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The Effect of Light and Sound Settings on the Physiological Responses in Premature Babies

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Most premature infant deaths are caused by the maladaptive response of the extrauterine environment, which causes stress to the baby's environment. This can cause problems in circulation, oxygenation, and metabolism that can interfere with the growth and neurophysiological development of the baby. Different characteristics in the mother and baby can affect the optimisation of the application of various methods of developmental care. This study aims to ascertain the effects of light and sound on the physiological responses (O2 saturation) in premature infants. The study used a descriptive correlation design with a cross-sectional approach. The sample was comprised of 52 infants with consecutive sampling techniques. Analysis of the correlation test was used to determine the strength of the relationship (r) and the 95% confidence interval. Subjects were divided into two groups: control (n = 30) and intervention (n = 22). The control group showed that there was no significant difference in SaO2 (p = 0.558) and pulse (p = 0.396) before and after 24 hours. The intervention group showed that there was no significant difference in pulse (p = 0.104) but significant differences in SaO2 (p = 0.011) before and after 24 hours. Sound and light arrangements effectively improve SaO2.

Keywords: *Light setting, Response Physiology, premature.*

Introduction

Being born at less than 37 weeks of gestational age can lead to perinatal morbidity and mortality (Zhang et al., 2012). Prematurity is the primary cause of morbidity and mortality in neonates worldwide, especially in developing countries (Patel, 2016 and Glass et al., 2015). The World Health Organisation (2015) estimates that 15 million babies are born each year and more than 1:10 births are premature. Preterm birth rates range from 5% to 18% of all babies born. In Indonesia, in 2016, there were approximately 675,700 premature babies born, or 19 per 1000 live births (Sutarjo, Primadi: 2017). Indonesia ranks at fifth in the world for the number of premature babies born (WHO, 2015). The Sustainable Development Goals (SDGs) target is a neonatal mortality rate of 12 per 1000 live births by 2030 (Sutopo, Fitriana and Rahmi, 2014).

Babies born prematurely have a greater risk of death, disease, and disability and can experience cognitive, visual, auditory, emotional, social, health, and growth problems when compared to a healthy baby (Zhang et al., 2012). Premature infant deaths can be a result of organs that are immature and unable to adapt adequately to the extrauterine environment . Immaturity of the baby's organs includes metabolic functioning, renal, hepatic, immunologic, hematologic, and nervous system functions. Premature babies do not generally have sufficient maturity in the body's defense system to adapt to the environment (Prasanna & Radhika, 2013; Chapman & Durham, 2010).

Premature babies have not been able to cope and adapt to environmental stresses. Environmental stress is generally derived from the drastic changes which pose a threat to infants such as the conditions of air temperature, bright light, and noise which introduce a very different environment to intrauterine conditions and can cause pain. This is due to immaturities and less stability in the nervous system of the baby. Premature neonates are particularly sensitive to stimuli that can cause stress (Wong et al., 2009). In Moon's (2011) research, he showed that the noise of equipment in the Neonatal Intensive Care Unit (NICU) causes stress in premature infants. This leads to vulnerability of the premature infant's brain which is developing amidst environmental stress in the NICU (Lucas 2015). Signs of autonomic stress in premature babies are changes in colour (pale, patches, cyanosis), tremors, shock, rapid heartbeat, pauses in respiration, gasping, and tachypnea (Wong et al., 2009). Stress in premature infants will increase the body's metabolism and thus require more consumption of oxygen to stabilise the body's physiological functions. Increased oxygen consumption will lead to a risk of respiratory distress, acidosis, and hypoxia (Sherman et al., 2006).

The failure of physiological functions and the behaviour of infants can be caused by various factors, one of which is that the organs in the neonatal are not properly functioning. Full term infants have sound physiological functions and mature organs so are more able to adapt to the extrauterine environment. Babies born prematurely have additional challenges in adapting to the extrauterine environment. The organ immaturity that can be found in neonates includes immaturity of the respiratory organs, circulation/hemodynamics, digestion, elimination, thermoregulation, and the immune system (Hockenberry & Wilson, 2009).

Roy's adaptation model explains that human beings are biopsychosocial as a whole. In meeting individual needs, people are always faced with various complex problems, and need to be adaptable. The use of coping methods or self-defense mechanisms helps people to function and respond optimally to the environment. The basic theory is that the individual is seen as an adaptive system. People are said to be adaptive because individuals continually interact with environmental stimuli, both in the internal and external environment (Alligood & Tomey, 2006).

Developmental care aims to facilitate a baby's healthy development, assist with attachment between infant and mother and strengthen adaptation to environmental stress in premature infants (Rustina, 2015). Developmental care refers to care that facilitates the healthy development of babies through environmental management, treatment and behavioural observation (Symington & Panelli, 2004). Als and Mc.Anulty (2011) suggested that developmental care is customised for each individual neonate in order to reduce the adverse effects of intensive treatments and developmental disorders. Interventions that support developmental care include a replacement, reducing light, minimal touch, positioning, wound management, giving babies drinks, and nesting (Rustina, 2015).

Costeloe et al. (2012) showed that of 2006 premature infants who were discharged from hospital, 68% (n = 705) had problems with bronchopulmonary dysplasia (receiving supplemental oxygen at 36 weeks postmenstrual), 13% (n = 135) had evidence of severe pathology in brain ultrasounds and 16% (n = 166) needed laser treatment for retinopathy of prematurity. The study concluded that the survival of infants between the ages of 22 and 25 weeks gestation has increased since 1995. However, the pattern of neonatal morbidity and health impacts in the proportion of premature babies has not changed.

A study conducted by Reilly and Kelly (2011) revealed a significant connection between the risk of premature death in children and adolescents who are overweight or obese. Premature infants that later had problems with obesity during adolescence are associated with a significantly increased risk of cardiometabolic morbidity (diabetes, hypertension, ischemic heart disease, and stroke) in adult life.

The light and sound settings in a room is expected to change the behaviour of perinatology nurses and optimise care and a premature baby's development. This was the reason behind the decision to investigate the influence of light and sound settings on the physiological responses of premature infants (Freudenthal, Van Stuijvenberg, van Goudoever: 2013).

Premature babies do not generally have sufficient organ maturity to adapt to the environment. A hostile environment poses a threat to infants, and includes a conditions connected to air temperature and bright lights; which presents a very different environment to that experienced intrauterine. Extrauterine conditions that are drastically different from intrauterine environments can cause a variety of physiological stress responses in babies. This is due to immaturity and a less stable nervous system.

Developmental care has evolved after seeing the impacts of adaptation to environmental stress faced by premature infants going from intrauterine to extrauterine environments.

Developmental care, in the NICU, is still seen as an option rather than a necessity (Als and Mc.Anulty (2011). Thus, there is a need to conduct a study on the implementation and importance of developmental care in preterm infants, especially as scientific evidence increases. It is for this reason that researchers wanted to determine the effect of light and sound settings on the pulse rate and oxygen saturation levels of premature babies in the NICU perinatology rooms in the hospital in Moeloek Lampung Province.

Methodology

This research was undertaken in the field of nursing with a quasi-experimental design with pre and post approaches with a control test. The research was developed with a purely experimental design, in which the control group had external variables that affected the implementation of the experiment (Notoatmodjo, 2010). Interventions for light and sound were restrictions on groups of respondents.

The population in this study has similar characteristics to those specified by the researchers in another study (Notoatmodjo, 2010). The population in this study were all premature babies who were treated in the perinatology room of Dr.H. Regional General Hospital, Abdul Moeloek Lampung Province, and were born prematurely at 30-36 weeks of age. In each group, the measures were performed twice, pre and post activities.

The sample size was 25 premature babies (added to by 10% to avoid the possibility of dropouts so that the total becomes 28 premature babies in each group). Until the end of the study obtained a sample of 30 control samples and samples of intervention as much as 25 samples.

Descriptive analysis was conducted to describe the characteristics of respondents. The measured values are central values (mean, median, and mode) and variation values (range, standard deviation), while the bivariate analysis was conducted to determine the relationship of two variables. To find out the average difference in oxygen saturation and pulse rate between the intervention and control groups, before and after the intervention, two different statistical tests were used to approach the t-test with a significance level of 95% (alpha 0.05).An independent t-test and T dependent was used to ascertain the difference in mean oxygen saturation and pulse rate between the intervention and control groups (Hastono, 2010). The bivariate analysis is detailed in Table 1.

Table 1. Variable Analysis Research and Test Statistics

Research variable	Statistic test
Oxygen saturation in premature babies who do experience light and sound settings	*Test dependent t-test*
The pulse frequency of premature babies who do experience light and sound settings	*Test dependent t-test*
The difference in oxygen saturation before and after the intervention group and the control group	Independent t-test
The difference in pulse rate before and after the intervention group and the control group	Independent t-test

Results

The mean gestational age of the control group was 31.7 weeks (95% CI 30.43 to 33.03), with a standard deviation of 3.48 and a minimum gestational age of 24 weeks and a maximum of 36 weeks. The mean value of neuromuscular maturity was 20.0 (95% from 16.98 to 23.09), with a standard deviation of 8.16, a minimum of neuromuscular maturity value of 0 and a maximum of 30. The mean birth weight was 1645.0 grams (95% CI 1503, 20-1786.80), with a standard deviation of 379.73 and a minimum weight of 550 grams and 2100 grams maximum. The mean length of the baby's body was 43.3 cm (95% CI 41.13 to 45.47), with a standard deviation of 5.81 and a minimum body length of 25 cm and a maximum of 50 cm. This is shown in Table 2.

Table 2. Distribution of infant characteristics based on gestational age, neuromuscular maturity, body weight and body length in the Control Group

variables	mean	SD	Min-Max	95% CI
Gestational age	31.7	3.48	24-36	30.43 to 33.03
Neuromuscular Maturity	20.0	8.16	0-30	16.98 to 23.09
Weight	1645.0	379.73	550-2100	1503.20 to 1786.80
Body length	43.3	5.81	25-50	41.13 to 45.47

The mean gestational age of the intervention group was 30.9 weeks (95% CI 29.80 to 31.93), with a standard deviation of 2.42 and a minimum gestational age of 27 weeks and a maximum of 36 weeks. The mean value of neuromuscular maturity was 17.3 (95% from 14.56 to 19.99), with a standard deviation of 6.12 and the value of neuromuscular maturity at a minimum of 10 and a maximum of 30. The mean birth weight was 1620.5 grams (95% CI 1450, 29-1790.62), with a standard deviation of 382.80 and a minimum weight of 1000 grams and 2400 grams maximum. The mean length of the baby's body was 42.1 cm (95% CI 40.72 to 43.46), with a standard deviation of 3.08 and a minimum body length of 38 cm and a maximum of 49 cm. This is shown in Table 3.

Table 3. Distribution characteristics based on gestational age, neuromuscular maturity, body weight, and body length in the Intervention Group

variables	mean	SD	Min-Max	95% CI
Gestational age	30.9	2.42	27- 36	29.80 to 31.93
Neuromuscular Maturity	17.3	6.12	10-30	14.56 to 19.99
Weight	1620.5	382.80	1000-2400	1450.29 to 1790.62
Body length	42.1	3.08	38-49	40.72 to 43.46

The mean value of oxygen saturation and pulse before the setting of light and sound in the control group was 95.5% (95% CI 94.06 to 96.94), with a standard deviation of 3.87 and a minimum value of oxygen saturation of 85% and a maximum of 100%. The mean pulse was 146.5 beats/min (95% CI 139.45 to 153.55), with a standard deviation of 18.89 and a minimum pulse 105 beats/min and a maximum of 180 times/minute. This is shown in Table 4.

Table 4. Distribution of respondents by mean of physiological responses before light and sound settings in the control group and the intervention group

variables	mean	SD	Min-Max	95% CI
Control				
SaO2	95.5	3.87	85-100	94.06 to 96.94
Pulse	146.5	18.89	105-180	139.45 to 153.55
Intervention				
SaO2	92.64	3.67	87-100	91.01 to 94.26
Pulse	150.0	11.89	105-167	144.77 to 155.32

In the intervention group, the average oxygen saturation was 92.64% (95% CI 91.01 to 94.26), with a standard deviation of 3.67, and a minimum oxygen saturation value of 87% and a maximum of 100%. The mean pulse was 150 beats/min (95% CI 144.77 to 155.32), with a standard deviation of 11.89 and a minimum pulse 105 beats/min and a maximum of 167 times/minute.

The mean value of oxygen saturation and pulse after light and sound settings in the control group showed that the average oxygen saturation was 95.77% (95% CI 94.41 to 97.12), with a standard deviation of 3.63 and a minimum value of oxygen saturation 84% and a maximum of 100%. The mean pulse was 149.1 beats/min (95% CI 141.12 to 157.01), with a standard deviation of 21.27 and a minimum pulse of 106 beats/min and a maximum of 210 times/minute. This is shown in Table 5.

Table 5. Distribution of respondents by the average physiological response after light and sound settings in the control group and the intervention group

variables	mean	SD	Min-Max	95% CI
Control				
SaO2	95.77	3.63	84-100	94.41 to 97.12
Pulse	149.1	21.27	106-210	141.12 to 157.01
Interventio				
n	94.82	2,54	91-99	93.70 to 95.94
SaO2	145.12	13.00	109-168	139.37 to 150.90
Pulse				

In the intervention group the average oxygen saturation gained was 94.82% (95% CI 93.70 to 95.94), with a standard deviation of 2.54 and a minimum oxygen saturation value of 91% and a maximum of 99%. The mean pulse is 145.12 beats/min (95% CI 139.37 to 150.90), with a standard deviation of 13 and a minimum pulse of 109 beats/min and a maximum of 168 times/minute.

In the control group the oxygen saturation before was 0.00, and after 24 hours it was still 0.00, which means that the data was not normally distributed. The pulse beforehand was 0.24, and after 24 hours it was 0.07 which means that the data was normally distributed. In the intervention group, the oxygen saturation was 0.06 before and after 24 hours it was 0.24 which means that the data was normally distributed. The pulse beforehand was 0.00 and after 24 hours it remained at 0.00 which means that the data was not normally distributed. This is shown in Table 6.

Table 6. Overview of data of physiological responses in the intervention group and control group

variables	*Shapiro-Wilk*
The control group	
SaO2 before	0,00
SaO2 after 24 hours	0,00
Nadi before	0.24
Nadi after 24 hours	0.07
The intervention group	
SaO2 before	0.06
SaO2 after 24 hours	0.24
Nadi before	0,00
Nadi after 24 hours	0,00

After being tested for normality and after the data showed as being normally distributed, the data was tested as bivariate using parametric tests (independent t-test). While the data was not normally distributed, bivariate was tested using a nonparametric test (Wilcoxon test). Table 7 shows a significant correlation between the physiological responses before and after the 24 hour intervention, in the control group and the intervention group. This can be seen in Table 7.

Table 7. Distribution of respondents by differences in physiological responses before and after 24 hours of light and sound settings in the control group and the intervention group

variables	Group	mean	SD	Mean difference	Different SD	p-value
	Control					
SaO2	Before	95.50	3.87	-0.22	0.24	.558
	After 24 hours	95.77	3.63			
	Control					
Pulse	Before	146.5	18.89	-2.6	-2.38	0.396
	After 24 hours	149.1	21.27			

The results of the physiological response differences before and after 24 hours of light and sound settings showed that the control group and the intervention group performed well and can be seen in Table 7. The difference in mean oxygen saturation of the control group before and after 24 hours is -0.22, which means that they decreased by 0.22. The results of the analysis obtained a p-value = 0.558 which means that there is no significant difference before and after 24 hours of the light and sound settings. Differences between the mean pulse before and after 24 hours was -2.6 which means the pulse decreased by 2.6. The results of the analysis obtained a p-value = 0.396 which means that there is no significant difference before and after 24 hours of the light and sound settings.

In the intervention group there was no difference in the mean oxygen saturation levels before and after 24 hours at -2.18, meaning that they decreased by 2.18. The results of the analysis obtained p-value = 0.011 means that there is a significant difference before and after 24 hours of light and sound settings. Differences between the mean pulse before and after 24 hours was 4.88 which amounts to an increase of 4.88. The results of the analysis obtained p-value = 0.044 which means that there is a significant difference before and after 24 hours of light and sound settings. This is shown in Table 8.

Table 8. Distribution of respondents based on differences in physiological responses before and after 24 hours of light and sound settings in the intervention group

variables	Group	mean	SD	Mean difference	Different SD	p-value
	Intervention					
SaO2	Before	92.64	3.67	-2,18	1.13	0,011
	After 24 hours	94.82	2,54			
	Intervention					
Pulse	Before	150.00	11.89	4.88	-1.11	0,044
	After 24 hours	145.12	13.00			

Discussion

In the intervention group, there was no difference in the mean oxygen saturation before and after 24 hours with the results of the bivariate analysis showing that there was no significant difference before and after 24 hours of light and sound settings. The average difference in pulse before and after 24 hours was 4.88 which means there was an increase of 4.88. The results of the analysis showed that researchers found no significant difference before and after 24 hours of light and sound settings.

This is supported by research conducted by Indriansari, Rustina, Y., & Hastono (2011) who found that maternal characteristics influenced the factors associated with preterm birth, including age, nutritional status, history of previous birth, parity, spacing, tingling or triplet, and diseases in pregnancy. Vogel's 2014 study stated that pregnant women at risk of preeclampsia were 1:25 times more likely to experience premature births. Research by Svensson et al. (2009) supports this result stating that pregnant women who experienced pre-eclampsia were at 6 times higher at risk of having a preterm birth. Premature conditions will lead to a disturbance in the physiological response of babies because they have not yet developed mature organs.

Premature babies are born with a variety of underdeveloped alveoli and many have not been able to expand as a result of the small number of surfactants that line the alveoli in premature infants. This can result in pulmonary alveoli that are not equal during aspiration and collapse at the end of respiration (Hockenberry & Davis, 2013). Impaired oxygen needs in neonates can cause impaired brain development that can occur in the early life of premature babies and can have both a short-term and a long-term impact (Fan, Portugues, Nunes: 2013). Another study concluded that four weeks of treatment in the NICU of preterm infants with a gestational age of 32 weeks significantly increased their heart rate, decreased SaO2 and slightly increased expression when compared with newborns of the same gestational age (Johnson & Stevens, 1996).

Research by Herliana, Wanda, and Hastono (2011) found no significant difference between the two periods (with the incubator cover and without cover), respectively, during 24 hours on the duration of sleep or sleep interval duration. However, there was a positive correlation between postnatal age in days, and the average period of sleep when the cover incubator was used ($r = 0.90$, $p\text{-value} = 0.001$). Premature babies have immature innervation causing inadequate physiological responses to outside stressors; as the baby gets older, the ability to adapt to the environment outside the womb increases.

One study, in which premature babies were exposed to light and sound control interventions, showed a significant difference in the physiological response saturation and pulse of babies. This does not occur in a control sample, where the results of the analysis showed no significant differences in light and sound settings on the physiological responses of premature infants. Interventions in developmental care consists of restricting excessive stimuli (visual, tactile, auditory, and vestibular), minimal handling, limiting intervention, positioning, minimising stress and pain, skin protection, involves parents, and maintains and optimises sleep quality nutrients. The role of developmental care in reducing long-term adverse effects was studied by Peters et al. (2009), with the results showing a reduction in the length of stay, a reduction in the number of chronic diseases and a reduction in the number of disabilities and instances of impaired mental development. Additionally, Burke (2018) concluded that the provision of developmental care in the NICU ward would provide positive values for brain development and the cognitive abilities in premature babies.

Conclusion

According to the results of this study, it can be concluded that the physiological responses before and after the action of light and sound regulation showed an increase in O2 saturation, both in the control group and the intervention group. While in the pulse results, there was a decrease in the control group but an increase in value in the intervention group. The results of the bivariate analysis showed the influence of light and sound settings in premature infants at O2 Saturation, while the pulse showed no significant effect.

To improve both the quality of life of premature infants and prevent other developmental impacts, the implementation of developmental care in premature babies who are cared for in the NICU room must be implemented and made an obligation. The ability to carry out these activities must be formulated by the hospital as part of standard operating procedures in the treatment of premature infants. Similar research needs to be conducted in order to develop the science and provide empirical evidence of the benefits of implementing developmental care in the care of premature babies in the NICU.

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