting.[13] Preterm infants were not eligible to take part in the study if they (a) presented a specific clinical condition influencing physiological stability or motor activity (eg, congenital defect, cardiac health problems, gastrointestinal disease, and Grade III or IV intraventricular hemorrhage), (b) required ventilatory support that provides a set respiratory rate, (c) were receiving medications like catecholamines that could influence physiological stability, or (d) had obtained an Apgar score less than 6 at 5 minutes of life.

Intervention

The preterm infants assigned to the cycled lighting group were exposed to lighting of 200 to 225 lux between 7 AM and 7 PM and under 20 lux between 7 PM and 7 AM as recommended by National Association of Neonatal Nursing[39] and Morag and Ohlsson.[28] To attain this light intensity, the incubator cover was partly raised during the daytime, the neon ceiling lights were turned on, and the window blinds closed. Only 2 panels of the incubator cover that covered the upper part of the incubator were lowered to avoid direct light exposure to the eyes of the preterm infants. During the evening and at night (7 PM to 7 AM), the incubator cover was lowered and the neon ceiling lights were turned off to reduce the lighting to under 20 lux. Only 1 of the 5 panels of the incubator cover could be raised to ensure the clinical monitoring of the participants by the care team.

Preterm infants randomized to the continuous near darkness lightning group were exposed to lighting less than 20 lux over 24 hours.[28] To attain this light intensity, the incubator cover was placed on the incubator and the neon ceiling lights were turned off. Only one of the 5 panels of the incubator cover was raised to ensure the clinical monitoring of the preterm infants by the care team.

Intervention fidelity was ensured by the continuous measurement of light intensity in the preterm

infants' incubators using an Omega HB3336-03 photometer. Participants randomized to the cycled lighting arm were exposed to an average light intensity of 215 lux in the daytime (7 AM to 7 PM) and an average of 0.84 lux in the nighttime (7 PM to 7 AM). Participants assigned to continuous near darkness were exposed to an average light intensity of 1.85 lux during the daytime and an average of 0.23 lux during the nighttime.

Measures

Several elements were measured such as sociodemographic data, primary and secondary variables as well as several other variables (handling, positioning, and kangaroo care) that could influence the dependent variables measured during the application of the assigned intervention.

Sociodemographic Data

Gestational age, Apgar score, birth weight, weight at the time of the data collection, number of days of life, SNAPPE II (Score for Neonatal Acute Physiology-Perinatal Extension II) score that made it possible to evaluate the clinical condition of the participants,[40] the type of delivery, and respiratory support required at the time of the data collection were noted on a specific form designed for this purpose. The preterm infants' medical records were consulted to provide these data.

Physiological Stability

Physiological stability was measured using the SCRIP score, which made it possible to evaluate heart rate, respiratory rate, and Spo_2 levels.[41] For each parameter, a score was attributed according to a scale and 3 categories: severe instability (0 point), minor instability (1 point), or stability (2 points). The scores could vary from 0 to 6. A higher score meant higher physiological stability. In this study, the evaluation rating of the SCRIP score proposed by Fischer et al[41] was adapted to existing standards in the NICU where the study took place (see Table 1).

The coefficient of variation (CV) (standard deviation divided by the mean) and the means were also calculated for each of the 3 parameters. The CV indicates the variability of the physiological parameter. This makes it possible to identify a physiological parameter that varies considerably, but whose mean is situated within the normal range. The means were calculated because they were frequently reported in studies that evaluated physiological stability in preterm infants[37,42-48] and this made it possible to compare findings from this study with those from previous studies.

To calculate the SCRIP scores, the CVs as well as the means and physiological parameters (heart rate, respiratory rate, and Spo_2 levels) were measured every 5 minutes during the 24-hour period using a General Electric cardiorespiratory monitor located at the bedside of each preterm infant admitted to the NICU. The data were printed from the cardiorespiratory monitor and then entered into an Excel spreadsheet. Desaturation, bradycardia, and apnea episodes were also noted in the database using the preterm infants' records that documented these events.

Motor Activity Level

Motor activity level was measured with an Actiwatch 2-type accelerometer from the company Respironics. The accelerometer was attached to the preterm infants' ankle during the entire exposure period of the assigned intervention as done by Rivkees et al[16] to promote the comparison of results obtained. The recorded data represented the presence or absence of motor activity in 15-second intervals. In this way, the number of intervals with activity was calculated to compare motor activity between these 2 intervention groups.

Other Variables That Were Considered

Other variables that could influence physiological stability and motor activity level in preterm infants were considered in this study. To this end, the duration of handling,[49,50] the preterm infant's positioning (ventral, dorsal, and lateral positions) in the incubator,[51,52] as well as the frequency and duration of kangaroo care[37,41,53-55] were evaluated using a monitoring form developed for this study. The bedside nurses entered

TABLE 1. SCRIP Score Rating Scale[a]

Variables[b]	Score 2	Score 1	Score 0
Heart rate	Between 120 and 160 BPM Does not exceed 200 BPM	Deceleration between 80 and 100 BPM	Bradycardia <80 BPM Tachycardia >200 BPM
Respiratory rate	Between 30 and 60 BrPM Does not exceed 100 BrPM	Periodic respiratory pauses (apneas <10s, regular breathing <20/s 3 times)	Apnea >10 s or tachypnea >100 RPM
Blood oxygen saturation level (Spo_2), %	Spo_2>85%	Spo_2 period(s) between 85% and 80%	Spo_2 period(s) <80%

Abbreviations: BPM, beats per minute; BrPM, breaths per minute; SCRIP, Stability of the Cardiorespiratory System in Premature Infants.
[a]Adapted from Fischer et al.[41]
[b]Scores attributed every 15 minutes for each variable.

the required information on this form over the 24-hour period. Furthermore, because noise can also influence a preterm infant's physiological stability[50,56-59] and motor activity level,[60,61] this variable was measured continuously in dBA using an Omega sonometer over the entire 24-hour period of exposure to the intervention. It must be specified that data collection for physiological stability and motor activity level was interrupted when the participants were placed in the kangaroo position, because they were taken out of the incubator, placed on one of their parents, and the incubator cover could no longer be used to control the lighting according to the assigned intervention.

Procedures

Recruitment took place in the NICU of a mother–child university hospital center in the greater metropolitan area of Montreal. The NICU had a section dedicated to intermediate care (level II) and another dedicated to intensive care (level III). These 2 sections had several care rooms where 2 patients per room in intensive care and up to 3 patients in intermediate care stayed. Participants were recruited in these 2 sections. Although this care unit did not have a lighting policy, there were some nursing practices related to lighting control at the time of the study. For example, all the incubators were covered with incubator covers. The main lighting in the room consisted of neon ceiling lights that were kept off for most of the day and night and, when needed, task lighting was used (eg, procedure lamps). When task lighting was used, the nursing practice involved covering the preterm infants' eyes with an opaque element such as a serviette or blanket. In addition, each window in the rooms had adjustable blinds.

After recruitment, the participants were randomized to 1 of the 2 intervention arms, either the cycled lighting group or the continuous near darkness group. Exposure to the assigned intervention and data collection lasted 24 hours for participants in both groups.

Statistical Analyses

The statistician who conducted the statistical analyses was blinded to the participant's assignment. Analyses to answer the research questions used a bilateral hypothesis test with a significance level of 0.05 using SAS version 9.3. Sociodemographic data from the 2 intervention groups were compared using the Fisher exact test for categorical data (Apgar, SNAPPE II score, etc) and the Student *t* test for continuous data (gestational age, weight when data were collected, etc). The SCRIP scores were compared between the 2 groups using the analysis of variance (ANOVA) with repeated measurements to evaluate physiological stability. The means and CVs of each of the 3 physiological parameters obtained in the 2 groups were compared using a Student *t* test or Wilcoxon test when the data did not follow a normal distribution. For motor activity level, the sum of the activity periods was compared between the 2 groups with a generalized estimating equation model. The data collected on the confounding variables (handling, positioning, kangaroo care, and noise) were compared between the 2 groups using the Student *t* test, Fisher exact test, or χ^2 test. For continuous variables, the Student *t* test was used when the data were distributed normally, whereas the Wilcoxon test was used for data that were not distributed normally. The Fisher exact test was used for categorical data when the categories did not contain more than 5 items.

RESULTS

Recruiting took place between March 2013 and May 2014 with a 51% refusal rate. The parents justified their refusal by giving the following reasons: they were not interested in their preterm infant participating in a research study (n = 29); they did not wish to see any changes to the preterm infant's environment, since the child had been admitted to the NICU, which implied to them that its state of health was fragile (n = 7); and they did not want their infant to be assigned randomly to a treatment group (n = 5). Out of the total of 38 patients recruited, 18 were assigned to the cycled lighting group and 20 to the continuous near darkness group. Out of the 18 patients assigned to the cycled lighting group, 2 did not receive the intervention because one of them became ineligible after recruitment and the other withdrew from the study after randomization according to its parents' wishes. Therefore, the analysis included 16 participants exposed to cycled lighting and 20 patients exposed to continuous near darkness. Figure 1 illustrates the recruitment of the participants.

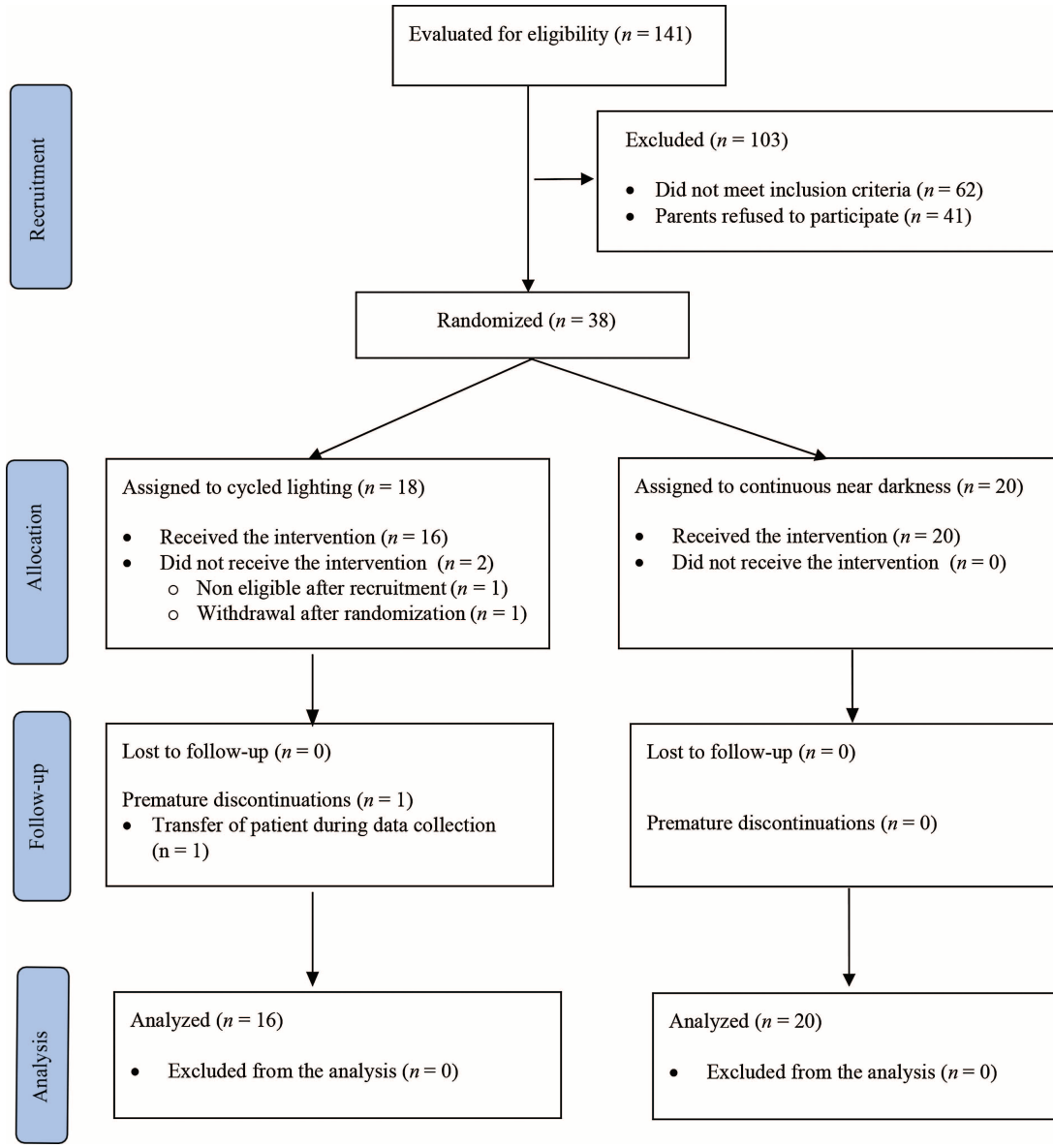
Sociodemographic Data

The sociodemographic data of the preterm infants randomized to the cycled lighting group and those randomized to the continuous near darkness group were comparable; that is, there was no significant difference between the 2 intervention groups with regard to these data (P = .10-.77, respectively; see Table 2).

Primary Outcome Variable

There was no significant difference between the SCRIP score of the preterm infants exposed to cycled lighting (5.84) and those exposed to continuous near darkness (5.84) for the 24-hour period (P = .96). Similarly, the analyses performed to compare the SCRIP scores of the 2 groups for the daytime, nighttime, and initial 10-minute periods did not reveal any significant difference (P = .86, .87, and .54, respectively; see Table 3). The means and CVs for heart rate, respiratory rate, and Spo_2 levels over the 24-hour, daytime, and nighttime periods were compared between the 2 study groups. A comparison of these

FIGURE 1



Recruitment of the participants.

2 groups using the means calculated for heart rate, respiratory rate, and Spo_2 levels revealed that there was no significant difference between the 2 groups for the 3 periods that were analyzed (P =.30-.99, respectively). Similarly, a comparison of these 2 intervention groups using the CV of the heart rate, respiratory rate, and Spo_2 levels for the 24-hour, daytime, and nighttime periods did not show any significant difference (P = .43-.99, respectively; see Table 3).

Secondary Outcome Variable

With regard to motor activity level, a comparison of the number of intervals during which an activity was recorded over the 24-hour, daytime, nighttime, and 10-minute periods after exposure to the intervention did not reveal any significant difference between the 2 intervention groups (P = .84, .88, .72, and .09, respectively; see Table 4).

Other Variables That Were Considered

There is no significant difference between the 2 intervention groups with regard to the duration of handling, positioning, duration, and frequency of kangaroo care and ambient noise (P = .12-.79, respectively; see Table 5).

DISCUSSION

This study found no statistically significant differences in physiological stability and motor activity level in

TABLE 2. Results for the Sociodemographic Data

Variables	Continuous Near Darkness (n = 20) Means (Standard Deviation)	Cycled Lighting (n = 16) Means (Standard Deviation)	*P* Value
Gestational age, wk	30.04 (1.28)	30.21 (1.29)	.68[a]
Apgar score 1 min	6.35 (2.11)	5.75 (2.67)	.22[b]
Apgar score 5 min	7.1 (1.25)	7.56 (1.67)	.1[b]
Apgar score 10 min	8.3 (1.17)	8.63 (1.20)	.43[b]
Birth weight, gm	1323.5 (231.57)	1349.25 (260.14)	.76[a]
Weight at data collection, gm	1429.65 (179.83)	1458 (273.94)	.71[a]
No of days of life	11.9 (6.69)	12.5 (5.44)	.77[a]
SNAPPE II score	4.6 (7.51)	2.25 (6.15)	.26[b]
Type of delivery			.72[b]
Vaginal, n	7	4	
Cesarean, n	12	11	
Respiratory support			.50[b]
Ambient air, n	9	5	
Nasal cannulas, n	11	11	

Abbreviation: SNAPPE II, Score for Neonatal Acute Physiology-Perinatal Extension II.
[a]*Student t test.*
[b]*Fisher exact test.*

preterm infants born between 28 and 32 weeks when exposed to cycled lighting and continuous near darkness for 24 hours. In addition, infants were physiologically stable throughout the study in both intervention groups. These findings are important given our study is one of the first to explore physiologic

TABLE 3. Results for Physiological Stability

	Continuous Near Darkness (n = 20)		Cycled Lighting (n = 16)		*P* Value	
	Means (SD)	CV (SD)	Means (SD)	CV (SD)	Means	CV
Physiological stability for the 24-h period						
SCRIP score	5.84 (0.19)		5.84 (0.27)		.96[a]	
Respiratory rate	51.02 (6.61)	0.27 (0.05)	53.91 (11.69)	0.26 (0.04)	.39[b]	.75[b]
Heart rate	162.47 (7.10)	0.07 (0.01)	161.02 (9.49)	0.07 (0.01)	.60[b]	.59[b]
Spo_2	94.88 (3.13)	0.02 (0.02)	95.16 (2.94)	0.02 (0.01)	.81[b]	.84[c]
Daytime physiological stability						
SCRIP score	5.82 (0.22)		5.84 (0.32)		.86[a]	
Respiratory rate	50.63 (6.40)	0.26 (0.06)	54.15 (12.11)	0.25 (0.04)	.30[b]	.44[b]
Heart rate	162.44 (6.97)	0.07 (0.014)	160.59 (10.13)	0.07 (0.012)	.52[b]	.43[b]
Spo_2	95.59 (2.93)	0.02 (0.02)	95.55 (2.74)	0.02 (0.01)	.91[c]	.59[c]
Nighttime physiological stability						
SCRIP score	5.85 (0.17)		5.84 (0.23)		.87[a]	
Respiratory rate	51.37 (8.01)	0.25 (0.06)	53.86 (12.41)	0.25 (0.04)	.48[b]	.83[c]
Heart rate	162.49 (7.57)	0.07 (0.014)	162.54 (8.62)	0.07 (0.016)	.99[b]	.71[b]
Spo_2	95.58 (2.59)	0.02 (0.01)	95.05 (2.94)	0.02 (0.01)	.41[c]	.99[c]
Physiological stability for the first 10 min						
SCRIP score	5.75 (0.14)		5.85 (0.12)		.54[c]	

Abbreviations: CV, coefficient of variation; SCRIP, Stability of the Cardiorespiratory System in Premature Infants; SD, standard deviation.
[a]*Repeated-measures ANOVA.*
[b]*Student t test.*
[c]*Wilcoxon test.*

TABLE 4. Results for Motor Activity

	Continuous Near Darkness (n = 20) Means (Standard Deviation)	Cycled Lighting (n = 16) Means (Standard Deviation)	*P* Value
Activity periods for the 24-h period	1656.05 (485.11)	1640.8 (416.14)	.84[a]
Daytime activity periods	856 (282.28)	769.25 (295.77)	.88[a]
Nighttime activity periods	800 (265.99)	840.53 (317.80)	.72[a]
Activity periods for the first 10 min	12.39 (8.44)	11 (9.44)	.09[a]

[a]*Generalized estimated equation model.*

stability and motor activity outcomes when comparing cycled lighting to continuous near darkness.

Previous studies with significant improvement in physiological stability and motor activity levels in premature infants compared a controlled lighting intervention to continuous bright light,[7,9] which is known to be related to physiological instability and increased motor activity level in premature infants.[28,62-65] Therefore, a controlled intervention (cycled lighting or continuous near darkness) may have systematically favored physiological stability and reduced motor activity level in the studies with a continuous bright light comparison group. The lack of differences in our study suggests that these light-controlled interventions are safe for physiologic stability of premature infants. Moreover, positive findings associated with previous studies may also be related to the fact that the light control intervention occurred over longer periods.[16-20,31,35,66] One study with intervention exposure time from birth until hospital discharge[31] observed improvement in oxygen saturation and in the rhythmicity of the heart rate in infants exposed to cycled lighting over continuous bright light. Another study compared infants who received cycled light for 25 days with infants who received continuous near darkness throughout their hospitalization found that infants in the cycled light group developed rhythmicity in their motor system, demonstrated by lower motor activity level at night, 21 to 30 days earlier than the continuous near darkness group.[16] Similarly, Guyer et al[18] reported that participants exposed to cycled lighting over 30 to 34 days showed greater rhythmicity of their motor activity level, as shown by a higher day/night activity ratio at the 11th week of life when compared with continuous near darkness. Given the limited research, evaluation of the impact of light control on physiological stability and motor activity in preterm infants for longer exposure periods is needed. Furthermore, previous studies had a more marked difference between daytime and nighttime lighting when applying cycled lighting.[9,18] Exposure to higher daytime light intensity is consistent with the recommendations of Morag and Ohlsson,[28]

TABLE 5. Results for Other Measured Variables

Variables	Continuous Near Darkness (n = 20) Means (Standard Deviation)	Cycled Lighting (n = 16) Means (Standard Deviation)	*P*
Handling			
Duration, min	116.85 (44.45)	94 (39.68)	.12[a]
Positioning (frequency)			
Dorsal	2.15 (1.14)	2.25 (2.02)	.31[b]
Ventral	2.15 (1.35)	2.13 (1.63)	.79[b]
Right side	2.30 (1.22)	1.75 (0.68)	.26[b]
Left side	1.70 (1.13)	2.25 (1.13)	.16[b]
Kangaroo care			
Duration, min	59.2 (68.26)	93.81 (104.31)	.24[a]
Frequency	0.7 (0.8)	1.0 (1.10)	.71[c]
Noise			
Intensity, dBA	52.48 (4.0)	51.16 (3.92)	.33[a]

[a]*Student t test.*
[b]*Fisher test.*
[c]χ^2 *test.*

Summary of Recommendations for Research and Practice	
What we know?	• Both cycled light and near darkness are safe for physiologic stability in premature infants. • Cycled lighting promotes the establishment of a circadian rhythm in preterm infants.
What needs to be studied?	• Evaluation of the impact of light controls on physiological stability and motor activity of preterm infants for a longer exposure period is needed. • For future research about the impact of lighting control on physiological stability and motor activity level, it would be interesting to differentiate participants' handling related to care from those related to comforting, because the latter favor psychomotor and neurological development in preterm infants. • Further studies are needed to compare cycled lighting and continuous near darkness.
What we can we do today?	• In light of the results obtained, the application of cycled lighting or continuous near darkness should be encouraged in NICUs for preterm infants born between 28 and 32 weeks of gestation by the establishment of clinical guidelines. • The Cochrane review conducted on cycled lighting and continuous near darkness reveals evidence favors the application of cycled lighting rather than continuous near darkness.

and the recommendations of experts who established *Recommended Standards For Newborn ICU Design*.[67] Thereby, it is possible that exposure to a daytime light intensity of more than 215 lux for the participants assigned to cycled lighting would promote the reactivity of the participants' physiological parameters and motor system in 1 of the 2 groups by accentuating the difference between cycled lighting and continuous near darkness.

Although our study had a small sample size (n = 36) and therefore our findings should be interpreted with caution, our sample size is comparable to previous studies that measured the impact of lighting control on physiological stability and motor activity level in preterm infants.[7,9,18,31] Our study did not differentiate handling related to care from those related to comforting. Because the latter favor psychomotor[23] and neurological development[21,25] in preterm infants, it would be interesting to evaluate the type of handling to which participants were submitted during the study period. Future research examining the impact of light control interventions for premature infants should include a more diverse group of preterm infants, employ longer intervention time frames, and examine both physiologic and circadian rhythm outcomes.

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