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Original Article

Immediate perineal cryotherapy during labor: effects on early postpartum pain, edema, and pelvic floor recovery in primiparous women

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Abstract: Objective: To evaluate the effects of immediate perineal cryotherapy during labor on early postpartum outcomes, with a special focus on pain relief, reduction of perineal edema, and promotion of pelvic floor recovery, among primiparous women. Methods: In this retrospective cohort study, 260 medical records of primiparous women who delivered vaginally at Quanzhou First Hospital between January 2022 and June 2025 were analyzed. According to the predefined inclusion and exclusion criteria, 135 women underwent instant perineal cryotherapy constituted the observation group, and the other 125 women that were not given cryotherapy were the controls. Baseline data of mothers and their newborns as well as postpartum outcomes were evaluated at set intervals. The primary outcome was pain intensity at the perineum assessed using visual analog scale (VAS) at 2 hours, 6 hours and 24 hours after delivery. The secondary outcome measures included perineal edema, pelvic floor functionality, wound healing, sleep quality, systemic inflammation, coagulation indices, and sexual function. Results: Cryotherapy was associated with lower perineal pain intensity at all time points (all $P < 0.001$), with fewer women reporting severe pain or requiring analgesics in the cryotherapy group. Functional pain during sitting, standing, and urination was significantly alleviated, and a greater proportion of participants achieved ≥ 30% pain reduction at 6 and 24 hours postpartum (both $P < 0.001$). Edema scores, perineal circumference, skin temperature, and subcutaneous thickness decreased more rapidly in the cryotherapy group (all $P < 0.001$), indicating effective attenuation of tissue swelling. Pelvic floor assessments demonstrated lower resting tone, higher maximal voluntary contraction, greater endurance, and stronger vaginal squeeze pressure in the cryotherapy group (all $P < 0.001$). Wound healing improved significantly across all REEDA score dimensions. Sleep quality in the cryotherapy group was improved notably, with significantly better PSQI scores, shorter latency, longer duration, and reduced disturbances (all $P < 0.001$). Furthermore, systemic proinflammation factors (CRP, IL-6, TNF-α) and coagulation parameters (fibrinogen, D-dimer) were also reduced markedly in the cryotherapy group without evidence of deteriorating hemostasis at one week postpartum. Sexual function outcomes, including FSFI total and domain scores, were markedly improved (all $P < 0.001$). Conclusion: Perineal cryotherapy administered immediately during childbirth significantly reduces the pain, edema, and systemic inflammation and improves the recovery of the pelvic floor and wound healing, sleep patterns, and sexual activity in women whose first birth was by cesarean section, highlighting its value as versatile, relatively safe, and non-pharmacological option to optimize early postpartum recovery.

Keywords: Perineal cryotherapy, postpartum pain, edema, pelvic floor recovery, primiparous women

Introduction

Childbirth carries significant health implications for mothers, especially during the immediate postpartum phase. This phase is usually characterized by significant physical challenges such as perineal pain, edema, and pelvic floor dysfunction. These complications not only delay recovery but may also lead to long-term consequences, including pelvic floor injuries, severely affecting a woman's quality of life [1]. Perineal pain and swelling are among the most

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frequent post-partum complications and usually resulted from perineal laceration or episiotomy [2, 3]. These conditions may prolong recovery, weaken mobility, and impair essential maternal functions, including breastfeeding and mother-baby bonding.

Effective management of perineal pain and edema is therefore a critical issue during the early post-partum period [4]. Though various pharmacological and non-pharmacological measures have been employed, available evidence regarding the optimal treatment modalities remains inconclusive. Cryotherapy, a common form of therapy, has been documented to exert analgesic and anti-inflammatory effects in many clinical situations [5]. By lowering the temperature of local tissues, it reduces pain perception, limits vascular permeability, and mitigates inflammatory responses. Despite its established utility in other contexts, the use of perineal cryotherapy during labor and its impact on postpartum outcomes are still understudied [6-8].

The effectiveness of instant perineal cryotherapy during delivery, particularly its roles in pain alleviation and peritoneal emissions, has not been fully investigated in the existing literature. Although several studies have reported the effectiveness of cryotherapy in post-operative recovery and the management of musculoskeletal injuries [9-11], few studies specifically address cryotherapy on post-partum perineal trauma. Moreover, despite some studies addressing the impact of cryotherapy on the postpartum period, there is lack of studies targeting primiparous women, who have unique recovery patterns due to the lack of experience in childbirth.

This study aims to address this literature gap by assessing the impact of immediate perineal cryotherapy during labor on early postpartum outcomes, i.e. pain, edema, and pelvic floor function in primiparous women. By providing evidence regarding the effectiveness of cryotherapy in this context, this study may contribute to optimizing postpartum care guidelines to support faster recovery and improve maternal health outcomes following vaginal birth.

Methods

Case section

In this retrospective cohort study, medical records of primiparous women giving birth at the Department of Obstetrics of the Quanzhou First Hospital between January 2022 and June 2025 were analyzed. A total of 260 women were eligible and included according to predetermined inclusion and exclusion criteria. Out of them, 125 women who did not receive perineal cryotherapy immediately after delivery were classified as the control group, and the rest 135 who received immediate perineal cryotherapy was classified as the observation group.

Inclusion criteria: (1) Primiparous women aged 18-40 years with singleton pregnancies; (2) Term delivery (gestational age 37 to 41 + 6 weeks); (3) Infant Apgar scores ≥ 8 at 1 and 5 minutes; (4) Perineal trauma requiring suturing, including first- or second-degree spontaneous lacerations or mediolateral episiotomy; (5) Complete obstetric records available. Exclusion criteria: (1) Presence of hypertensive disorders of pregnancy, gestational diabetes, placenta previa, placental abruption, intrauterine infection, or significant intrapartum bleeding; (2) Instrument-assisted vaginal deliveries (forceps or vacuum-assisted); (3) Obstetric interventions associated with third-degree tears, cervical or vagina lacerations; or (4) loss to postpartum follow-up within 7 days.

This study was approved by the Ethics Committee of Quanzhou First Hospital, and all procedures were in accordance with the Declaration of Helsinki. Due to its retrospective nature and the use of anonymized medical records, the need for informed consent was waived. However, all patients included in the study retained the right to decline the use of their data for research purposes, in accordance with the hospital policy.

Intervention protocol

In the observation group, immediate perineal cryotherapy was applied within 30 minutes after delivery. The cryotherapy involved the use of gel-based cold compresses wrapped in a soft, non-adhesive cloth to avoid direct skin contact. The temperature of the compresses was maintained at approximately 4°C, measured using a calibrated thermometer. Each application lasted for 20 minutes, with a 10-minute interval. The procedural was repeated at 2, 6, and 24 hours postpartum. For the control group, no specific cold therapy was applied, and only routine postpartum care was

provided, including the use of standard analgesics and perineal care as per the hospital's routine practices. No additional interventions were provided to the control group during the study period.

Data extraction

Clinical records and standardized patient assessments were used to ensure consistent data extraction among all participants. Baseline maternal and neonatal information, such as maternal age, pre-pregnancy body mass index (BMI), gestational age at delivery, neonatal birth weight, labor induction method, episiotomy, type of perineal laceration, and the length of hospital stay were extracted for both groups. Postpartum outcomes were assessed at preset time points, including pain intensity and severity distribution, functional pain during activities (sitting, standing, urination), analgesic use, and the proportion of women obtaining a clinically significant pain reduction. Perineal edema was evaluated using edema scores, perineal circumference, local skin temperature, and subcutaneous tissue thickness. Pelvic floor function was assessed based on resting tone, maximum voluntary contraction, endurance, and vaginal squeeze pressure. Wound healing was evaluated using the REEDA scale, which measures redness, edema, ecchymosis, discharge, and wound edge approximation. Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), encompassing latency and duration, along with disturbances, medication usage, restfulness, nocturnal awakenings, and daytime fatigue. Inflammation makers (C-reactive protein [CRP], interleukin-6 [IL-6], and tumor necrosis factor-alpha [TNF-6]) and coagulation parameters (fibrinogen, D-dimer, platelet count) were measured after one week of pregnancy. Sexual function was assessed using the Female Sexual Function Index (FSFI), including total and domain-specific scores, as well as partner satisfaction.

Outcome measures

The primary outcome was post-partum perineal pain intensity, measured both subjectively and functionally. A 10-cm visual analog scale (VAS) [12] was used to measure pain severity (0 indicates no pain and 10 indicates the worst imaginable pain). Assessments were conducted at 2, 6, and 24 hours postpartum. Moreover, pain severity was further divided into mild (VAS 0-3), moderate (4-6), and severe (7-10) levels for sub-group analysis based on pain severity distribution. The presence of functional pain was also evaluated during common postpartum activities such as sitting, standing and first urination. Analgesic consumption during the first 24 hours of postpartum was also recorded. In accordance with the accepted standards of pain research, clinically meaningful improvement was defined as a $\geq$ 30% reduction in VAS relative to baseline.

Secondary outcomes included perineal edema, pelvic floor muscle, wound healing, quality of sleep, systemic inflammatory and coagulation responses, and sexual function. Perineal edema was measured either with a validated four-point edema score (0 = none; 3 = severe) [13] or objective anthropometric and imaging indices. In particular, perineal circumference was measured at the point of the greatest swelling using a flexible, nonelastic tape, skin surface temperature was measured using a calibrated infrared thermometer, and subcutaneous tissue thickness was measured using B-mode ultrasonography at predetermined perineal landmarks. The blinded assessors carried out all the assessments at 2, 6, and 24 hours postpartum. Pelvic floor muscle function was assessed using a high-sensitivity vaginal manometry system. Measurements of resting tone, maximal voluntary contraction, endurance (long-lasting contraction more than 10 s) and vaginal squeeze pressure were taken in a standardized lithotomy position. Each measure was repeated three times, and the mean value was used for analysis. Perineal wound healing was evaluated using the REEDA scale (Redness, Edema, Ecchymosis, Discharge, Approximation) [14]. Each domain was rated from 0 to 3, with a total maximum score of 15, and lower scores indicates better physical recovery. Maternal sleep quality in the first postpartum week was assessed using the PSQI [15], which measures subjective sleep latency, duration, disturbances, as well as daytime dysfunction. A total PSQI score $\geq$ 5 indicated poor sleep quality. One week postpartum, systemic inflammation markers and coagulation parameters were measured. Serum CRP, IL-6, and TNF-6 in venous blood samples were determined using standardized ELISA kits. Coagulation indices, including plasma fibrinogen, D-dimer and platelet

Table 1. Comparison of clinical characteristics between the two groups

Variable	Control Group (n = 125)	Observation Group (n = 135)	χ^2/t/Z	*p*-value
Maternal age	28.55 ± 3.71	29.07 ± 4.10	-1.072	0.285
Pre-pregnancy BMI	23.08 ± 3.05	22.68 ± 3.05	1.081	0.281
Gestational age at delivery (weeks)	39.06 ± 1.25	39.02 ± 1.21	0.221	0.852
Neonatal birth weight (g)	3255 ± 458	3307 ± 423	-0.949	0.343
Induction of labor (n, %)	18 (14.4%)	22 (16.3%)	0.179	0.672
Episiotomy performed (n, %)	58 (46.4%)	60 (44.4%)	0.100	0.752
Type of perineal laceration - First-degree (n, %)	42 (33.6%)	46 (34.1%)	0.007	0.936
Type of perineal laceration - Second-degree (n, %)	83 (66.4%)	89 (65.9%)	0.007	0.936
Length of hospital stay (days)	3.62 ± 0.91	3.58 ± 0.75	0.370	0.712

count, were analyzed using automated coagulation analyzers employing tight control measures. Sexual function at the 6-week postpartum (usually) was assessed using the FSFI [16], covering desire, arousal, lubrication, orgasm, satisfaction, and pain. The result is a weighted score in each domain, resulting in a total score of between 2 and 36, with higher scores indicating better sexual function. The satisfaction of the partners was also measured using a validated five-point Likert scale.

Sample size estimation

The sample size was calculated based on the primary outcome of perineal pain intensity, measured using the VAS. A total of 260 participants (135 in the cryotherapy group and 125 in the control group) were estimated to achieve 80% power at a significance level of 0.05, assuming a minimum clinically significant difference of 1.5 points on the VAS. This calculation was based on previous studies investigating similar interventions, with an anticipated effect size of 0.6 and a standard deviation of 2.0 in pain scores.

Statistical analysis

All statistical analyses were performed using SPSS 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were first assessed for normality using the Shapiro-Wilk test; normally distributed data were presented as mean ± standard deviation (SD), while non-normally distributed data were expressed as median with interquartile range (IQR). Between-group comparisons of continuous variables were conducted using independent-samples t tests or the Mann-Whitney U test, depending on distribution. Categorical variables were expressed as frequencies and percentages and were compared using the χ^2 test. Repeated measures data, including pain scores, edema indices, and pelvic floor function parameters across multiple time points were analyzed using mixed-effects models with fixed effects for group, time, and group × time interaction, and random intercepts for participants to account for within-subject correlation. Post hoc pairwise comparisons were adjusted using the Bonferroni correction. All tests were two-tailed, and a *p* value < 0.05 was considered statistically significant.

Results

Comparison of clinical characteristics between the two groups

As shown in **Table 1**, there were no significant differences in maternal age (P = 0.285), pre-pregnancy BMI (P = 0.281), gestational age at delivery (P = 0.852), or neonatal birth weight (P = 0.343). Additionally, induction of labor (P = 0.672), episiotomy (P = 0.752), and types of perineal laceration (first-degree: P = 0.936, second-degree: P = 0.936), as well as length of hospital stay (P = 0.712) showed no significant difference between the two groups.

Comparison of postpartum perineal pain between the two groups

Cryotherapy was consistently associated with lower perineal pain intensity at 2, 6, and 24 hours postpartum (mean VAS 5.74 ± 1.39 vs. 3.93 ± 1.25, 5.07 ± 1.37 vs. 3.46 ± 1.08, and 4.17 ± 0.80 vs. 2.82 ± 0.81, respectively; all P < 0.001). At 2 hours postpartum, a higher pro-

Table 2. Comparison of postpartum perineal pain between the two groups

Parameter	Time Postpartum	Control Group (n = 125)	Observation Group (n = 135)	*p* Value
VAS score	2 h	5.74 ± 1.39	3.93 ± 1.25	< 0.001
	6 h	5.07 ± 1.37	3.46 ± 1.08	< 0.001
	24 h	4.17 ± 0.80	2.82 ± 0.81	< 0.001
Pain severity distribution (n, %)	2 h Mild (VAS ≤ 3)	18 (14.4)	45 (33.3)	< 0.001
	2 h Moderate (VAS 4-6)	71 (56.8)	70 (51.9)	0.424
	2 h Severe (VAS ≥ 7)	36 (28.8)	20 (14.8)	0.006
Pain during sitting/standing (VAS)	2 h	6.28 ± 1.53	4.65 ± 1.16	< 0.001
	6 h	5.42 ± 1.32	4.01 ± 1.11	< 0.001
	24 h	4.70 ± 1.34	3.16 ± 1.01	< 0.001
Pain during first urination (VAS)	6 h	5.66 ± 1.47	4.23 ± 1.29	< 0.001
	24 h	4.87 ± 1.06	3.28 ± 0.97	< 0.001
Analgesic medication use (n, %)	Within 24 h	58 (46.4)	32 (23.7)	< 0.001
Proportion achieving ≥ 30% pain reduction from baseline (n, %)	6 h	34 (27.2)	79 (58.5)	< 0.001
	24 h	52 (41.6)	96 (71.1)	< 0.001

portion of women in the cryotherapy group reported mild pain (VAS ≤ 3; 33.3% vs. 14.4%, P < 0.001), whereas severe pain (VAS ≥ 7) was less frequent (14.8% vs. 28.8%, P = 0.006); the proportion of women reporting moderate pain (VAS 4-6) did not differ significantly between the groups (51.9% vs. 56.8%, P = 0.424).

Functional pain during sitting, standing, and first urination was also milder in the cryotherapy group at all assessed time points (all P < 0.001). In addition, fewer women receiving cryotherapy required additional analgesic medication within 24 hours (23.7% vs. 46.4%, P < 0.001). Moreover, a greater proportion of participants in the cryotherapy group achieved ≥ 30% pain reduction from baseline at both 6 hours (58.5% vs. 27.2%) and 24 hours (71.1% vs. 41.6%) postpartum (both P < 0.001). Detailed results are presented in **Table 2**.

Comparison of perineal edema score and tissue swelling index between the two groups

Perineal edema scores were significantly reduced in the observation group at 2 hours, 6 hours, and 24 hours postpartum, compared to the control group (all P < 0.001). Similarly, perineal circumference measurements showed a significant reduction in the observation group across all time points (all P < 0.001). Skin temperature was significantly lower in the observation group at 6 and 24 hours postpartum (both P < 0.001). Additionally, subcutaneous thickness was significantly reduced in the observation group at 2 hours, 6 hours, and 24 hours postpartum (all P < 0.001) (**Figure 1**).

Comparison of pelvic floor function recovery between the two groups

Resting tone was significantly lower in the observation group at postpartum 3 weeks and 6 months (P < 0.001) (**Figure 2A**). Maximal-voluntary contraction was significantly higher in the observation group at both postpartum 3 weeks and 6 months (P < 0.001) (**Figure 2B**). Endurance, as measured by the duration of sustained contraction, was also significantly improved in the observation group at both time points (P < 0.001) (**Figure 2C**). Furthermore, vaginal squeeze pressure was significantly higher in the observation group at 3 weeks and 6 months postpartum (P < 0.001) (**Figure 2D**).

Comparison of wound healing between the two groups (REEDA score)

At 3 weeks postpartum, the observation group demonstrated significantly less redness (1.19 ± 0.39 vs. 1.86 ± 0.37, P < 0.001), edema (1.26 ± 0.61 vs. 1.89 ± 0.58, P < 0.001), and ecchymosis (1.00 ± 0.00 vs. 1.38 ± 0.49, P < 0.001) compared with the control group. Discharge was also less frequent in the observation group (0.51 ± 0.50 vs. 1.00 ± 0.00, P < 0.001), and wound approximation was better (0.17 ± 0.43 vs. 1.02 ± 0.20, P < 0.001) in the observation group. The total REEDA score was significantly lower in the observation group (4.23 ± 0.81 vs. 6.70 ± 1.06, P < 0.001) (**Table 3**), suggesting enhanced wound healing in the observation group.

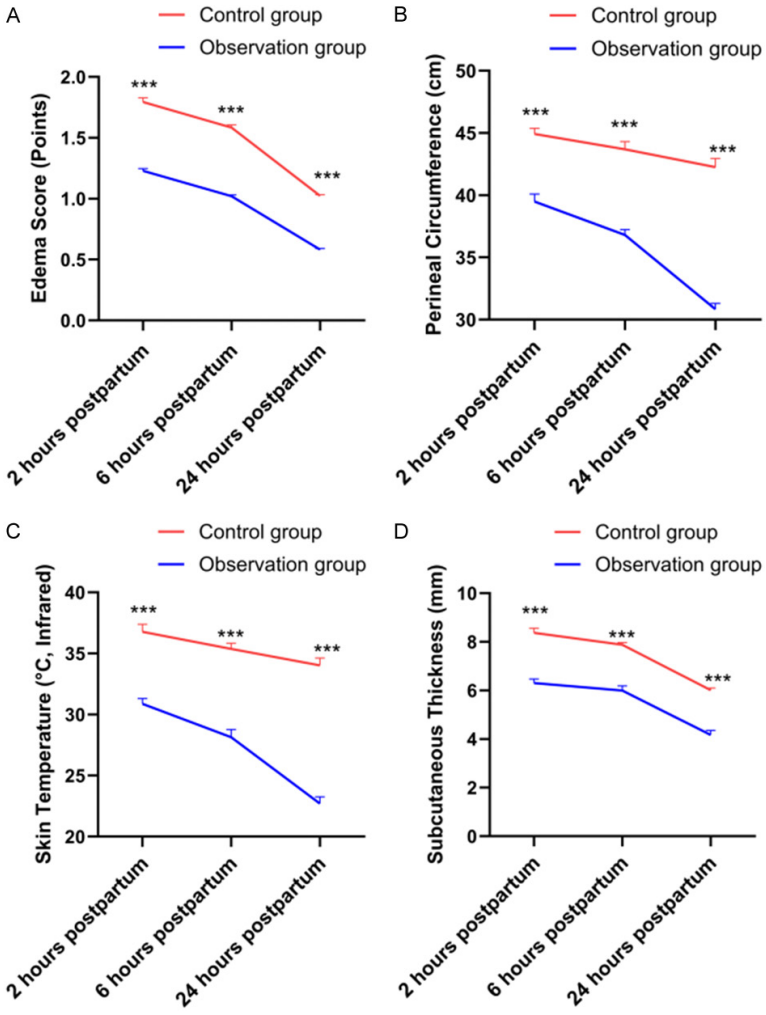

Figure 1. Comparison of perineal edema score and tissue swelling index between the two groups. (A) Edema score, (B) Perineal circumference, (C) Skin temperature, (D) Subcutaneous thickness. Compared to the control group, ***P < 0.001.

Comparison of sleep quality between the two groups

The total PSQI score was significantly lower in the observation group compared with the control group (6.16 ± 2.26 vs. 8.31 ± 2.16, P < 0.001). Specifically, sleep latency was shorter (17.14 ± 7.65 vs. 22.73 ± 9.48 minutes, P < 0.001) and sleep duration was longer (6.14 ± 1.20 vs. 5.36 ± 1.19 hours, P < 0.001) in the observation group. Moreover, the observation group demonstrated significantly reduced sleep disturbance index (1.73 ± 0.63 vs. 2.72 ± 0.89, P < 0.001), fewer participants requiring sleep medications (14% vs. 36%, P < 0.001), and higher restfulness scores (6.98 ± 1.24 vs. 4.68 ± 1.37, P < 0.001). The frequency of night waking was lower (2.11 ± 0.65 vs. 3.66 ± 1.06 times, P < 0.001), and daytime fatigue scores were reduced (4.24 ± 1.36 vs. 6.47 ± 1.81, P < 0.001) in the observation group (**Table 4**).

Comparison of blood biochemical indices between the two groups at one week postpartum

At one week postpartum, serum levels of CRP, IL-6, and TNF-α were significantly reduced in the observation group compared with the control group (all P < 0.001) (**Figure 3A-C**). In addition, the levels of coagulation parameters, including platelet count, D-dimer, and fibrinogen, were significantly lower in the observation group (all P < 0.001) (**Figure 3D-F**).

Comparison of sexual function between the two groups

The total FSFI score was significantly higher in the observation group at both postpartum 3 weeks and 6 months (all P < 0.001) (**Figure 4A**). Partner satisfaction also improved significantly in the observation group (P < 0.001) (**Figure 4B**). Desire, arousal, and lubrication were all significantly better in the observation group (**Figure 4C-E**). Additionally, orgasm, satisfaction, and pain scores were significantly improved in the observation group (P < 0.001 for all) (**Figure 4F-H**).

Subgroup analyses of postpartum outcomes

The mean differences in 24-hour pain scores were significantly lower in all age and tear degree subgroups in the observation group compared to the control group (P < 0.05) (**Figure 5A**). The 48-hour perineal edema was also significantly reduced in the observation group across all subgroups, with more substantial improvements observed in women aged 36-40 years and those with a second-degree tear (P < 0.05) (**Figure 5B**). Moreover, the mean

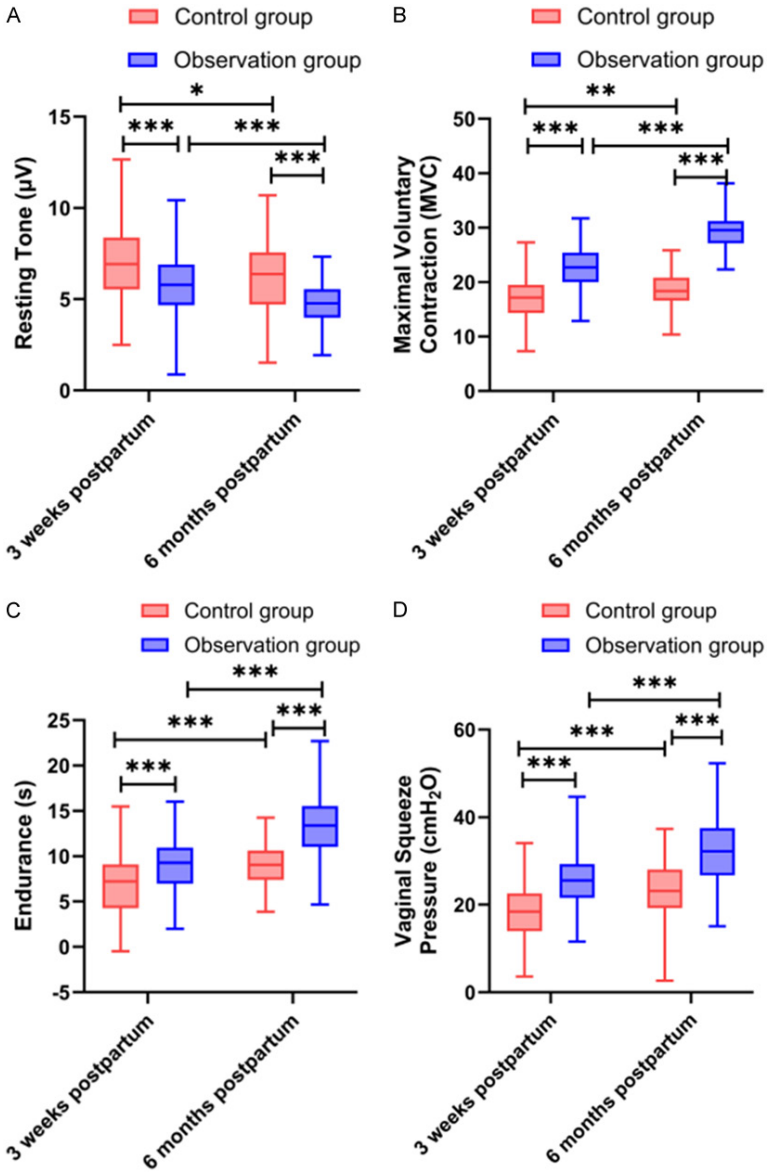

Figure 2. Comparison of pelvic floor function recovery between the two groups. (A) Resting tone, (B) Maximal voluntary contraction, (C) Endurance, (D) Vaginal squeeze pressure. *P < 0.05; **P < 0.01; ***P < 0.001.

differences in 72-hour pelvic floor muscle strength were significantly higher in the observation group across all subgroups (P < 0.05) (**Figure 5C**). Finally, the risk ratios for perineal complications were significantly lower in the observation group in all subgroups, indicating a reduced risk of perineal complications in the observation group (P < 0.05) (**Figure 5D**).

Discussion

This study offers comprehensive evidence that immediate perineal cryotherapy during delivery confers multidimensional advantages to primiparous women in the early postpartum period. Compared with the standard care, cryotherapy more effectively relieved perineal pain, alleviated edema and tissue swelling, as well as systemic inflammation, accelerated pelvic floor functional recovery and wound healing, and improved sleep quality and sexual functional recovery.

Perineal pain is one of the most common complaints in the early puerperium, and our results show that cryotherapy significantly reduced the pain at both rest and during daily activities, with fewer women requiring pharmacologic analgesics. Previous literature has pointed out taht cryotherapy slows nerve conduction velocity and dampens local inflammatory responses, thereby producing analgesia effects [17-19]. These reports are consistent with our data and also support the observed improvements in functional domains such as mobility and urination.

Improvements in edema and wound healing also showed significant improvements in the cryotherapy group. Previous randomized studies reported that localized cold treatment decreased tissue edema by inducing vasoconstriction and decreasing capillary permeability [20-22]. In line with these mechanisms, our study revealed significant reductions in perineal circumference, skin temperature, and subcutaneous thickness. The lower REEDA scores further indicate improved wound edge approximation and alleviated tissue trauma. Clinically, prompt edema management is essential not only for comfort but also for minimizing infection risk and functional recovery.

Table 3. Comparison of wound healing between the two groups (REEDA Score)

Component	Control Group (n = 125)	Observation Group (n = 135)	t value	*p*-value
Redness	1.86 ± 0.37	1.19 ± 0.39	14.430	< 0.001
Edema	1.89 ± 0.58	1.26 ± 0.61	8.466	< 0.001
Ecchymosis	1.38 ± 0.49	1.00 ± 0.00	8.984	< 0.001
Discharge	1.00 ± 0.00	0.51 ± 0.50	10.892	< 0.001
Approximation	1.02 ± 0.20	0.17 ± 0.43	20.164	< 0.001
Total Score	6.70 ± 1.06	4.23 ± 0.81	21.302	< 0.001

Table 4. Comparison of sleep quality between the two groups

Parameter	Control Group (n = 125)	Observation Group (n = 135)	t/χ^2 Value	*p* Value
PSQI Total Score	8.31 ± 2.12	6.16 ± 2.26	7.929	< 0.001
Sleep Latency (minutes)	22.73 ± 9.48	17.14 ± 7.65	5.247	< 0.001
Sleep Duration (hours)	5.36 ± 1.19	6.14 ± 1.20	-5.259	< 0.001
Sleep Disturbance Index (0-5 scale)	2.72 ± 0.89	1.73 ± 0.63	10.501	< 0.001
Use of Sleep Medications (n, %)	45 (36%)	19 (14%)	16.815	< 0.001
Restfulness (1-10 scale)	4.68 ± 1.37	6.98 ± 1.24	-14.205	< 0.001
Frequency of Night Waking (times)	3.66 ± 1.06	2.11 ± 0.65	14.309	< 0.001
Daytime Fatigue (1-10 scale)	6.47 ± 1.81	4.24 ± 1.36	11.254	< 0.001

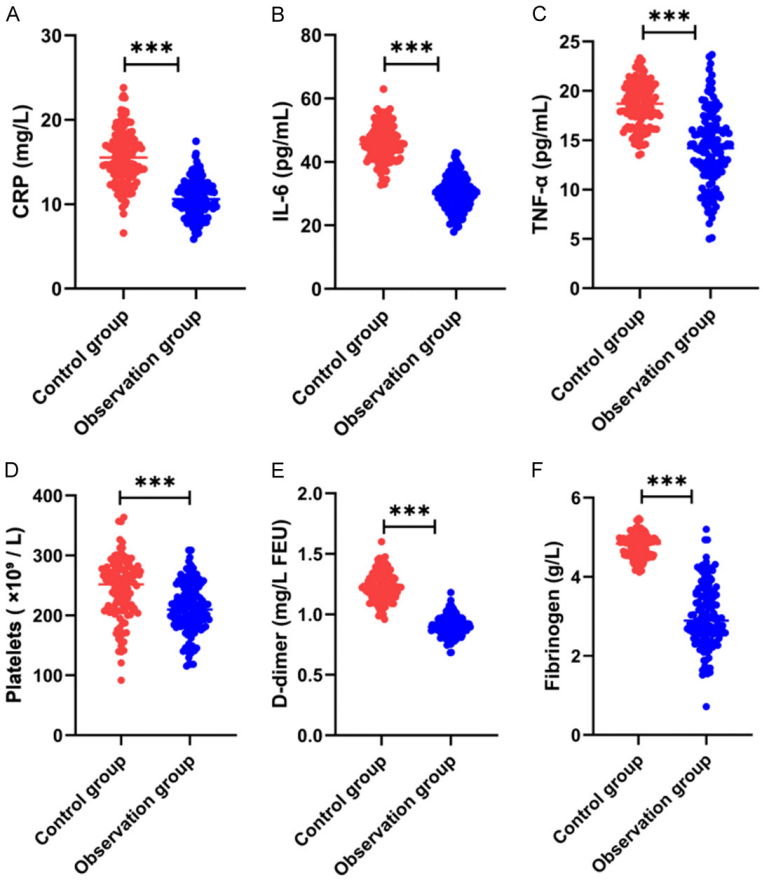

Figure 3. Comparison of blood biochemical indices between the two groups at one week postpartum. (A) CRP; (B) IL-6; (C) TNF-α; (D) Platelets; (E) D-dimer; (F) Fibrinogen. ***P < 0.001. CRP: C-reactive protein; IL-6: interleukin-6; TNF-α: tumor necrosis factor-alpha.

The cryotherapy group achieved significantly faster recovery of pelvic floor muscle strength and endurance, as demonstrated by improvements in resting tone, maximal voluntary contraction, endurance, and vaginal squeeze pressure. Our findings are noteworthy since little research has been conducted concerning the effects of cryotherapy on the function of the pelvic floor. Reduced local inflammation and tissue edema could potentially mitigate neuromuscular impairment during the immediate postpartum period [23], making cryotherapy a cost-efficient adjunct to pelvic floor restoration therapy and potentially helping to prevent long-term sequelae (e.g., urinary incontinence and prolapse of pelvic organs).

Other significant findings included significant improvements in sleep quality and sexual function among women who received cryotherapy. Po-

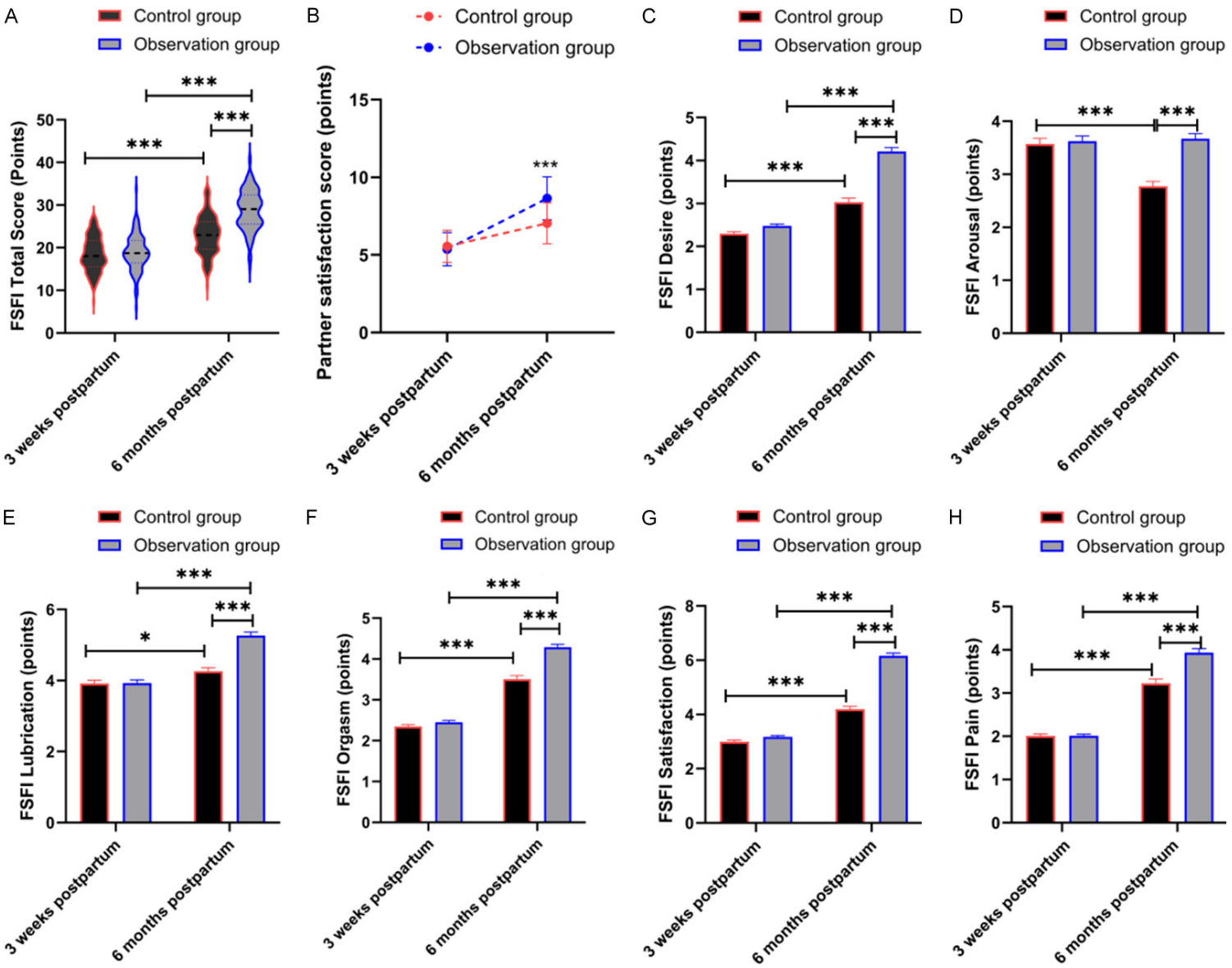

Figure 4. Comparison of sexual function between the two groups. (A) FSFI-total score, (B) Partner satisfaction score, (C) FSFI-desire, (D) FSFI-arousal, (E) FSFI-lubrication, (F) FSFI-orgasm, (G) FSFI-satisfaction, (H) FSFI-pain. *P < 0.05; ***P < 0.001. Note: FSFI: female sexual function index.

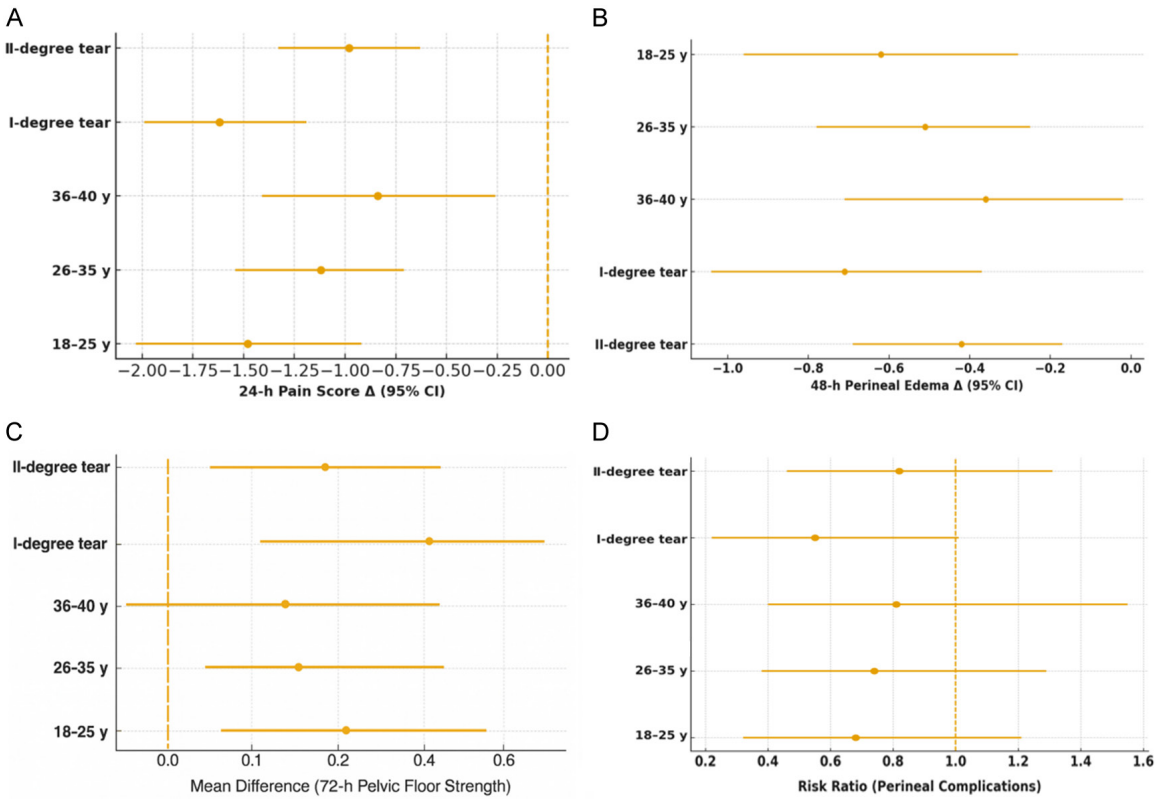

Figure 5. Subgroup analyses of postpartum outcomes. (A) The mean differences in 24-h pain scores with corresponding 95% confidence intervals; (B) The mean differences in 48-h perineal edema; (C) The mean differences in 72-h pelvic floor muscle strength; (D) The risk ratios for perineal complications.

stpartum sleep deprivation is commonly associated with pain, hormonal fluctuations, and psychological distress [24]. Cryotherapy alleviates perineal pain and discomfort, thereby achieving longer sleep duration, less awakenings, and better subjective restfulness, which are essential to maternal recovery. Moreover, increased FSFI scores across all domains indicate that the benefits of cryotherapy extend beyond physical recovery to relational well-being. This dimension is rarely discussed in previous research, and our data show that early perineal comfort can be converted into better intimacy and/or partner satisfaction. Such outcomes underscore the need for clinicians to consider the psychosocial implications of early postpartum interventions.

Systemically, cryotherapy was associated with reduced CRP, IL-6 and TNF-α and decreased fibrinogen and D-dimer, indicating anti-coagulant and anti-inflammatory-modulating effects. These data are consistent with experimental evidence showing that cooling can inhibit pro-inflammatory cytokine production and improve microvascular hemodynamics [25-27]. Significantly, platelet counts were lower in the observation group compared to the control group. However, the reduction in platelet levels, while statistically significant, was still within the normal physiological range. Therefore, cryotherapy did not have a detrimental impact on hemostasis, as evidenced by the fact that platelet counts remained within acceptable limits and no adverse bleeding complications were observed. Translational implication of these findings is that such a local intervention may confer systemic protective benefits during a period characterized by increased inflammatory and hypercoagulable states, both of which contribute to postpartum morbidity.

Although this study has several strengths, certain limitations should be acknowledged. First, the single-center retrospective design may restrict the generalizability of the findings, as cultural differences in pain perception and postpartum practices may influence outcomes. Second, although we evaluated a broad range

of objective and subjective indicators, longer-term follow-up beyond the early postpartum period was not conducted, leaving the durability of the observed benefits uncertain. Importantly, while we substantially expanded the discussion to summarize relevant basic and translational evidence on how low-temperature stimulation may regulate nociceptive signaling, inflammatory cytokine cascades, microvascular responses, and tissue repair processes, our study did not include biological sample collection or molecular measurements. As such, we were unable to directly examine the mechanistic pathways - such as modulation of neurotransmitter release or cellular repair factors - that may underlie postpartum recovery. Future multi-center prospective studies incorporating targeted biomarker assessments and mechanistic experiments (e.g., cellular or animal models) are therefore needed to validate these pathways and to determine the long-term clinical and biological effects of perineal cryotherapy.

Conclusion

Perineal cryotherapy administered immediately during labor is an inexpensive, safe, and simple intervention with a wide range of benefits in the early postpartum period. In addition to its conventional analgesic effect, cryotherapy can significantly reduce edema, promote wound healing and pelvic floor recovery, improve sleep and sexual activity and modulate systemic inflammatory and coagulation cascades. Collectively, these findings support the incorporation of cryotherapy into standard obstetric care practice and suggest that its use may help achieve better short-term outcomes and long-term maternal health in primiparous women.

Disclosure of conflict of interest

None.

Abbreviations

VAS, Visual Analog Scale; PSQI, Pittsburgh Sleep Quality Index; FSFI, Female Sexual Function Index; ELISA, Enzyme-Linked Immunosorbent Assay; SD, Standard Deviation; IQR, Interquartile Range; BMI, Body Mass Index; REEDA, Redness, Edema, Ecchymosis, Discharge, Approximation (wound healing scale); CRP, C-Reactive Protein; IL-6, Interleukin-6; TNF-α, Tumor Necrosis Factor-alpha; MVC, Maximal Voluntary Contraction; PFM, Pelvic Floor Muscle.

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