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Shahla Shafaati Laleh, Sevil Inal & Mojgan Mirghafourvand

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The effect of maternal scent-infused blanket on the stress level, crying duration and physiological parameters of premature newborns

Shahla Shafaati Laleh[a], Sevil Inal[b] and Mojgan Mirghafourvand[c]

[a]Department of Midwifery, Urmia Islamic Azad University, Urmia, Iran; [b]Faculty of Health Sciences, Midwifery Department, Istanbul University- Cerrahpasa, Istanbul, Türkiye; [c]Social Determinants of Health Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

ABSTRACT

Background: Olfactory cues from the mother may soothe distress in premature infants in the Neonatal Intensive Care Unit (NICU). This study evaluated the effect of a maternal scent-infused blanket on stress, crying duration, and physiological parameters in premature newborns.

Methods: This double-blind randomized clinical trial included 69 premature infants who were randomly assigned to one of three groups: maternal scent–infused blanket, unscented blanket, or control (no blanket) group. Infants were covered with the assigned blanket for 60 min daily for 3 consecutive days. The maternal scent was obtained by placing a clean blanket in contact with the mother's bare chest overnight prior to each day's exposure, with fragrance-free cleansing products used and a new blanket for each session. Primary outcomes were stress level (Newborn Stress Scale, NSS), crying duration (chronometer), and Secondary outcomes were physiological parameters (heart rate, respiratory rate, oxygen saturation, and body temperature). Measurements were collected at 5 min before intervention, immediately after, and at 15, 30, 45, and 60 min during intervention, plus 5 min after intervention, each day for three consecutive days. Data were analyzed using one-way ANOVA and ANCOVA adjusting for baseline values; $p < 0.05$ denoted significance.

Results: Stress scores and crying duration differed significantly among groups during the intervention, with the maternal scent-infused blanket group showing lower NSS scores and shorter crying times than the unscented and no-blanket groups ($p < 0.001$). During exposure, heart rate, oxygen saturation, and body temperature differed among groups (significant at multiple time points, $p < 0.001$); by contrast, respiratory rate did not differ significantly ($p > 0.05$). Differences were not observed at baseline or immediately after the intervention for these physiological measures.

Conclusion: The maternal scent-infused blanket may reduce stress and crying duration, with transient improvements in some physiological parameters during exposure. Maternal olfactory cues could serve as a feasible non-pharmacological adjunct to support comfort and well-being in vulnerable newborns, emphasizing parental involvement in neonatal care.

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Olfactory stimulation; maternal scent; preterm infants; neonatal intensive care unit (NICU); stress

Introduction

The sense of smell plays a central role in early mother–infant bonding and may facilitate feeding behaviors such as latch-on. Olfactory development begins *in utero*, with olfactory cells differentiating by about 11 weeks and functional maturity reached by 26–28 weeks gestation. At this stage, olfaction contributes to motor and emotional responses similar to other senses and may also support the developing visual system by aiding adaptation to the changing environment [1–3].

Premature infants in the Neonatal Intensive Care Unit (NICU) frequently undergo painful procedures and experience separation from their mothers, both of which are important stressors that can influence brain development during critical periods [4–6]. Non-pharmacological approaches, including tactile and

CONTACT Shahla Shafaati Laleh Shafaati.sh@gmail.com Department of Midwifery, Urmia Islamic Azad University, Urmia, Iran.
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olfactory stimulation, have shown therapeutic potential in reducing distress and facilitating comfort in newborns. In particular, fetal–maternal scents (breast milk, body odor, and amniotic fluid) have been associated with decreased crying, reduced motor activity, and attenuated discomfort during painful procedures, with some evidence suggesting involvement of endogenous endorphin pathways [7–11].

Despite this background, no study has yet evaluated whether delivering a maternal scent through a blanket that covers the infant can provide sustained soothing beyond odor exposure alone. While informal clinical experience suggests that such a maternal-scent infused blanket may calm and relax preterm infants, this question remains untested in a rigorous, evidence-based framework. Addressing this gap, we designed a randomized trial to examine whether a maternal-scent infused blanket—covering the infant for 60 min daily over three consecutive days—can reduce stress, shorten crying duration, and improve physiological stability compared with an unscented blanket or no blanket.

The primary objectives are to assess the effects on stress level (Newborn Stress Scale), crying duration, and physiological parameters (heart rate, respiratory rate, oxygen saturation, and body temperature). We also evaluate feasibility and safety to inform potential integration into NICU care and parental involvement practices. This study aims to provide evidence on a practical, non-pharmacological intervention that leverages maternal olfactory cues to support comfort and well-being in vulnerable newborns.

Study hypotheses

Primary hypothesis

Premature infants exposed to a maternal scent–infused blanket will demonstrate lower stress scores compared to infants in the unscented blanket and control groups during the intervention period.

Secondary hypotheses

1. Crying duration will be shorter in the maternal scent–infused blanket group compared to the other groups.
2. Physiological parameters (heart rate, body temperature, and oxygen saturation) will show favorable changes during the intervention period in the maternal scent–infused blanket group.

Materials and methods

Study design

This study was a double-blind randomized clinical trial conducted in accordance with CONSORT guidelines (Figure 2). Additionally, the trial was registered on the website https://clinicaltrials.gov under the ClinicalTrials.gov ID: NCT06437106. The purpose of the study, its risks, and the voluntary nature of participation were explained to the mothers in accordance with the Helsinki Declaration; written and verbal consent was obtained. The data were stored anonymously.

Participants

The study was conducted in the Neonatal Intensive Care Units (NICUs) of Al-Zahra Teaching and Research Hospital and Taleghani Teaching and Research Hospital in Tabriz, Iran.

Newborns

Inclusion criteria

- Age 0–28 d
- Admission to the NICU

- Gestational age at birth 28–36 weeks
- Clinically stable
- No analgesics or sedatives administered in the last 6 h
- Finished feeding 30 min before the procedure
- Weight > 1000 g
- Apgar score > 7

Mothers

Inclusion criteria

- Mother able to attend the hospital
- Informed consent obtained from the family

Exclusion criteria

- Readmission for other reasons during data collection
- Parents illiterate

Sample size

The sample size for the study was determined using G*Power software (version 3.1.9.7) based on the findings of Deniz and Sarıalioğlu [12], which investigated the effects of maternal milk scent on pain and stress levels during endotracheal aspiration in newborns. The study found significant differences in the ALPS-Neo Newborn Pain and Stress Assessment Scale scores (ALPS-Neo), with the intervention group showing pretest averages of 2.18 ± 1.56 before the procedure, 4.50 ± 3.47 during the procedure, and 1.55 ± 2.37 after the procedure. In the control group, the scores were 1.73 ± 1.19 before, 8.68 ± 1.19 during, and 1.64 ± 1.42 after the procedure. Using the "ANOVA: Repeated measures, within-between interaction" method, an effect size of ($f = 0.237$) was calculated, leading to a required sample size of 54 observations with 80% power and a 5% significance level. Considering a 10% attrition rate, the final sample size was set at 69. The randomization included 23 premature infants in each of the two experimental groups and the control group. Ultimately, 69 mothers and their infants who met the inclusion criteria were included in the study.

Randomization and blinding

Initially, the principal investigator used computer-assisted randomization to form the sample groups (https://www.random.org/). To ensure blinding in determining the type of intervention, randomly assigned numbers were written on opaque envelopes and were sequentially numbered. The envelopes were opened in the order of participants entering the study, and the type of intervention received was determined. A person, who was not involved in the sampling and data collection process, determined the allocation sequence. Specifically, stress scores, crying duration, and physiological measurements (temperature, heart rate, respiratory rate, and oxygen saturation) were performed by the study investigator who remained blinded to allocation. The blankets were prepared and distributed by trained NICU staff who were not involved in data collection, using neutral study codes so the investigator remained unaware of the group identity. Data analyses were performed by a statistician blinded to group labels during the primary analyses.

Outcome measures

Data were collected using the following tools:

Neonatal and maternal introductory information form

The form for sharing information about the neonate and the mother was developed by the researcher and advisor based on the literature [3,5,13]. This introductory form contains a total of 23 questions regarding the characteristics of the infant, including the mother's age, mother's education level, infant's birth weight, height, head circumference, chest circumference, gender, and gestational age, mode of delivery, diagnosis, infant's feeding method, whether analgesics or sedatives were administered within the last 6 h, whether a painful procedure was performed in the last half hour, and feeding status in the last 30 min. The answers to these questions were collected from patient files, nurse/midwife observation forms, and face-to-face interviews with parents.

Newborn stress scale (NSS)

NSS Developed by Ceylan and Bolışık to assess stress in premature infants and consists of 24 items divided into 8 subgroups: "facial expression," "body color," "respiration," "activity level," "ability to be consoled," "muscle tone," "extremities," and "posture" [14]. It is sufficient for the infant to show only one behavior from each sub-dimension for scoring. If the infant displays symptoms from two different sub-dimensions during observation (for example, if the infant shows signs corresponding to both 1 and 2 points), the highest value is considered valid. Each group is rated on a 3-point Likert scale ranging from 0 to 2. The maximum score from the scale is 16, while the minimum is 0. A score of 0 indicates no stress in the infant, while an increasing score indicates a higher level of stress. The observer who administered the NSS was fluent in Turkish and a PhD student at Istanbul University, so the Turkish version of the NSS was used directly without Persian adaptation. No official Persian translation/back translation was performed. Since the scale is used in Turkish, validity and reliability are not necessary; however, due to changes in the research environment and its implementation in Iran, the Cronbach score was calculated by measuring 30 infants. In our study, the Cronbach alpha value for the NSS was determined to be 0.726. In the study, the infants' stress levels were assessed using NSS at various times: 5 min before the procedure, immediately after the procedure, every 15 min during the procedure, and 5 min after the procedure. The stress levels of the control group infants will be assessed in the same manner during the same time periods.

Neonatal follow-up form

In the newborn follow-up form, the baby's physiological parameters, including heart rate, respiratory rate, and oxygen saturation, evaluated and recorded before, during, and after the procedure. The form also documents the total crying time (from the beginning to the end of the procedure and over the course of 1 h) and stress level scores, which assessed 5 min before the procedure, every 15 min during the procedure, and 5 min after it by the observer. For the control group infants, stress levels during the same time periods observed and recorded by the observer on this form. Additionally, the crying duration and respiratory rate of the newborns measured with a chronometer and noted. The time taken for the newborn to return to normal values for these parameters also evaluated (Figure 1).

Blanket for covering the neonate

The blanket used to cover the infants is a thin, square cloth made of washable cotton, measuring 50×50 cm. It is designed to cover the entire body of the neonate from the shoulders down, excluding the head. The same structural features, thickness, and size of the blanket were used for all infants. Before use, the blanket was washed with a fragrance-free cleaner compatible with baby skin and rinsed thoroughly. After drying, it was stored in a sealed bag to prevent exposure to external odors (for a maximum of 2 h).

In the maternal-scent infused blanket group (Group 1), the blanket was given to the mother one day before the procedure to be carried against her bare skin on her chest overnight. In the morning, it was taken from the mother and placed on the infant for 1 h each day for 3 d. Each time the infant was covered, a new blanket was used. In maternal-scent infused blanket group, the maternal scent was infused into the new blanket using the same method for each application.

Criteria to be Evaluated	Day	5 minutes before intervention	Immediately after the intervention	15th minute	30th minute	45th minute	60th minute	5 minute after intervention
Stress Scale Score (observed)	Day 1							
	Day 2							
	Day 3							
Pulse rate/min	Day 1							
	Day 2							
	Day 3							
Respiratory rate/min	Day 1							
	Day 2							
	Day 3							
Body temperature/°C	Day 1							
	Day 2							
	Day 3							
O2 saturation	Day 1							
	Day 2							
	Day 3							
Crying time (seconds)	Day 1							
	Day 2							
	Day 3							

Figure 1. The neonatal follow-up form.

In the unscented blanket group (Group 2), the blanket was taken out of the sealed bag and placed on the infant for 1 h daily over the course of 3 d without infusing it with maternal scent. A new and clean blanket was used for each application. The covering process unscented blanket was applied over 3 d. Control group infants were cared for without any blanket, following the unit's routine practices. In all three groups, care was taken to avoid using scented cleaning products and disinfectants during treatment and care at the times the research was conducted.

Oxygen saturation measurement device

The oxygen saturation measurement device (pulse oximeter) is suitable for use in pediatric patients, infants, and neonates. The standard measurements include oxygen saturation, heart rate, and perfusion rate. The device was used to assess the heart rate and oxygen saturation of the neonates 5 min before the procedure (maternal-scent infused and unscented blanket for 3 d), at 15-min intervals during the procedure, and at the fifth minute after the procedure. The oxygen saturation levels of the control group infants were measured during the same time periods.

Chronometer

The chronometer was used to determine the crying durations of the neonates during the procedure (maternal-scent infused and unscented blanket for 3 d). The crying duration of the control group infants was also measured during the same time periods.

Intervention procedures

The intervention lasted 1 h and was designed as a feasible, non-disruptive exposure to olfactory stimuli within the NICU. It allows multiple standardized measurements and can be repeated across three consecutive days without significantly disrupting feeding schedules or routine care. To maintain hygiene and prevent scent contamination, a new, clean blanket was used for each session across all 3 d. Group 1 received a maternal-scent infused blanket, prepared by placing a square cotton blanket in direct contact with the mother's bare skin after her shower; after about 12 h the blanket was removed and sealed to prevent cross-contamination, and all fabrics were washed with fragrance-free, baby-friendly detergent before distribution. Mothers were instructed to use fragrance-free cleansing products, avoid scented items, and refrain from introducing new products during the study. Group 2 received an unscented blanket; Group 3 served as control with no blanket. Newborn care included changing diapers and ensuring full feeding at least 30 min before the intervention. Infants were kept in the incubator wearing only a diaper to minimize heat loss. The intervention occurred for 1 h each morning over three consecutive days, with no painful interventions performed within 30 min before or after. Physiologic measures (body temperature, heart rate, respiratory rate, and oxygen saturation) were recorded 5 min before intervention, immediately after intervention, every 15 min during, and 5 min after intervention; crying duration was measured with a chronometer; stress scores were assessed by a blinded researcher at the same time points. The planned sample size was 23 infants per group (Figure 2).

Outcome measures and time points

Primary outcomes

Stress level (NSS) and crying duration during the 60-min intervention.

Secondary outcomes

physiological parameters (heart rate, respiratory rate, oxygen saturation, and body temperature).

Time points

Stress level, crying duration, and physiological measurements were collected at 5 min before intervention, immediately after intervention, and at 15, 30, 45, and 60 min during intervention, plus 5 min after intervention, each day for three consecutive days.

Statistical analysis

After data collection, analyses were conducted in SPSS version 24. The normality of numerical variables was assessed using the Kolmogorov-Smirnov test. Descriptive statistics included means ± SD for continuous variables and frequencies (%) for categorical variables. Baseline characteristics were compared across groups using chi-square tests (and chi-square for trend where appropriate) or Fisher's exact test for categorical variables and one-way ANOVA for continuous variables. For primary outcomes (stress level) and Secondary outcomes physiological parameters (heart rate, respiratory rate, oxygen saturation, and body temperature), baseline group differences were evaluated with one-way ANOVA; post-intervention differences were tested with ANCOVA, with group as a fixed factor and the corresponding pre-intervention value as the covariate (i.e. baseline stress score for stress score; baseline pulse rate for pulse rate; etc.), reporting adjusted means (least-squares means) and p values. Crying duration, being non-parametric, was analyzed with Kruskal-Wallis. Stress level and physiological measures are presented as mean ± SD at each time point; crying duration is presented as median (Interquartile Range, IQR). The Type I error rate was set at $\alpha = 0.05$ for all hypothesis tests.

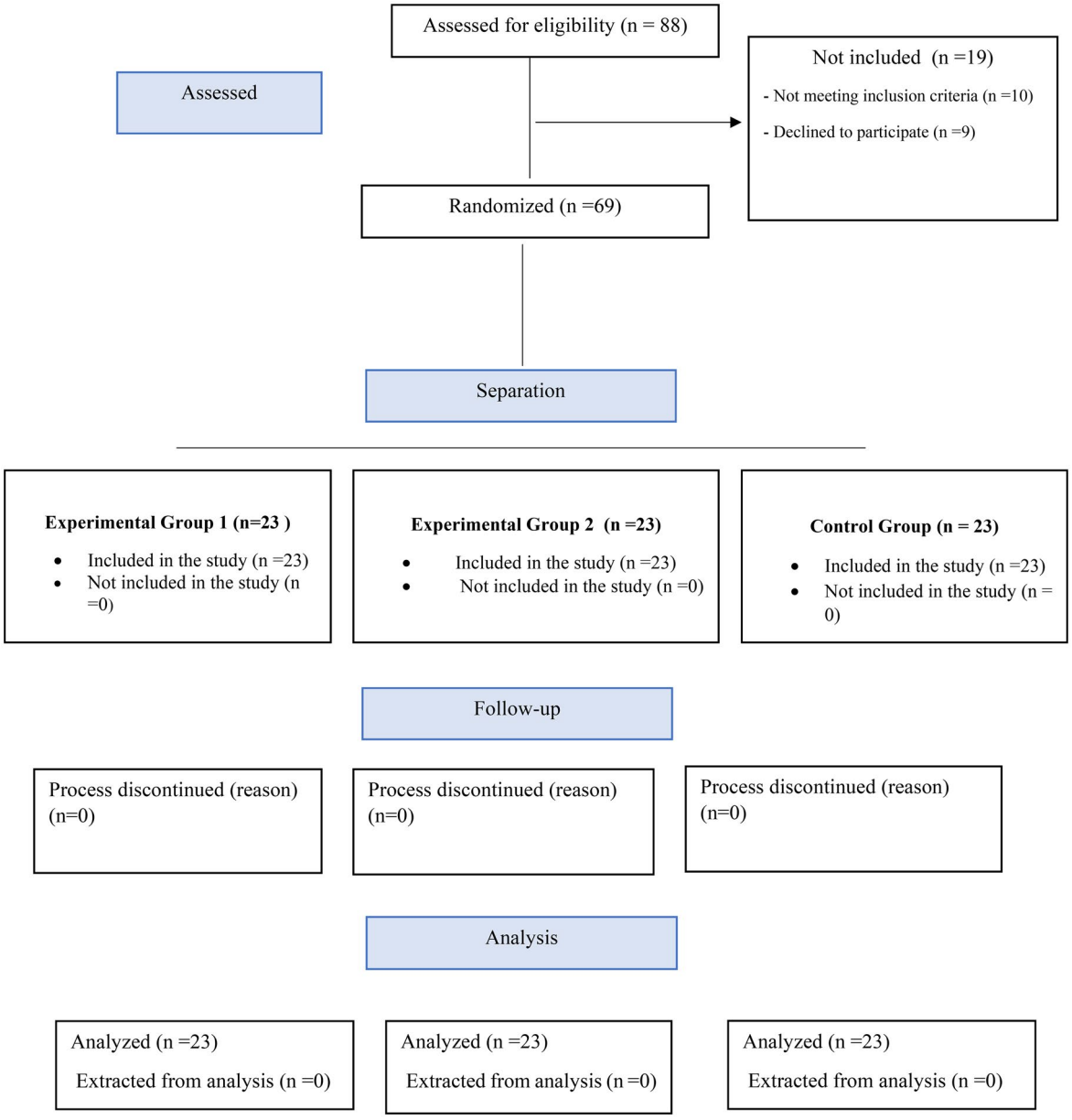

Figure 2. Flowchart of the study (CONSORT 2025).

Results

The results showed no statistically significant differences among the three groups in socio-demographic characteristics, including maternal age, gestational age, postnatal age, birth weight, number of invasive procedures, maternal education level, type of delivery, infant gender, infant diagnosis, and the infant's general condition ($p > 0.05$). These findings are presented in Table 1 and Supplementary Table 1.

Stress levels, assessed using the Neonatal Stress Scale (NSS), are presented in Table 2 and Supplementary Table 2. At baseline, no statistically significant differences were observed among the three groups, indicating comparable stress levels prior to the intervention. Beginning immediately after the intervention and at all subsequent measured time points—15, 30, 45, and 60 min into the intervention, as well as 5 min after its conclusion—statistically significant differences in NSS scores were found between the groups ($p < .001$ for all comparisons). At each of these assessments, the maternal scent-infused blanket group consistently exhibited the lowest stress scores compared to both the unscented blanket group and the control group. While a minor increase in stress scores toward

Table 1. Baseline characteristics of participants by the study groups ($N = 69$).

Variables	Group 1 ($n = 23$) *n* (%)	Group 2 ($n = 23$) *n* (%)	Control ($n = 23$) *n* (%)	*p* value
Variables	Group 1 ($n = 23$) Mean ± SD	Group 2 ($n = 23$) Mean ± SD	Control ($n = 23$) Mean ± SD	p^c
Mother's age (year)	29.91 ± 8.32	30 ± 7.63	30.86±.4.52	0.878
Gestational age (week)	31.78 ± 2.84	31.95 ± 2.73	32.30 ± 2.56	0.803
Postnatal age (day)	9.13 ± 5.32	6.21 ±.5.56	5.52 ± 4.86	0.054
Birth weight (g)	1806 ± 937.36	1662 ± 447.32	1710 ± 616.90	0.777
Number of several invasive procedures*	2.34 ± 0.48	2.13 ± 0.34	2.08 ± 0.28	0.053
	n (%)	*n* (%)	*n* (%)	*p* value
Mother's education level	–	–	–	0.857[a]
Elementary	10 (43.5)	10 (43.5)	6 (26.1)	
High School	10 (43.5)	2 (8.7)	11 (47.8)	
University	3 (13.0)	11 (47.8)	6 (26.1)	
Diagnosis of the baby	–	–	–	0.489[b]
Respiratory distress	18 (78.3)	17 (73.91)	14 (60.9)	
Hyperbilirubinemia	3 (13)	4 (17.41)	4 (17.4)	
Intrauterine growth retardation (IUGR)	2 (8.7)	1 (4.34)	5 (21.7)	
Congestive heart disease (CHD)	0 (0.0)	1 (4.34)	0 (0.0)	
Type of delivery	–	–	–	0.272[a]
Cesarean section	15 (65.2)	19 (82.6)	19 (82.6)	
Vaginal	8 (34.8)	4 (17.4)	4 (17.4)	
General condition of the baby	–	–	–	0.104[b]
Good	11 (47.8)	12 (52.2)	5 (21.7)	
Average	10 (43.5)	11 (47.8)	16 (69.6)	
Bad	2 (8.7)	0 (0.0)	2 (8.7)	
Baby's gender	–	–	–	0.558[a]
Female	10 (43.5)	12 12 (52.2)	14 (60.9)	
Male	13 (56.5)	11 (47.8)	9 (39.1)	

[a]Chi square; [b]Fisher's Test; [c]One Way ANOVA; Group 1: maternal scent-infused blanket Group 2: unscented blanket Group 3: Control.
*Number of several invasive procedures (Blood sampling, venipuncture, vaccination, endotracheal tube, aspiration).

Table 2. Comparison of average stress scores of newborns in experimental and control groups at key time points ($N = 69$).

Variables	Control ($n = 23$) Mean ± SD	Group 2 ($n = 23$) Mean ± SD	Group 1 ($n = 23$) Mean ± SD	*p* value
5 min before intervention	8.04 ± 2.01	8.17 ± 1.99	8.86 ± 1.71	0.295[c]
Immediately After intervention	7.95 ± 2.07	8.04 ± 2.09	9.52 ± 2.04	<0.001[d]
15th minute of intervention	6.86 ± 1.91	7.73 ± 1.78	9.47 ± 1.97	<0.001[d]
30th minute of intervention	5.30 ± 2.30	7.17 ± 1.99	9.30 ± 2.40	<0.001[d]
45th minute of intervention	4.95 ± 2.43	7.17 ± 1.99	9.34 ± 2.46	<0.001[d]
60th minute of intervention	4.86 ± 2.51	7.17 ± 1.99	9.30 ± 2.40	<0.001[d]
5 min after intervention	5.21 ± 2.50	7.39 ± 2.01	9.30 ± 2.40	<0.001[d]

[c]One Way ANOVA; [d]ANCOVA test; Group 1: maternal scent-infused blanket; Group 2: unscented blanket; Group 3: Control.

baseline was noted across all groups after the intervention, the maternal scent-infused blanket group maintained the lowest mean stress levels throughout the entire observation period. These results indicate that the intervention had a significant effect on reducing newborn stress, with the most pronounced and sustained benefit occurring during the intervention and in the immediate after intervention period.

Crying duration during the intervention period is presented in Table 3. A statistically significant difference in crying duration was observed between the three groups on all intervention days (Day 1, Day 2, and Day 3; $p < 0.001$ for all comparisons). On Day 1, the median crying duration was shortest in the maternal scent–infused blanket group [15 s (IQR: 10–18)], followed by the unscented blanket group [30 s (IQR: 14–60)], while the longest crying duration was observed in the control group [100 s (IQR: 60–230)]. A similar pattern was observed on Day 2, with median crying durations of 7 s (IQR: 0–22), 31 s (IQR: 20–47), and 150 s (IQR: 65–240) in the maternal scent–infused blanket, unscented blanket, and control groups, respectively ($p < 0.001$). On Day 3, median crying durations were 6 s (IQR: 0–15) in the maternal scent–infused blanket group, 29 s (IQR: 10–37) in the unscented blanket group, and 85 s (IQR: 43–185) in the control group ($p < 0.001$). Across all 3 d, crying duration

consistently remained lowest in the maternal scent–infused blanket group and highest in the control group, indicating a stable between-group difference throughout the intervention period.

The findings regarding the comparison of average heart rates, body temperatures, and oxygen saturation for the research group are presented in Tables 4–6 and Supplementary Table 3-6. There was no statistically significant difference in heart rates, body temperatures, and oxygen saturation among the maternal-scent infused blanket group (Group 1), the unscented blanket group (Group 2), and the control group over the 3 d, at the fifth minute before the intervention, and immediately after the intervention ($p > 0.05$). However, a statistically significant difference in heart rates, body temperatures and oxygen saturation among the maternal-scent infused blanket group, the unscented

Table 3. Comparison of the average crying duration of the newborns in the experimental and control groups before, during and after the procedure. ($N = 69$).

	Group 1 ($n = 23$)	Group 2 ($n = 23$)	Control ($n = 23$)	
Variables	Medium (percentiles 25 to 75)	Medium (percentiles 25 to 75)	Medium (percentiles 25 to 75)	p value
Day 1	15 (10 to18)	30 (14 to 60)	100 (60 to 230)	<0.001
Day 2	7 (0 to 22)	31 (20 to 47)	150 (65 to 240)	<0.001
Day 3	6 (0 to 15)	29 (10 to 37)	85 (43 to 185)	<0.001

Group 1: maternal scent-infused blanket; Group 2: unscented blanket; Group 3: Control.

Table 4. Comparison of average heart rate of newborns in experimental and control groups at key time points ($N = 69$).

	Control ($n = 23$)	Group 2 ($n = 23$)	Group 1 ($n = 23$)	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	p value
5 min before intervention	159.43 ± 13.33	150.65 ± 10.18	159.30 ± 13.03	0.026[c]
Immediately After intervention	158.30 ± 13.78	151.30 ± 10.40	158.95 ± 13.67	0.305[d]
15th minute of intervention	152.21 ± 13.26	147.47 ± 12.05	158.60 ± 14.56	<0.001[d]
30th minute of intervention	147.08 ± 13.47	146.13 ± 11.66	157.21 ± 14.09	<0.001[d]
45th minute of intervention	144.08 ± 14.01	145.82 ± 12.13	157.56 ± 14.53	<0.001[d]
60th minute of intervention	142.56 ± 13.47	145.82 ± 10.97	157.65 ± 14.42	<0.001[d]
5 min after intervention	145.47 ± 12.78	148.86 ± 9.72	157.78 ± 14.60	<0.001[d]

[c]One Way ANOVA; [d]ANCOVA test; Group 1: maternal scent-infused blanket Group 2: unscented blanket Group 3: Control.

Table 5. Comparison of average body temperature of newborns in experimental and control groups at key time points ($N = 69$).

	Control ($n = 23$)	Group 2 ($n = 23$)	Group 1 ($n = 23$)	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	p value
5 min before intervention	36.61 ± 0.28	36.60 ± 0.23	36.65 ± 0.24	0.745[c]
Immediately After intervention	36.62 ± 0.28	36.59 ± 0.24	36.65 ± 0.23	–
15th minute of intervention	36.66 ± 0.23	36.64 ± 0.23	36.66 ± 0.23	0.007[d]
30th minute of intervention	36.73 ± 0.28	36.74 ± 0.34	36.66 ± 0.23	0.003[d]
45th minute of intervention	36.76 ± 0.28	36.74 ± 0.25	36.67 ± 0.23	<0.001[d]
60th minute of intervention	36.78 ± 0.28	36.76 ± 0.27	36.68 ± 0.23	<0.001[d]
5 min after intervention	36.69 ± 0.27	36.67 ± 0.26	36.66 ± 0.23	<0.001[d]

[c]One Way ANOVA; [d]ANCOVA test; Group 1: maternal scent-infused blanket Group 2: unscented blanket Group 3: Control.

Table 6. Comparison of average oxygen saturation of newborns in experimental and control groups at key time points ($N = 69$).

	Control ($n = 23$)	Group 2 ($n = 23$)	Group 1 ($n = 23$)	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	p value
5 min before intervention	93.13 ± 3.01	93.17 ± 2.26	94.30 ± 2.72	0.251[c]
Immediately After intervention	93.59 ± 0.15	93.48 ± 0.15	93.13 ± 0.15	0.093[d]
15th minute of intervention	94.21 ± 2.48	93.78 ± 2.39	93.65 ± 2.77	<0.001[d]
30th minute of intervention	95.82 ± 2.03	94.30 ± 2.30	94.08 ± 2.67	<0.001[d]
45th minute of intervention	96.26 ± 1.83	94.60 ± 2.12	93.60 ± 3.12	<0.001[d]
60th minute of intervention	96.26 ± 1.78	94.39 ± 2.14	93.78 ± 2.82	<0.001[d]
5 min after intervention	95.52 ± 1.95	93.73 ± 2.13	93.73 ± 2.59	<0.001[d]

[c]One Way ANOVA; [d]ANCOVA test; Group 1: maternal scent-infused blanket; Group 2: unscented blanket; Group 3: Control.

blanket group and the control group over the 3 d, at the 15th, 30th, 45th, 60th minutes, and at the 5th minutes after intervention ($p < 0.001$) (Table 4–6 and Supplementary Table 3-6). Additionally, there was no statistically significant difference in respiratory rates among the maternal-scent infused blanket group (Group 1), the unscented blanket group (Group 2), and the control group over the 3 d ($p > 0.05$, Supplementary Table 6).

Discussion

The present study found that covering premature infants with a maternal scent–infused blanket significantly reduced observed stress and crying during NICU care compared with both unscented blankets and no blanket. These benefits were most evident during the 60-min intervention period and were accompanied by transient improvements in several physiological parameters (heart rate, oxygen saturation, and body temperature) while the blanket was in place, whereas respiratory rate did not differ among groups. Taken together, these results suggest that maternal olfactory cues delivered *via* an inanimate object can modulate neonatal stress responses even in the absence of direct maternal contact, offering a feasible, non-pharmacological adjunct to support comfort in vulnerable newborns. Due to limited research directly examining maternal scent on newborn stress, studies on breast milk scent provide a relevant foundation. Existing evidence shows that maternal scent, particularly from breast milk, plays a key role in increasing infant comfort and reducing stress. A quasi-experimental study found that mechanically ventilated infants exposed to a warm, maternally scented simulated hand during invasive procedures experienced significantly less discomfort and pain than those receiving standard care, demonstrating the potential of maternal scent to comfort and reduce pain in premature infants, especially when mothers are absent [15]. Another study showed that swaddling and playing music during venipuncture effectively reduced infant pain and stress. Importantly, a blanket infused with maternal scent offered both swaddling comfort and enhanced olfactory stimulation, reducing stress more effectively than a regular covering [16]. A systematic review of fifteen studies on alternative therapies for infant pain and stress, including massage, swaddling, light touch, and combined methods like pacifier use with swaddling, found these interventions effectively promoted relaxation and reduced pain, with combined techniques showing the best outcomes and safety for both preterm and term infants [17]. Additionally, a pilot study showed that continuous exposure to maternal breast milk odor significantly lowered salivary cortisol levels in preterm infants, indicating a lasting soothing effect [18].

The theory of attachment and bonding between mother and infant proposes that unique olfactory cues from the mother act as powerful signals, reinforcing feelings of security and comfort in the infant. These odors help infants recognize and prefer their mothers, and evidence suggests that maternal scents stimulate reward pathways in the infant's brain, emphasizing the critical role of smell in establishing a positive emotional foundation for infant well-being and infant comfort [19]. While prior research has firmly established that an infant's direct exposure to maternal scent (e.g. from skin or breast milk) has a calming effect, our results provide novel evidence that this powerful olfactory cue retains its efficacy when transferred to a passive object. This suggests that the stress-regulatory properties of maternal odor are not contingent on the mother's physical presence but can be effectively mediated through a familiar scent object, supporting the concept of a primary, non-learned olfactory pathway for infant soothing.

Infants cannot verbally express pain, so behaviors like crying and facial changes are common indicators [7,9]. This study found that newborns covered with a maternal-scent infused blanket showed reduced crying duration, indicating lower stress. Supporting this, research demonstrated that swaddling combined with holding and breastfeeding—which includes maternal breast milk scent—was most effective in reducing pain and calming healthy term neonates during heel lance procedures [20]. Other studies confirm the calming effects of maternal scent, especially breast milk, showing shorter crying times and analgesic effects during painful procedures [10,21–23]. Exposure to maternal scents consistently correlates with reduced crying and stress in infants during painful interventions [19,24,25].

Infants covered with blankets scented with their mother's scent showed lower mean heart rates compared to other groups, with the lowest rates observed during the intervention phase. Similarly, a study found that exposure to breast milk aroma during heel prick sampling reduced heart rate variability in infants [26]. Additionally, listening to music for 15 min alongside swaddling resulted in lower average heart rates in newborns [27]. Another study compared swaddling and music listening interventions, noting that heart rates in the intervention groups were significantly lower than in the control group, suggesting that the reduced heart rate in the swaddling group might be attributed to the restricted movement caused by swaddling [28].

The study found that premature infants in the experimental groups maintained higher body temperatures during procedures compared to the control group. However, a comparison of infants with hyperbilirubinemia across different intervention groups showed no changes in body temperature. These discrepancies may be due to differences in study materials, sample characteristics, measurement methods, or intervention timing [24].

Oxygen saturation levels in premature infants remained above 90% before, during, and after the procedure, with no significant decreases observed. The control group had the lowest oxygen saturation, while the intervention groups maintained higher levels throughout the procedure. Supporting these findings, a meta-analysis of 14 studies on olfactory stimulation interventions—such as breast milk, vanilla, and amniotic fluid scents—showed that familiar scents effectively increased oxygen saturation in infants without reported side effects [25]. Furthermore, a study comparing non-pharmacological methods on pain profiles and physiological parameters found that swaddling combined with expressed breast milk resulted in a lesser drop in oxygen saturation compared to routine care. This suggests that swaddling, similar to the method of covering infants with maternal scent, positively influences physiological responses [29].

No significant differences were observed between groups in respiratory rate before, during, or after the intervention. This aligns with previous studies showing that breast milk scent and non-nutritive sucking did not significantly affect respiratory variables during painful procedures, possibly due to breath counting being performed when infants were calm and not crying [30,31].

The study introduces the innovative concept of maternal scent-infused blankets as a means of providing sensory stimulation independent of direct maternal contact. This approach is particularly relevant in NICUs, where physical contact may be limited due to medical conditions or the need for interventions. Emphasizing this novelty, the research suggests that even in the absence of direct maternal interaction, olfactory cues can foster a calming environment for premature infants, thereby enhancing their physiological responses and overall development. By providing a portable source of familiar olfactory comfort, this intervention could help bridge gaps in maternal-infant dyadic care, potentially mitigating the cumulative stress experienced by preterm infants in the NICU environment.

Strengths and limitations

This study's strengths include its randomized clinical trial design, which enhances the validity of the findings by minimizing bias and ensuring reliable comparisons between groups. The use of a maternal scent-infused blanket represents an innovative non-pharmacological intervention that could be easily integrated into NICU practices to improve the care of premature infants. Additionally, the comprehensive assessment of stress levels, crying duration, and physiological parameters provides a well-rounded understanding of the intervention's effects. However, several limitations should be noted. First, the relatively small sample size may affect the generalizability of the results. Additionally, variations in the intensity of maternal scent could influence the outcomes. The study also focused solely on infants within a specific gestational age range, which may limit its applicability to all premature infants. It is important to recognize the potential confounding effects of covering (e.g. warmth and calming effects) versus olfactory stimulation alone. While the primary focus was on the impact of maternal scent, the warmth and physical comfort provided by the blankets may also have contributed to the observed reductions in heart rates. Lastly, the reliance on observational measures for stress assessment may introduce subjectivity, although trained researchers were employed to help mitigate this issue.

This limitation underscores the need for further research to isolate the effects of olfactory stimulation from other sensory inputs.

Implications of research and practice

The findings from this study on maternally scent-infused blankets for premature infants have significant implications for clinical practice and neonatal care. Incorporating this non-pharmacological intervention into NICU routines can effectively reduce stress and crying duration in preterm infants, potentially leading to improved clinical outcomes and overall well-being. Additionally, these results may inform healthcare policy by advocating for the inclusion of maternal scent exposure as a standard practice in infant stress management. The study underscores the importance of parental involvement in infant care, promoting practices that strengthen the bond between mothers and their infants. Furthermore, it lays the groundwork for future research to explore the long-term effects of olfactory stimuli and other sensory interventions on premature infants. Finally, educational programs for NICU staff could be developed to enhance awareness of non-pharmacological approaches, equipping healthcare professionals with the knowledge to reduce stress and pain in infants effectively.

Conclusions

This study suggests that covering premature infants with a maternal scent–infused blanket during NICU care may reduce stress and crying duration compared with unscented blankets or no blanket. Some physiological parameters showed favorable changes during the exposure (for example, heart rate and oxygen saturation at several time points), while others, such as respiratory rate, did not differ significantly. Given the modest sample size and single-center design, these findings should be interpreted with caution and do not constitute definitive evidence of clinical benefit. Further multicenter randomized trials with standardized exposure protocols are needed to confirm these observations, determine optimal duration and timing of exposure, and evaluate potential effects on longer-term outcomes. Nonetheless, the results raise the possibility that maternal olfactory cues could serve as a non-pharmacological adjunct to support comfort and well-being in vulnerable newborns, emphasizing the value of parental involvement in neonatal care.

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Ethical approval

Our two-blind randomized clinical trial was approval from the Ethics Committee of Tabriz University of Medical Sciences, which assigned the ethical code **IR.TBZMED.REC.1402.850**.

Ethics approval and consent to participate

Our double-blind randomized clinical trial was approval from the Ethics Committee of Tabriz University of Medical Sciences, which assigned the ethical code IR.TBZMED.REC.1402.850. Additionally, the trial was registered on the website https://clinicaltrials.gov under the ClinicalTrials.gov ID: NCT06437106. The study was conducted on premature infants admitted to the Neonatal Intensive Care Units in Tabriz, Iran.

Prior to the commencement of data collection, families of eligible infants were informed about the aims and content of the study, and written consent was obtained through an "Informed Consent Form."

Consent for publication

Not applicable.

Authors' contributions

CRediT: **Shahla Shafaati Laleh**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software; **Sevil Inal**: Conceptualization, Formal analysis, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – review & editing; **Mojgan Mirghafourvand**: Conceptualization, Formal analysis, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft.

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Funding

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ORCID

Shahla Shafaati Laleh http://orcid.org/0000-0002-4546-0508
Sevil Inal http://orcid.org/0000-0002-3260-1770
Mojgan Mirghafourvand http://orcid.org/0000-0001-8360-4309

Data availability statement

The datasets used and/or analyzed for this study are available by the corresponding author upon reasonable request.

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