

Easing Heel Lance Pain: The Role of Nesting Position as Nursing Intervention in Preterm Neonates

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ABSTRACT

Background: The role of neonatal nurses is pivotal in the assessment and management of pain, as unmanaged pain in premature infants triggers hemodynamic volatility, leading to physiological instability and aberrant neurodevelopmental trajectories. Nesting positioning is a method for mitigating systemic pain responses. **Objectives:** To evaluate the effect of nesting position on procedural pain among preterm neonates undergoing heel lance procedures. **Methods:** A quasi-experimental research design was conducted at the Neonatal Intensive Care Unit (NICU) at Assiut University Children Hospital, Egypt, on a purposive sampling of 60 preterms whose gestational age ranged from 28-36 weeks. Data collection was conducted over an eight-month period, from October 2024 to May 2025. Preterm neonates were divided into two groups equally: 30 in the nesting group and 30 in the control group. Pain assessed by trained neonatal nurses blinded to group assignment to minimize observer bias. Data quantification relied on structured questionnaire form, and Premature Infant Pain Profile-Revised (PIPP-Revised) scale. **Results:** The study found that 56.7% of preterm neonates in the nesting group were pain-free during the heel lance procedure, compared to 0% in the control group. Immediately after the procedure, 83.3% of preterm neonates in the nesting group were pain-free, compared to 10.0% in the control group. **Conclusion:** The study findings confirm that the implementation of nesting position as a nursing intervention significantly reduced pain severity during and immediately after the procedure. The study recommends institutionalizing this positioning strategy as a fundamental component of routine neonatal nursing practice is strongly advocated.

Keywords: Neonatal Intensive Care Unit; Non-Pharmacological Pain Management; Premature Infant Pain Profile-Revised

INTRODUCTION

Preterm neonates are those born alive before 37 completed weeks of pregnancy and require greater clinical attention than term neonates (Yang *et al.*, 2026). Globally, preterm births account for approximately 9.6% of all births, representing 12.9 million births annually, with an increasing trend reported in recent studies (Ciora *et al.*, 2024; Park *et al.*, 2024). Due to the immaturity of multiple organ systems, these infants are particularly vulnerable to respiratory, gastrointestinal, hematological, immunological, and central nervous system complications, as well as long-term sensory, motor, and cognitive impairments.

Immature neurobehavioral development increases their vulnerability to cerebral palsy, impaired motor coordination, delayed cognitive development, postural instability, inattentiveness, and behavioral distress. Appropriate positioning is therefore essential, as improper positioning may increase the risk of apnea, neurobehavioral stress, and cerebral bleeding (Tang *et al.*, 2021; Obeidat & Aloweidi *et al.*, 2021).

Preterm neonates in the NICU are frequently exposed to painful invasive procedures, averaging approximately 14 painful procedures daily during the first two weeks of life (Esin, 2026). Repeated heel lancing is a common procedure, and factors such as excessive tissue squeezing, insufficient blood collection, contamination, and repeated punctures can increase procedural pain (Yilmaz & Inal, 2020). Poorly managed or

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prolonged pain during this critical period of brain development may have adverse long-term effects on behavior, cognition, executive function, and visual abilities (Walker, 2019; Özdemir *et al.*, 2026).

Pain management includes pharmacological and non-pharmacological approaches. Nesting is a supportive non-pharmacological intervention in which rolled sheets are arranged in an “O” or “U” shape to provide containment similar to the intrauterine environment. It promotes flexion and midline orientation, supports neuromotor development and self-regulation, stabilizes vital signs, and may reduce stress by modulating sensory input (Figure 1) (Hassan, 2025).

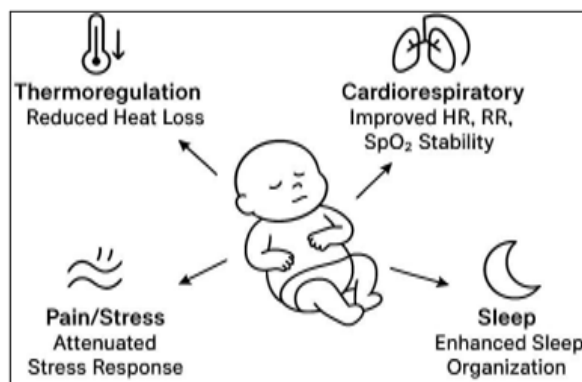


Figure 1: The Multisystem Mechanisms of Nesting position (Hassan, 2025)

Neonatal nurses play a key role in recognizing and managing pain and stress in preterm infants. Their responsibilities include implementing evidence-based pain management and supportive interventions such as therapeutic touch, kangaroo mother care, and positioning. Therefore, nesting should be considered as part of supportive NICU care when appropriate (Wu *et al.*, 2020).

Although several recent studies have investigated the effect of nesting on pain responses in preterm neonates, including breastfeeding, skin-to-skin contact, and non-nutritive sucking, limited attention has been given to nesting during heel lancing (Karga Yilmaz & Yavuz, 2025; Akbari *et al.*, 2026); evidence regarding its effectiveness during heel lance procedures remains limited and inconsistent. Variations in study designs, sample sizes, and pain assessment methods make it difficult to draw definitive conclusions. Therefore, further well-designed research is needed to clarify the effectiveness of nesting as a simple, feasible, and cost-effective nursing intervention for reducing heel lance pain in preterm neonates.

Significance of the Study

Heel lance procedures are a common source of procedural pain in preterm neonates in the NICU, and repeated exposure during a critical period of brain development may adversely affect physiological stability and neurodevelopment (Rahmawati *et al.*, 2024; Wu *et al.*, 2025). Although several non-pharmacological interventions have been investigated, nesting remains a feasible, and nurse-led approach that may reduce pain and promote physiological stability (Yanti *et al.*, 2025). However, evidence regarding its effectiveness specifically during heel lance procedures remains limited and inconsistent. Therefore, this study aims to evaluate the effect of nesting positioning on heel lance pain in preterm neonates, providing evidence to support its potential use as a practical, safe, and cost-effective nursing intervention in NICU care.

Aim of the Study

To evaluate the effect of nesting positioning on procedural pain among preterm neonates undergoing heel lance procedures.

Research Hypothesis

H1: Implementing the nesting position is expected to reduce the pain severity levels of preterm neonates during and post-procedure.

METHODOLOGY

Research Design

A quasi-experimental research design was implemented to conduct this investigation.

Setting

The study was conducted at the NICU of Assiut University Children Hospital, Egypt.

Sample

A purposive sample of sixty preterm neonates who met the eligibility criteria was assigned sequentially to the nesting position group first, followed by the control group, with thirty preterm neonates in each group from October 2024 to May 2025.

The sample size was calculated based on the study conducted by Khalf-Allah *et al.* (2024). Using a one-way ANOVA with fixed effects, an effect size (f) of 0.65, a significance level (α) of 0.05, and an actual power ($1-\beta$) of 0.89, the calculated minimum required sample size was 57 preterm neonates. To ensure an equal allocation between the two groups, the sample size was increased to 60 preterm neonates, with 30 neonates assigned to each group. All 60 eligible preterm neonates were included in the final analysis.

Inclusion Criteria

Preterm neonates whose gestational age ranged from 28 to 36 weeks and verified stability of vital signs (heart rate, blood pressure, respiratory rate, and oxygen saturation) In addition, preterm neonates were restricted to neonates who were neither sedated in the 24 hours preceding the study nor within the time frame of the study.

Exclusion Criteria

Preterm neonates who had orthopedic abnormalities such as congenital dislocation of the hip or other musculoskeletal issues. Preterm neonates who had congenital defects or intraventricular hemorrhage. Preterm neonates who had severe systemic diseases such as sepsis or necrotizing enterocolitis. Preterm neonates who connected to mechanical ventilation.

Study Tools

Three tools were utilized by the researchers in this study.

Tool I

Structure Questionnaire form: It was meticulously constructed by the study team to aggregate essential data, grounded in the frameworks established by recent scholarship (Sumathy, 2020; Kaur *et al.*, 2022). The tool is segmented into two primary components:

Part I: Demographic data of the preterm neonate, capturing variables including gender, chronological age, gestational age, and birth weight.

Part II: Clinical data, documenting method of delivery, Apgar score at 5th minute, medical diagnosis on admission, admission date and method of feeding.

Tool II

Premature Infant Pain Profile-Revised (PIPP- Revised): According to Stevens *et al.* (2014), PIPP was a reliable and validated measure for the assessment of pain in preterm neonates. This multidimensional measure comprises seven specific physiological, behavioral, and contextual variables: gestational age, oxygen saturation, heart rate, behavioral state, nasolabial furrowing, brow bulging, and eye squeezing. Various dimensions methods are evaluated against a four-point scale (0-3). In the end, the total score of the PIPP-R is found by summing the individual scores together, giving a final score ranging from 0 to 21.

Scoring System

Pain severity was categorized based on the total score as follows: scores ranging from 0 and 6 indicated no

pain, scores of 7–12 indicated mild to moderate pain, and scores greater than 12 indicated severe pain (Stevens *et al.*, 2014).

Validity: PIPP- R is a validated pain assessment tool for preterm neonates. Its construct validity, and feasibility have been established in previous studies (Gibbins *et al.*, 2014; Stevens *et al.*, 2014).

Reliability: To measure the internal consistency and stability of the tools, Cronbach's Alpha coefficient was utilized. Analysis yielded a reliability coefficient of $r = 0.85$ for the PIPP-R scale.

Pilot Study: A preliminary trial was executed with six preterm neonates to verify the clarity and logistical feasibility of the data collection tools, as well as to estimate the time required for completion. As no modifications were deemed necessary, these six preterm neonates were integrated into the final sample; including these preterm neonates increased the overall sample size, improving the statistical power of the study while maintaining consistency and validity of the results.

Procedure

Approval from the NICU director at Assiut University Children Hospital was obtained. Data collection was conducted over an eight-month period, from October 2024 to May 2025. The researcher visited the NICU twice weekly for four hours per day, from 8:30 a.m. to 12:30 p.m., applying the intervention on preterm neonates. After verification for fulfilling the inclusion criteria, preterm neonates assigned sequentially to the nesting position group first, followed by the control group, with thirty preterm neonates in each group, which included:

Assessment Phase

The preterm neonates' medical records provided demographic and clinical variables in approximately 5 minutes per subject. The PIPP-R tool was used during and immediately after the procedure to quantify pain.

Preparation Phase

Hygiene procedures were hand washing, and the neonatal nurse used radiant warming. The neonatal nurse built the nest; essential materials (pillows, blankets, and linens) were collected as the blanket was folded diagonally and placed upright and linen spread over it. To maintain gastric stability, preterm was monitored for 30 minutes following milk feeds.

Intervention Phase

Preterm neonates were positioned in a properly sized O-shaped nest to provide containment and support flexion, with limbs tucked and hands positioned near the face. A 15-minute stabilization period was allowed before heel lance to promote physiological stability and reduce pain response while preterm neonates in the control group were put in a supine position and held.

Evaluation Phase

After intervention, the pain level was assessed for the preterm neonate in the nesting position during and immediately after the heel lance for 1 min by using the PIPP scale. Assessments were performed by trained neonatal nurses who were blinded to group assignment to minimize observer bias.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 22. Categorical variables were presented as percentages and compared using the chi-square test or Fisher's exact test when expected cell counts were small, as appropriate. An independent samples t-test was used for analysis. A p -value < 0.05 was considered statistically significant. Degrees of freedom (df) are reported where applicable. The 95% confidence intervals (95% CI) were calculated to assess the precision of the mean differences between groups. Degrees of freedom and 95% confidence intervals (95% CI) were obtained from the independent samples t-test used to compare the means between the two groups.

Ethical Consideration

The research obtained ethical clearance from the Faculty of Nursing, Assiut University, Egypt with Reference Number 1120240816 on 27th May 2024.

RESULTS

Table 1: Personal Data of the Studied Preterm Neonates (n = 60)

	Nesting Position Group (n=30)		Control Group (n=30)		Total		χ^2	Df	P-value	95% CI	Test Used
Birth weight (in kg)	No.	%	No.	%	No.	%					Chi-square test
0.8 - < 1Kg	4	13.3%	2	6.7%	6	10%	1.090	2	0.580		
1 - < 1.5 Kg	10	33.3%	13	43.3%	23	38.3%					
≥ 1.5 Kg	16	53.3%	15	50%	31	51.7%					
Mean±SD (Range)	1.6±0.6 (0.8-2.7)		1.7±0.6 (0.8-3)				T=0.645	58	0.521	-0.41 to 0.21	Independent t-test
Gestational (age at birth week)											Chi-square test
28 - < 31 weeks	8	26.7%	6	20%	14	23.3%	1.070	2	0.586		
31 - <33weeks	8	26.7%	7	23.3%	15	25%					
33 - 36 weeks	14	46.7%	17	56.7%	31	51.7%					
Mean±SD (Range)	31.9±2.6 (28-36)		32.6±2.6 (28-36)				T=-1.042	58	0.302	-2.04 to 0.64	Independent t-test
Mean±SD (Range)	6.4±2.4 (2-12)		5.2±2.4 (2-11)				T=1.936	58	0.058	-0.04 to 2.44	Independent t-test

Chi-square test. Independent t - test

Table 1 shows that there were no significant differences ($P > 0.05$) between the nesting position group and the control group regarding birth weight, gestational age, and postnatal age, with the majority of neonates in both groups having a birth weight ≥ 1500 grams and illustrates that there was no statistically significant difference (P -value 0.091) related to gender between groups.

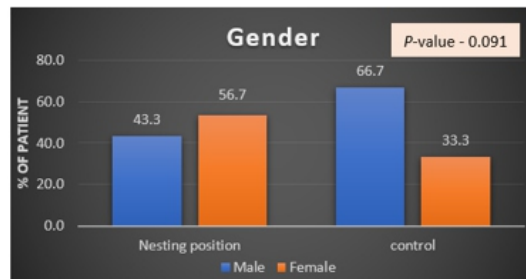


Figure 1: Distribution of Gender for Preterm Neonates in the Nesting and Control Groups

Figure 1 shows that more than half (56.7%) of preterm neonates in the nesting group were females, while one-third (33.3%) of them were female in the control group.

Table 2: Medical Data of the Studied Preterm Neonates (n= 60)

	Nesting Position Group (n=30)		Control Group (n=30)		Total		Test Used	df	P-value
	No.	%	No.	%	No.	%			
Medical diagnosis on admission									
RDS	25	83.3%	25	83.3%	50	83.3	$\chi^2=3.00$	3	0.392
Jaundice	2	6.7%	2	6.7	4	6.7			
Jaundice and RDS	1	3.3%	3	10	4	6.7			
Low birth weight, RDS	2	6.7%	0	0	2	3.3			
Method of delivery									
Vaginal	7	23.3%	6	20	13	21.7	0.098	1	0.754
Caesarean section	23	76.7%	24	80	47	78.3			
Apgar score at birth									
Mean±SD (Range)	7.7±1.6 (1-10)		7.4±0.7 (7-10)				T=0.95	58	0.343
Method of feeding									
Oral feeding	11	36.7%	4	13.3%	15	25%	$\chi^2=7.75$	4	0.101
Nasogastric tube	15	50%	15	50%	30	50%			
TPN	2	6.7%	5	16.7%	7	11.7%			
Oral feeding &nasogastric tube	2	6.7%	3	10%	5	8.3%			
Nasogastric tube & TPN	0	0	3	10%	3	5%			

Chi-square test and fisher in 2*2. TPN: Total Parental Nutrition Independent T - test

As shown in Table 2, most preterm neonates in the nesting position were diagnosed with respiratory distress syndrome (RDS) (83.3%) and delivered via cesarean section (76.7%). In addition, the feeding method was used the same, with 50% of both groups using nasogastric tube feeds compared to 83.3% and 80% in the control, respectively, with no significant differences between groups ($P > 0.05$).

Table 3: Premature Infant Pain Profile Scale during Heel Lance in the Studied Preterm Neonates (n = 60)

Premature Infant Pain Profile Scale	Nesting Position Group (n=30)		Control Group (n=30)		Test Used	Effect Size	Interpretation	Df	P-value
	No.	%	No.	%					
During heel lance									
No pain	17	56.7%	0	0%	$\chi^2=35.04$			2	<0.001**
Mild to moderate pain	13	43.3%	12	40%					
Severe pain	0	0 %	18	60%					
Mean±SD	6.9±2		12.3±2.4		t= 9.274	Cohen's d=2.39	Very large effect size	58	<0.001**
Range	3-11		8-16						

Chi-square test. Independent T- test

** Highly statistically significant difference ($p < 0.01$)

Table 3 shows pain scores had a highly statistically significant difference in the nesting group ($P < 0.001$ **). The majority of the control group (60%) experienced severe pain, compared to none in the nesting group.

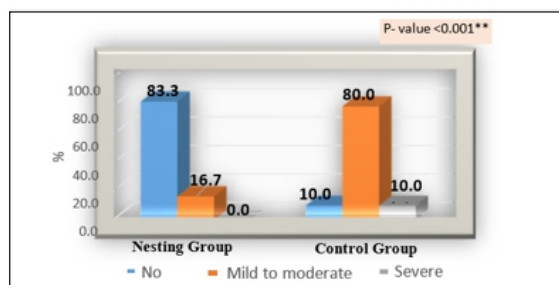


Figure 2: Pain Levels Immediately after Heel Lance in the Studied Preterm Neonates (n = 60)

Figure 2 reveals the majority of the preterm neonates in the nesting group appeared with no pain, while only ten in the control group appeared with no pain immediately after heel lance.

Table 4: Association between Selected Neonatal Characteristics and PIPP Categories in the Nesting Position Group

Nesting Position (Group)	Premature Infant Pain Profile	
	No Pain	Mild to Moderate Pain
	No. (%)	No. (%)
Gender		
Male	8 (26.7%)	5 (16.7%)
Female	9 (30%)	8 (26.7%)
Fisher test (<i>P</i> -value)	Fisher's Exact Test, <i>P</i> =0.721	
Birth weight (Kg)		
0.8 - < 1 Kg	2 (6.7%)	2 (6.7%)
1 Kg - <1.5 Kg	9 (30%)	1 (3.3%)
≥ 1.5 Kg	6 (20%)	10 (33.3%)
χ ² (<i>P</i> -value)	6.991 (0.051)	
Gestational age week		
28 - < 31 weeks	5 (16.7%)	3 (10%)
31 - <33weeks	5 (16.7%)	3 (10%)
33 - 36 weeks	7 (23.3%)	7 (23.3%)
γ ² (<i>P</i> -value)	0.475 (0.789)	

Table 4 reports that no significant association was found between PIPP and personal data variables like gender, birth weight, and gestational age in both groups.

DISCUSSION

This study emphasized the critical role of nursing assessment and intervention in optimizing the effectiveness of nesting position, which has been used as a nursing intervention to reduce heel lance pain in preterm neonates since nesting position is a developmental care intervention aimed at promoting physiological stability, reducing excessive motor activity, and providing a soothing environment that supports pain relief and neurobehavioral organization (Khusna *et al.*, 2025). It encourages flexion patterns and postural containment, which may enhance self-regulation and conserve energy in preterm neonates.

In terms of demographic characteristics, within the current analysis, the mean birth weight for the nesting group and control were 1600 ± 600.0 g and 1700 ± 600.0 g, respectively. These results aligned with Poulouse *et al.* (2015), who revealed the mean $\pm$ SD of birth weight in the study group was 1735 ± 375.6 . These findings were compatible with the study of Reyhani *et al.* (2016), who reported that the mean $\pm$ SD of birth weight in the experimental group weighed 1958.7 ± 415.2 grams.

Regarding gender distribution, females constituted more than half of the neonates in the nesting group, whereas females represented approximately one third of the control group. This finding is consistent with Ismail *et al.* (2024), who also reported that females constituted more than half of their study population. However, the findings differ from those of Ahmed *et al.* (2024), who reported a predominance of male neonates. These differences in sex distribution between studies may be attributable to variations in sample characteristics, study populations, clinical settings, or other demographic and clinical factors. Therefore, the observed differences should be interpreted cautiously, and no causal explanation regarding the effect of sex on neonatal outcomes can be inferred from the present findings alone.

In terms of medical data, the most common cause of admission to NICU is RDS. This is not consistent with Tane *et al.* (2019), who cited bilirubinemia as the cause of admissions. The high prevalence of RDS is ascribed to pulmonary immaturity and surfactant deficiency, which limits proper alveolar expansion. Caesarean section was the predominant mode of delivery in both groups, accounting for 76.7% of deliveries in the nesting group and 80% in the control group. According to Rizk *et al.* (2022), more than half of the data was also delivered by C-section. In the opinion of the researcher, the surgical strategy is designed to manage interventions during birth to prevent birth trauma and hypoxic risk in the hope of resulting in a positive outcome. This surgical strategy is offered to clinically unstable neonates and those with low birth weight.

Regarding the primary outcome of this research, which was pain. Pain assessment demonstrated that preterm neonates in the nesting group exhibited lower behavioral and physiological responses during and immediately after heel lance compared to the control group. Over half of the nested neonates were pain-free during the procedure, whereas none in the control group achieved this outcome. These findings support the mechanism of nesting in limiting motor disorganization, reducing excessive sensory input to the central nervous system, and providing postural containment, which collectively dampens nociceptive transmission (ELGhany & Mahmoud, 2023)

The results are consistent with prior research indicating the analgesic benefits of supportive positioning and nesting (Ugucu *et al.*, 2024; Karadag *et al.*, 2022). Some studies, however, report alternative interventions, such as the combination of kangaroo mother care and oral dextrose, as more effective than supine nesting alone (Kapoor *et al.*, 2021), highlighting the importance of context and intervention specifics. Also in agreement with the study by Ranjbar *et al.* (2020), in which they conducted a similar study. They reported that facilitated tucking and oral dextrose are two effective methods of pain reduction during heel prick.

The findings are consistent with previous studies demonstrating that various non-pharmacological interventions can effectively reduce pain during heel-stick procedures in preterm neonates. Akbari *et al.* (2026) reported that preterm infants who received non-nutritive sucking experienced less heel-stick pain than those in the control group. Similarly, Ghodsi *et al.* (2020) found that vibration was an effective technique for reducing pain associated with heel lance blood sampling in preterm neonates. In addition, Peng *et al.* (2018) demonstrated that the combined use of non-nutritive sucking, oral breast milk, and facilitated tucking effectively reduced mild and moderate-to-severe pain during heel-stick procedures and promoted recovery from pain across the different phases of the procedure. Although these studies evaluated interventions different

from nesting, their findings support the effectiveness of non-pharmacological approaches for reducing procedural pain in preterm neonates.

Concerning pain level immediately after the heel lance, the current data revealed another divergence: over three-quarters of the preterm neonates in the nesting position group showed no signs of pain, while less than one-quarter of those in the control group showed no signs of pain. Similarly, Magor *et al.* (2024) noted a comparable difference, in which the majority of the study group remained pain-free, while only a minority of the control group remained pain-free immediately after the heel lance.

According to the relationship between the pain level of the studied preterm neonates and their demographic data in the nesting position and control groups, the study found that pain outcomes were not significantly associated with demographic factors, aligning with previous evidence that gender, gestational age, and birth weight do not substantially affect procedural pain responses (Ganguly *et al.*, 2020). On the other hand, a strong and highly significant association was noted between the implementation of the nesting position and pain severity. Kahraman *et al.* (2018) found similar results in a retrospective study, showing that nesting is an effective analgesic intervention for premature infants undergoing painful procedures. The nesting position is a simple, safe, and highly effective non-pharmacological intervention that significantly reduces heel lance pain in preterm neonates. Integrating nesting into routine neonatal care can enhance comfort, minimize procedural stress, and contribute to better short- and long-term outcomes in this vulnerable population.

Nurses should spearhead rigorous studies to confirm and refine nesting as an effective, low-risk strategy for reducing heel lance pain in preterm neonates-identifying optimal positioning, timing, and synergistic combinations with other comfort measures-while bedside nurses implement standardized, evidence-informed nesting protocols, document pain responses, and integrate nesting into routine procedural care as a family-centered, developmentally supportive intervention. Concurrently, nurse educators must build competency-based training and parent teaching into curricula to ensure safe positioning, evaluate outcomes, and empower families to participate in comforting their infants.

Limitations

Although the study included a sample size that exceeded the minimum required, the relatively limited number of eligible preterm neonates who fulfilled the strict inclusion criteria (i.e., stable vital signs and preterm neonates who were not connected to mechanical ventilation) available during the study period and the single-center design may limit the generalizability of the findings. This study was conducted in a single-center study because other hospitals declined to implement the study due to institutional policies.

Future Scope

Further studies should be done on large sample sizes, other gestational age groups, and different hospitals to further investigate the effects of nesting position on preterm neonates. The nesting position should become an essential component of routine nursing clinical practice for preterm neonates during and immediately after heel lance to decrease pain level.

CONCLUSION

The present study demonstrated that nesting positioning as a nursing intervention significantly reduced pain severity during and immediately after heel lance procedures in preterm neonates. These findings suggest that nesting is a simple, safe, and practical non-pharmacological intervention that may be incorporated into routine neonatal intensive care practice to support comfort during painful procedures.

CrediT Authorship Contribution Statement

N.M.A.: Conceptualization, methodology, data collection, formal analysis, writing – original draft. **A.E.A.:** Supervision, data collection revision and editing. **N.H.R.:** Supervision, revision and editing. **A.A.H.:** Clinical supervision, data collection revision and editing.

AI Assistance Declaration

AI tools were used only for language editing and grammar correction. The authors reviewed the final

manuscript and take full responsibility for its content.

Conflict of Interest

The authors declare that they have no competing interests.

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