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Optimizing Oxygen Saturation and Pulse Rate in Premature Infants: The Role of Nesting and Prone Positioning

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ABSTRACT

Background: Low birth weight babies often experience complications in the form of respiratory distress syndrome and increased heart rate. A method to help prevent these complications is positioning the infant in a nesting and prone arrangement. **Objective:** This study aimed to examine the effect of nesting and prone positions on oxygen saturation and heart rate in premature infants. **Methods:** Pre-experimental design included 44 premature infants selected through consecutive sampling from the neonatal care unit at Arifin Achmad Hospital Pekanbaru. Data analysis was performed using univariate and bivariate techniques, with the Wilcoxon test applied for the bivariate analysis. **Results:** The mean oxygen saturation of respondents before intervention was 92.95%, which increased to 97.34% post-intervention. The mean heart rate before intervention was 129.66 and 150.86 after intervention. Statistical testing indicated a significant difference in oxygen saturation before and after using the nesting and prone positions ($p < 0.05$). **Conclusion:** Implementing nesting and the prone position can improve oxygen saturation in premature babies, as it lowers body metabolism, reduces heat loss, and enhances respiratory efficiency.

Keywords: Nesting; Nursing; Premature; Prone Position

INTRODUCTION

Premature infants face considerable challenges in adapting to the external environment due to immature organ systems, which increase their vulnerability to stress and complications (Park *et al*., 2024). Underdeveloped organs disrupt physiological and biochemical balance, predisposing these infants to conditions such as hypoglycemia, hypercalcemia, and hyperbilirubinemia, which can result in severe or even fatal outcomes (Noor, Hasanah & Glinting, 2016). Their difficulty in adapting to environmental stressors and their unstable physiological responses elevate the risk of morbidity and mortality, with complications including asphyxia, bradycardia, chronic lung disease, seizures, respiratory distress, transient hypothyroxinaemia, and metabolic disorders (Saprudin & Sari, 2018).

Although global efforts have contributed to a decline in preterm birth rates, premature infants continue to face critical health threats. Complications associated with prematurity remain a major contributor to neonatal mortality, accounting for nearly three-quarters of perinatal deaths and one-third of neonatal deaths worldwide. Furthermore, preterm birth stands as the second leading cause of infant mortality after pneumonia (Elsagh *et al*., 2019). These statistics highlight the urgent need for effective, evidence-based interventions in neonatal care.

Premature infants are particularly prone to hypothermia due to thin skin, large surface area, and low-fat reserves, which make them lose body heat more easily. The high energy demand for thermoregulation can compromise weight gain in low-birth-weight (LBW) infants. Developmental care strategies such as kangaroo mother care, baby massage, music therapy, nesting, and prone positioning have been implemented to enhance growth and health outcomes in this population. Evidence shows that these approaches support physiological stability, improve neurodevelopment, and facilitate recovery, enabling premature infants to return home in better health (Akter *et al*., 2023).

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Among developmental care interventions, nesting and prone positioning are widely recognised for their benefits in reducing morbidity and mortality. Nesting, which involves placing the infant in a flexed, supportive position, promotes body alignment, conserves energy, minimizes stress, and reduces weight (Rahmawati *et al*., 2024). As a non-pharmacological nursing intervention, nesting enhances comfort, decreases pain, and supports physiological and neurological development (Kahraman *et al*., 2018). Similarly, the prone position, where the infant is placed on the abdomen with knees flexed has been associated with improved oxygen saturation, lung development, chest wall stability, and reduced apnoea episodes in premature infants (Noor, Hasanah & Glinting, 2016).

Nesting also creates a womb-like environment, supporting midline orientation and leg flexion to mimic intrauterine conditions (Prescott *et al.*, 2024). This posture facilitates vital stability, neuromuscular development, respiratory efficiency, and optimal circulation (Indartik, 2019). Evidence further suggests that prone positioning increases basal temperature, promotes vasodilation, and enhances cardiac output, although findings on its cardiovascular effects remain mixed (Karabulut & Uslu, 2024). A controlled trial by Oishi *et al*. (2018) demonstrated that prone positioning improves oxygen saturation and pulmonary function in neonates, which was further supported by El-sayd *et al*. (2023). Building on these findings, the present study aims to examine the effects of nesting and prone positioning on oxygen saturation and heart rate in premature infants treated in the Neonatal Intensive Care Unit (NICU) at Arifin Achmad Hospital, Riau Province, Indonesia.

METHODOLOGY

Study Design

This study employed a quantitative pre-experimental approach using a one-group pre-test and post-test design, which allows researchers to measure changes in outcomes before and after the intervention within the same group of participants (LoBiondo-Wood, Haber & Berry, 2022). This design was chosen to evaluate the effect of nesting and prone positioning on oxygen saturation and heart rate in premature infants. Prior to data collection, informed consent was obtained from parents or legal guardians of all participating infants.

Study Setting and Population

The study was conducted in 2024 at the Neonatal Care Unit (NICU) of Arifin Ahmad Hospital, Pekanbaru, Indonesia. The target population consisted of 49 premature infants who were admitted to the NICU during the study period. These infants represented a high-risk group due to their low birth weight and immature physiological systems, making them appropriate for evaluating developmental care interventions.

Sample and Sampling Technique

The study sample consisted of 44 premature infants who were recruited from the same Neonatal Intensive Care Unit (NICU) using a consecutive sampling method. Participants were enrolled sequentially as they fulfilled the eligibility criteria until the required sample size was achieved. The inclusion criteria were premature infants with a birth weight ranging between 1,500 and 2,000 grams, placed in incubators, and whose parents or legal guardians provided written informed consent. Infants were excluded if they had been diagnosed with Necrotising Enterocolitis (NEC), anaemia, sepsis, hyperbilirubinemia, congenital abnormalities, or significant respiratory conditions that could interfere with the study outcomes. In addition, infants who passed away during the course of the study were classified as dropouts and were excluded from the final analysis.

Instruments and Materials

Data collection in this study utilised several instruments to ensure the accuracy and consistency of measurements. An observation sheet was prepared to document the demographic and clinical characteristics of each infant, including identification code, sex, gestational age, body temperature, pulse rate, and oxygen saturation. Oxygen saturation and pulse rate were measured using a calibrated fingertip pulse oximeter, which was standardised according to the manufacturer's guidelines to guarantee reliable results. In addition, nesting equipment in the form of soft rolls and supportive materials was employed to create a womb-like environment, enabling the infants to maintain a flexed, midline posture that closely resembled intrauterine positioning. This combination of instruments ensured that both clinical data and intervention conditions were systematically monitored throughout the study.

Procedure

The study was implemented through a structured series of procedures to ensure consistency and reliability. Initially, participants were selected by screening premature infants based on predetermined inclusion and exclusion criteria, after which informed consent was obtained from their parents or legal guardians. Once eligibility was confirmed, baseline measurements of oxygen saturation and pulse rate were recorded while the infants were maintained in a neutral position to establish pre-test values. Following this, the intervention was carried out by positioning the infants in a curled, flexed posture resembling the foetal position, with the arms placed near the chest and the chin slightly flexed. Nesting was used to provide postural support and maintain body alignment, after which the infants were carefully placed in the prone position inside the incubator. Post-test measurements of oxygen saturation and pulse rate were obtained using pulse oximetry after 20 minutes of the intervention to assess immediate physiological changes. This intervention was administered once daily for seven consecutive days, and all observations were systematically recorded on the observation sheets to ensure accurate data collection and analysis.

Data Analysis

Data analysis was conducted using SPSS software to ensure accuracy and statistical rigour. Univariate analysis was first performed to describe the demographic and clinical characteristics of the infants, providing an overview of the study sample. Prior to hypothesis testing, normality testing was carried out to examine the distribution of numerical data and determine the appropriate statistical approach. Since the data were paired (pre- and post-test) but did not meet the assumptions of normality, the Wilcoxon signed-rank test was applied. This non-parametric test was used to compare pre- and post-intervention values of oxygen saturation and pulse rate, thereby assessing the effectiveness of the nesting and prone positioning intervention.

Ethical Consideration

The researchers obtained ethical clearance from the Research Ethics Committee of the Institute of Health Technology Cendekia Utama Kudus, Indonesia with reference number 10/EC/KEPITEKES-CU/V/2014 on 31st May 2024.

Written informed consent was secured from parents prior to participation. Data confidentiality was maintained through anonymised patient codes, and all procedures complied with ethical principles of beneficence, respect for autonomy, and justice.

RESULTS

Table 1: Gender Frequency Distribution of Premature Babies in the Neonatal Care Unit at Arifin Achmad Hospital (n=44)

Gender	Frequency	Percentage (%)
Male	27	61.4
Female	17	38.6
Amount	44	100

From Table 1 above, it is shown that out of the 44 respondents, most of them were male, totalling 27 individuals (61.4%).

Table 2: Gestational Age and Chronological Age of Premature Babies in the Neonatal Care unit (n=44)

Variable	n	Mean	Median	Minimum	Maximum
Gestational Age (Weeks)	44	35.20	35.00	30	40
Chronological Age (Times/Minute)	44	11.57	9.50	2	66

Based on Table 2, the mean gestational age was 35.20 weeks, and the median chronological age was 9.5

days, indicating that most infants were moderate to late preterm and had been hospitalised for over a week.

Table 3: Description of Oxygen Saturation and Pulse Frequency of Premature Babies (n=44)

Variable		n	Median	Min	Max
Oxygen Saturation(%)	Pre-test	44	93.00	90	96
	Post-test	44	97.00	94	100
Pulse Frequency (Times/Minute)	Pre-test	44	131.00	105	146
	Post-test	44	152.00	141	158

The average oxygen saturation of respondents before being placed in the nesting and prone position was 93.95, increasing to 97.34 after the intervention. The average pulse rate of respondents was 129.66 before and 150.86 after the nesting and prone position. Based on the above, the median oxygen saturation was 93.00 before and 97.00 after the intervention. Meanwhile, the median pulse rate was 131 beats per minute before and 152 beats per minute after the nesting and prone position.

Table 4: Optimizing Oxygen Saturation in Premature Infants

		n	Mean Rank	z	*df*	*P value*	*Effect size (r)*
Pre - Post	Negative Rank	0^a	0.00	-5.804	43	0.000	–0.88
	Positive Rank	44^b	22.50				

a. Negative Ranks = cases where post-test < pre-test; b. Positive Ranks = cases where post-test > pre-test; c. Ties = cases where post-test = pre-test

The Wilcoxon signed-rank test results yielded a highly significant *p*-value ($p < 0.001$), with all infants showing positive ranks. This indicates that oxygen saturation was significantly improved following the use of nesting and prone positioning in premature infants, with a very large effect size ($r = –0.88$).

Table 5: Optimizing Pulse Frequency in Premature Infants: The Role of Nesting and Prone Positioning in the Neonatal Care Unit at Arifin Achmad Hospital

		n	Mean Rank	z	*df*	*P value*	*Effect size (r)*
Pre - Post	Negative Rank	0^a	0.00	-5.779	43	0.000	–0.87
	Positive Rank	44^b	22.50				

a. Negative Ranks = cases where post-test < pre-test; b. Positive Ranks = cases where post-test > pre-test; c. Ties = cases where post-test = pre-test

The Wilcoxon signed-rank test results yielded a highly significant *p*-value ($p < 0.001$), with all infants showing positive ranks. This indicates that pulse frequency was significantly reduced following the use of nesting and prone positioning in premature infants, with a very large effect size ($r = –0.87$).

DISCUSSION

In the field of maternal–foetal medicine, gender differences in neonatal outcomes are well documented, with male infants being disproportionately affected by prematurity. Sekhavat and Tezerjani (2013) found that, among 2,450 deliveries, 10% were preterm and male infants had a higher incidence of prematurity with a male-to-female ratio of 1.71, accompanied by greater mortality (30% vs. 21%). These findings highlight the heightened vulnerability of male preterm infants, many of whom require neonatal intensive care due to comorbidities. Within nursing practice, such evidence underscores the critical importance of early and accurate monitoring of oxygen saturation, which is assessed non-invasively using pulse oximetry (Kuehne, 2022). Nurses are directly responsible for titrating oxygen therapy to maintain safe saturation levels, particularly since oxygen saturation at birth may be as low as 30% and must rise to the acceptable range of 85–95% (Schmölzer *et al.*, 2024; Wyckoff *et al.*, 2020). This makes nursing vigilance fundamental in ensuring optimal transition and survival in extremely low birth weight (ELBW) infants.

Prone positioning has been widely studied as a non-pharmacological intervention with significant physiological and developmental benefits for preterm infants. Evidence indicates that this position improves oxygen saturation, supports lung and chest wall development, and reduces apnoea episodes (Chaturvedi *et al.*, 2020; Richmond *et al.*, 2023; Tufail *et al.*, 2023; Loi *et al.*, 2023). For nurses, positioning is not a routine task but a deliberate therapeutic intervention that contributes to holistic neonatal care. Nesting and prone positioning support postural alignment, reduce stress, and conserve infant energy for growth (Indartik, Khasanah & Wahyuni, 2025); Jani *et al*. (2021); Skelton *et al*. (2023); Gözen *et al*. (2022); Lee, Park & Cho (2022) and Rad *et al*. (2021) demonstrated that infants in the prone position show improved blood flow, longer sleep, enhanced digestion, and better neuromotor development. These outcomes emphasise the role of nurses in applying developmental care principles to integrate physiological stability with comfort and growth promotion.

The respiratory benefits of prone positioning are particularly relevant for neonatal nursing practice. Studies have shown that it increases lung volume, prevents atelectasis, improves alveolar ventilation, and enhances secretion clearance, thereby elevating oxygen saturation (Saputro *et al*., 2023; Sun *et al*., 2024; Tufail *et al*., 2023). Miller-Barmak *et al.* (2020) and Rahayu, Indarwati and Anisah (2025) confirmed that prone positioning is effective in increasing oxygen saturation among neonates with respiratory distress syndrome, while Oishi *et al*. (2018) and Alinejad, Peyrovi & Shoghi (2021), emphasised its role in enhancing lung capacity and ventilation efficiency. From a nursing perspective, this reinforces the value of integrating simple, low-cost, and non-invasive interventions into standard care protocols. Particularly in resource-limited NICUs, such interventions provide nurses with practical tools to complement advanced respiratory support while improving overall outcomes for pre-time infants.

The influence of prone positioning on Heart Rate (HR) remains controversial, requiring careful nursing assessment and monitoring. Ghorbani, Asadollahi and Valizadeh (2013) observed a reduction in HR, whereas Karabulut and Uslu (2024) reported mild increases due to elevated basal temperatures and vasodilatation. Similarly, Ma *et al.* (2015) suggested possible decreases in cardiac output, while Elsagh *et al*. (2019) highlighted conflicting findings between preterm and term infants. For nurses, these inconsistencies point to the need for individualised care, where interventions are tailored to infants' unique physiological responses. Monitoring HR and respiratory patterns during positioning is therefore crucial to balance the benefits of improved oxygenation against potential cardiovascular risks, ensuring safe and evidence-based practice.

Despite these promising findings, this study is limited by a small sample size and the absence of a control group, which restricts generalisability and reduces statistical power. Nevertheless, the results are consistent with previous evidence showing that prone positioning enhances oxygen saturation and physiological stability in preterm infants (Ghorbani *et al*., 2013; Oishi *et al.*, 2018). For nursing practice, these findings highlight that positioning should not be viewed as a supplementary routine but as an integral part of neonatal care that directly contributes to survival, comfort, and developmental outcomes. Future studies with larger samples and controlled designs are essential to strengthen the evidence base, but current findings affirm that nurses play a central role in implementing structured, evidence-based positioning strategies to optimise the care of pre-term infants in NICUs.

Nursing Implications

This study's main strength lies in the implementation of a structured, developmentally appropriate storytelling intervention tailored to the cognitive and cultural context of preschool-aged children. Delivered consistently by trained paediatric nurses using engaging, age-appropriate picture books in a calm, child-friendly setting, the intervention enhanced ecological validity and therapeutic engagement. The quasi-experimental pretest-posttest control group design enabled meaningful comparisons and revealed a statistically significant reduction in anxiety among children who received the intervention (p<0.001), highlighting the potential of storytelling-based communication as an effective non-pharmacological approach in paediatric care. However, the absence of randomisation may introduce selection bias and limit internal validity, while the short, three-day intervention period and single-site setting may reduce the generalisability and fail to capture long-term effects. Future studies should consider randomised, multi-centre designs, longer follow-up periods, parental involvement, and digital storytelling formats to strengthen the evidence base and expand applicability.

This study provides valuable insights into the potential benefits of prone positioning for premature infants, particularly in improving oxygen saturation and pulse rate stability. A notable strength lies in the use of a structured and standardised intervention protocol, which ensures consistency in implementation and enhances the reliability of the observed outcomes. In addition, data collection employed calibrated instruments and systematic observation, contributing to the accuracy of the measurements obtained.

Limitation

In this study several limitations must be acknowledged. The relatively small sample size reduces the statistical power of the study and limits the extent to which the findings can be generalised to the wider population of preterm infants. Moreover, the absence of a control group restricts the ability to attribute the improvements in physiological outcomes solely to the intervention, as natural recovery or other environmental factors may have also influenced the results. These limitations underscore the importance of conducting further research with larger, more diverse samples and the inclusion of well-defined control groups. Such efforts will strengthen the evidence base, enhance the robustness of conclusions, and provide stronger guidance for clinical nursing practice in neonatal care.

CONCLUSION

This study demonstrated that nesting and prone positioning significantly improved physiological stability in premature infants, as shown by increased oxygen saturation and pulse rate, highlighting their role in supporting cardiorespiratory adaptation. From a nursing perspective, these findings emphasise developmental care as a simple, non-invasive, and cost-effective intervention that can be routinely integrated into neonatal practice to optimise oxygenation, stabilise vital signs, and promote comfort. Consistent application of these evidence-based strategies enables nurses to directly influence clinical outcomes, enhance survival, and provide holistic, family-centred care. While the limited sample size and absence of a control group restrict generalisability.

Future research with larger and more diverse populations is needed to validate these results. Overall, nesting and prone positioning should be considered essential nursing interventions in neonatal units to improve both short-term stability and long-term outcomes in premature infants.

Recommendation

Multidisciplinary collaboration: Promote collaboration between nurses and physicians to provide a holistic approach to patient education and management, ensuring all aspects of patient care are covered. Conduct further research to explore other factors and interventions that may affect infant oxygen saturation and feeding frequency.

Conflict of Interest

The authors declare that they have no competing interests.

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