IJN
Iranian Journal of Neonatology
http://ijn.mums.ac.ir

Open Access

Original Article

Comparing the Effectiveness of Local Heat and Foot Massage in Reducing the Pain Caused by Heel Blood Sampling in Neonates

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ABSTRACT

Background: Given the inevitability of heel blood sampling for thyroid testing in neonates, this study aimed to compare the effectiveness of local heat and foot massage in reducing pain caused by the procedure.

Methods: This experimental study was conducted on neonates admitted to a healthcare center for thyroid testing in Rafsanjan, southeast Iran. Neonates were selected through convenience sampling and randomly assigned to one of three groups: foot massage, local heat, or control. In the foot massage group, the outer part of the neonates' heel was massaged for three minutes before blood collection. In the local heat group, the neonates' heel was heated to 40 °C for 3 minutes using a hair dryer before blood sampling. No specific intervention was performed in the control group. The Neonatal Infant Pain Scale (NIPS) was used to measure pain intensity. Data were analyzed using SPSS software.

Results: Data analysis revealed a statistically significant difference between the mean pain scores in the local heat group and the control group ($P<0.001$), as well as between the massage group and the control group ($P<0.001$). However, there was no significant difference in mean pain scores between the massage and local heat groups ($P=0.83$).

Conclusion: The findings suggest that both local heat and foot massage interventions are effective in reducing pain caused by heel blood sampling. Therefore, either method can be used for pain reduction depending on the neonates' condition.

Keywords: Heel blood sampling, Local heat, Foot massage, Neonates, Pain

Introduction

Congenital hypothyroidism is a leading cause of preventable mental retardation in children (1). The overall incidence of congenital hypothyroidism ranges from 1 in 3000 to 1 in 4000 live births (2). Early diagnosis is crucial because delayed treatment can result in irreversible neurological deficits (3). Most neonates with hypothyroidism are asymptomatic at birth, and clinical symptoms gradually appear 6-12 weeks postpartum (4). Therefore, newborns should undergo screening to diagnose hypothyroidism promptly and prevent complications through timely treatment (3). Hypothyroidism screening programs were initiated in North America in 1972 and subsequently expanded to other countries (5). Iran has implemented a screening program for this disease since 2006 (6).

Heel blood sampling is a fundamental procedure

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Please cite this paper as:
Barzegari R, Seyed Bagheri SH, Khodadadi H, Sadeghi T. Comparing the Effectiveness of Local Heat and Foot Massage in Reducing the Pain Caused by Heel Blood Sampling in Neonates. Iranian Journal of Neonatology. 2025 Jul: 16(3). DOI: 10.22038/ijn.2025.80268.2547

for collecting blood samples in neonates (7), particularly for newborn screening tests. Given its widespread use, palliative methods should be employed whenever possible to manage pain associated with this procedure (8). The long-held belief that neonates cannot perceive pain has been disproven, and it is now well-established that neonates do experience pain (9). Evidence indicates that neonates not only feel pain but may also be more sensitive to pain and its long-term effects compared to older children (10). Unrelieved pain can lead to both short-term and long-term detrimental effects (7). Painful and stressful procedures can affect a neonate's pain threshold, pain perception, and pain tolerance, potentially lowering the pain threshold and thereby increasing physiological and behavioral responses to painful conditions. Thus, accurate assessment and effective pain management are essential (7).

Since neonates cannot articulate their pain experiences, nurses must rely on objective data to assess infant behaviors. When neonatal pain is appropriately assessed, it can be alleviated using both pharmacological and non-pharmacological interventions (11). Numerous studies have explored pain relief in neonates and have proposed various methods, such as the use of oral sucrose (12), non-nutritive sucking (13), breastfeeding (14), skin-to-skin contact with the mother (15), music therapy (16), hugging and touching (17), hot and cold compresses (17), and relaxation techniques (18) during painful procedures. While sucrose is a commonly used method for managing mild pain, concerns exist regarding potential neurological complications with repeated administration (19).

Heat therapy is another recognized method for pain reduction in neonates. Increased blood flow due to heat can facilitate the removal of pain-initiating factors released by tissue damage (20). To ensure sufficient blood samples are obtained and prevent repeated heel sticks, it is recommended to warm the heel before inserting the lancet (19); however, this practice is not consistently implemented.

Massage therapy is another technique employed for pain control (21). Foot massage, in particular, is a practical complementary intervention (22, 23). Tactile stimuli influence the central nervous system and trigger the release of pain-relieving substances, including beta-endorphin and enkephalin, which prevent the release of neurotransmitters and inhibit pain sensation (24). Massage therapy enables nurses to provide comprehensive care (25). Foot massage is often a viable option when there is limited time or opportunity for a full body massage (26). Studies have demonstrated the positive impact of massage on pain and anxiety associated with bone marrow aspiration in children with cancer (27), the regulation of physiological parameters in 3-6-year-old children (28), and the reduction of pain caused by vaccination in neonates (29). However, a literature review indicated that no studies have specifically addressed pain associated with heel blood sampling for screening tests, despite its routine and essential nature. Therefore, the present study sought to compare the effectiveness of local heat and foot massage in reducing pain caused by heel blood sampling for thyroid tests in neonates.

Methods

Study design and participants

This experimental study was conducted on three groups ofneonates who visiteda Comprehensive Healthcare Center in Rafsanjan, between January 2023 and May 2023. The criteria for entering the study were parental consent for the infant to participate in the study, the infant being full term (gestational age more than 37 weeks), weighing 2,500 to 3,500 grams, not taking acetaminophen or any other pain reliever the night before, and not having foot massage contraindications (baby's health, healthy skin, absence of infection), absence of contraindications to the use of heat (oily skin, skin damage, eczema), and no history of taking blood samples from the heel. The exclusion criteria were the refusal of parents to continue participating in the study during the intervention and the failure to take blood from the heel in the first round.

Sampling

Following a similar study byGhobadi Mohebi et al. (29), the sample size was estimated using the following formula ($\alpha = 0.05$, $\beta = 0.1$, $\sigma1 = 0.6$, $\sigma2 = 0.3$, $\Delta = 0.4$, and $K = 1$):

$$n = \frac{(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2(\sigma_1^2 + \sigma_2^2)}{\Delta^2}$$

The sample size was equal in the three groups. Thus, the sample size was estimated as 29.5 persons per group, and given three groups and any possible dropout, the sample size was considered to be 45 persons. The neonates were randomly assigned to three groups using a Google

random number generator method.

Instrument

Data were collected using a demographic information questionnaire (including fetal age, infant age, weight, gender, height, head circumference, and body temperature) and the Neonatal Infant Pain Scale (NIPS). The NIPS, published by Laurence in 1993, has been widely used in studies to measure pain in neonates. The NIPS score ranges from 0 to 7 (30), based on six items: (1) facial expression (0 for relaxed, 1 for frowning), (2) crying (0 for no crying, 1 for whining, 2 for intense crying), (3) breathing patterns (0 for relaxed, 1 for changes in breathing), (4) arm position (0 for relaxed, 1 for flexed or extended), (5) leg position (0 for relaxed or lying, 1 for flexed or extended), and (6) state of arousal (0 for sleeping or awake, 1 for screaming or agitated). The validity and reliability of the NIPS have been frequently confirmed in various studies. The reliability coefficient of this scale for determining pain intensity in Iran ranges from 0.93 to 0.99 (30).

Intervention and Data Collection

For data collection, the researcher visited the research setting. After obtaining informed consent and completing the demographic information questionnaire with the neonates' parents, the neonates were randomly assigned to one of three groups: foot massage, local heat, or control. The massage intervention was performed following protocols from previous studies (24-27, 31). Before blood sampling, the researcher gently massaged the selected sole longitudinally and transversely from heel to toes for 3 minutes using the fingers of both hands (32).

In the local heat group, the infant's heel was heated to 40°C for 3 minutes using a 1200-watt hair dryer fixed at a distance of 60 cm from the heel (19). The temperature of the sole was monitored using a strip thermometer. Neonates in the control group received no intervention.

Blood samples were collected by first rubbing the baby's heel with antiseptic alcohol. A lancet was then inserted into the side of the heel with a swift, controlled motion. After blood flow was established, the first drop was removed, and a second drop was allowed to form. Blood drops were then collected on filter paper. All blood samples were taken in a consistent environment (temperature and light) by the same person using the same type of lancet. To assess pain, the infant's face and body were filmed by a research team member with a mobile camera during lancet insertion and for two minutes afterward. The films were subsequently reviewed and scored separately by another member of the research team.

Data Analysis

Data were analyzed using descriptive statistics (frequency, percentage, mean, median, standard deviation) and inferential statistics (ANOVA and Tukey's or Scheffe's post hoc tests, paired samples t-tests, and chi-square or Fisher's exact tests) with SPSS version 22. A significance level of $p < 0.05$ was used.

Ethical Approval

The research project was approved by the Ethics Committee in Biomedical Research of (University Name Deleted for Anonymity) with the code IR.RUMS.REC.1401.194. The researcher provided parents with information about the study's objectives and ensured the confidentiality of their information. Parents were assured that their neonates would not be harmed and that they were free to withdraw from the study at any time. All procedures were performed in accordance with the ethical guidelines outlined in the Declaration of Helsinki.

Results

Baseline Characteristics

Based on the Kolmogorov–Smirnov test, parametric tests were used for normally distributed data, and non-parametric tests were used for data with non-normal distribution. No statistically significant differences were found between the three groups in terms of demographic variables ($p > 0.05$), indicating that the groups were homogeneous (Table 1).

Pain

A statistically significant difference was observed in the mean pain scores among the three groups during and after blood sampling ($p < 0.001$), with the control group exhibiting higher mean pain scores than the other two groups. Paired samples t-tests revealed a statistically significant reduction in mean pain scores in both the local heat and foot massage groups during and after blood sampling ($p < 0.001$). Similarly, the control group also showed a statistically significant decrease in mean pain scores after blood sampling ($p < 0.001$); however, the magnitude of pain reduction was greater in the

Table 1. Comparison demographic characteristics of neonates between three groups

Demographic data		Local heat group	Massage group	Control group	P-value
Gestational age(Week)	(Third quartile-first quartile) Median	(38.01-39.01) 38.01	(37.55-39.01) 38.01	(38.01-39.01)38.01	0.541*
Age(Day)	(Third quartile-first quartile) Median	(4.01-5.01)4.01	(4.01-5.01) 5.01	(4.01-6.01) 5.01	0.816*
Height(Cm)	(Third quartile-first quartile) Median	(47.01-50.01)49.01	(48.01-49.75) 48.50	(47.01-49.50) 49.01	0.788*
Head circumference(Cm)	(Third quartile-first quartile) Median	(32.75-35.01)34.01	(33.50-35.01) 34.01	(33.75-35.01) 34.01	0.745*
Temperature(°C)	(Third quartile-first quartile) Median	(37.01-37.01) 37.01	(36.90-37.10) 37.01	(36.90-37.01) 37.01	0.806*
Gender	Male Female	20(44.4) 25(55.6)	27(60) 18(40)	21(46.7) 24(53.3)	0.280**
Sum		45(100)	45(100)	45(100)	

* Kruskal Wallis test
** Chi-squared test

Table 2. Comparison the mean score of pain between three groups during and after heel blood sampling

Variable	Pain score(Mean ± SD)			
	Local heat group	Massage group	Control group	*P-value
During Blood Sampling	4.15±1.55	4.35±1.89	5.73±1.52	< 0.001
After Blood Sampling	2.62±1.81	2.77±2.29	4.41±2.37	< 0.001
Mean Differences	-1.53±1.15	-1.57±1.27	-1.33±1.27	< 0.001
P-value **	< 0.001	< 0.001	< 0.001	

* ANOVA
**Pair T test

two intervention groups compared to the control group (Table 2).

Tukey's post hoc test indicated a statistically significant difference in mean pain scores during blood sampling between the local heat group and the control group ($p < 0.001$) and between the massage group and the control group ($p < 0.001$). However, there was no statistically significant difference between the massage group and the local heat group ($p = 0.83$) (Table 3).

After blood sampling, Tukey's post hoc test demonstrated a statistically significant difference in mean pain scores between the local heat group and the control group and between the massage group and the control group ($p < 0.05$). Again, no statistically significant difference was found between the massage group and the local heat group ($p = 0.93$) (Table 4).

Table 3. Pair Comparison between the mean score of pain during heel blood sampling

Groups, pain score (Mean ± SD)		*P-value
Local heat (4.15±1.55)	Massage (4.35±1.89) Control (4.41±2.37)	0.837 < 0.001
Massage (4.35±1.89)	Local heat (4.15±1.55) Control (4.41±2.37)	0.837 < 0.001

* Tukey Post Hoc Test

Table 4. Pair Comparison between the mean score of pain after heel blood sampling

Groups, pain score (Mean ± SD)		*P-value
Local heat (2.62±1.81)	Massage (2.77±2.29) Control (5.73±1.52)	0.939 < 0.001
Massage (2.77±2.29)	Local heat (2.62±1.81) Control (5.73±1.52)	0.939 0.002

* Tukey Post Hoc Test

Discussion

The present study's findings indicated a statistically significant difference in mean pain scores among the three groups of neonates during and after blood sampling, with the control group experiencing higher mean pain scores. These results align with those of Gholami et al., who reported less pain intensity in neonates receiving massage and kangaroo care compared to a control group. However, Gholami et al. used whole-body massage performed by the mother, whereas our study involved foot massage performed by the researcher. Furthermore, kangaroo care was administered as a second intervention. Given that kangaroo care requires specialized clothing, a specific setting, and maternal training, and is better suited for hospitalized neonates rather than outpatients undergoing medical tests, local heat

may serve as a practical alternative.

Özkan et al. investigated the effects of acupressure and foot massage on pain intensity during heel lancing in neonates, finding statistically significant differences between the acupressure and massage groups and a control group in NIPS scores during and 1 minute after heel lancing, but no significant difference between the acupressure and massage groups (33). Thus, heat can be used instead of massage when contraindications such as skin damage are present.

In agreement with our study, Shu et al. compared the effect of swaddling and heel warming on the pain response to heel blood sampling, demonstrating that both interventions significantly reduced pain during and after blood collection (34). A strength of our study was the use of foot massage instead of swaddling. Incorrect swaddling can cause discomfort, while massage therapy consistently offers relaxation and relief, making it a recommended intervention for neonates.

Ghobadi Mohebi et al. examined the effect of local heat on pain intensity caused by heel blood sampling in term neonates, finding that the heat group (using a hair dryer) had significantly lower mean pain intensity during blood sampling compared to groups receiving hair dryer sound or no intervention. After blood sampling, the heat group continued to have significantly lower pain intensity (29). These results are consistent with our findings, although we found both interventions equally effective. This difference may be attributed to their use of hair dryer sound as a second intervention, while we used foot massage, which is known for its calming effects.

Nurbayantie examined the effect of breastfeeding and massage on neonatal pain during venous blood sampling, reporting significantly lower mean pain scores in the breastfeeding and massage groups compared to the control group (35). In that study, the lower limb was massaged for 2 minutes, while we massaged the soles of the feet for 3 minutes. Furthermore, they measured pain during venous blood sampling, while we focused on heel pain. Future studies should address pain associated with venous blood sampling.

In line with our study, Zahed Pasha et al. showed that local heat application before minor painful procedures such as intramuscular vitamin K injection in neonates can effectively reduce pain (36). While they used a radiant heater, we used a hair dryer, which is more convenient and practical for outpatients undergoing procedures like thyroid testing.

Our data showed a statistically significant difference between the mean pain scores in the local heat group during and after blood sampling, with pain scores decreasing after blood sampling. Similarly, Sapkota et al. demonstrated that applying heat (a hot water bag at 38–40°C) before heel blood sampling effectively reduces pain in neonates (37). However, maintaining a constant temperature with a hot water bag is challenging, and there is a risk of burns. The dry heat from a hair dryer avoids these side effects and can be recommended as an alternative.

Herrington and Chiodo investigated the effect of infant touching on pain reduction and found that warming neonates by touch before heel blood sampling effectively reduces pain (38). It's important to note that therapeutic touch may not provide uniform heat transfer, and the physical condition of the person providing the touch can influence the results. The consistent intensity and temperature of the heat intervention in our study ensured that all neonates were treated under the same conditions.

Our data also showed a statistically significant difference in mean pain scores in the foot massage group during and after blood sampling, with pain scores decreasing after blood sampling. Karamisefat et al. reported similar findings, with statistically significant differences in mean pain intensity scores before and after massage in young children (39). However, they used the FLACC scale to measure pain.

Chik et al. examined the effect of upper limb massage on pain caused by venipuncture in neonates, finding significantly lower average pain scores during and 30 seconds after venipuncture in neonates who received massage (40). These results align with our findings, although they massaged the upper limbs and measured pain caused by venipuncture.

The present study revealed a statistically significant difference in mean pain scores in the control group during and after blood sampling, with pain intensity decreasing after blood sampling. While pain reduction is expected as the infant's condition stabilizes, foot massage and local heat interventions can further reduce pain intensity during and after blood collection. Especially in the jaundiced newborns, that need continuous measurement of blood bilirubin levels (41). Given the inevitability of heel blood sampling for thyroid testing and the feasibility of the two interventions, they can be applied to reduce pain

based on the infant's condition.

This study was conducted in a small healthcare center, focusing only on heel blood sampling for thyroid tests. Future research should be conducted in larger healthcare centers using other procedures, such as venipuncture and intramuscular injections.

Conclusion

The findings of the present study indicate that local heat and foot massage reduce pain intensity during and after heel blood collection in neonates. As both procedures are easy, safe, and do not require complex equipment or expert personnel, they can be applied during painful procedures in neonates.

Acknowledgments

This paper reports the results of a master's thesis and a research proposal approved by Rafsanjan University of Medical Sciences. The authors would like to thank university officials and the parents of infants who participated in this research project. We also extend our gratitude to the officials of Rafsanjan Comprehensive Healthcare Center No. 1 for their cooperation and support in conducting this research project.

Conflicts of interest

The authors declare that they have no competing interests.

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