Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 10
https://bbwpublisher.com/journal/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Structured after the Milk Scheme on Postpartum Milk Secretion Insufficiency, Maternal Lactation and the Impact and Outcomes

Juanjuan Ning[1], Mingqun Li[1,2], Shuang Xu[1], Li Hu[1], Miao Xu[1], Lin Cao[1], Shuping Gao[1]

[1]Xiangyang No.1 People's Hospital, Hubei University of Medicine, Xiangyang 441000, Hubei, China
[2]Hubei Provincial Clinical Research Center for Accurate Fetus Malformation Diagnosis, Xiangyang 441000, Hubei, China

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Abstract: *Objective*: To investigate the effect of a structured catch-up feeding scheme on lactation volume, serum prolactin level, feeding outcome, and maternal and infant health-related indicators of postpartum women with insufficient milk secretion. *Methods*: A randomized controlled trial design was used, and pregnant women who met the criteria were divided into an intervention group and a control group. The intervention group implemented a structured breastfeeding program including systematic evaluation, personalized lactation plan, skill guidance, nutrition and psychological support. The control group received routine obstetric care. The 24-hour lactation volume, serum prolactin level, exclusive breastfeeding rate, neonatal weight gain and maternal feeding self-efficacy were compared between the two groups at designated time points after delivery. *Results*: Compared with the control group, the 24-hour lactation volume and serum prolactin level were significantly higher in the intervention group on postpartum days 7 and 42. The success rate of exclusive breastfeeding 42 days after delivery in the intervention group was significantly higher than that in the control group; the weight gain of newborns was more ideal; and the feeding self-efficacy score of mothers was also significantly improved ($P < 0.05$). *Conclusions*: The structured catch-up feeding program can effectively increase the milk yield and exclusive breastfeeding rate of women with postpartum hypolactation, and improve the short-term health outcomes of mothers and infants.

Keywords: Structured milk catch-up program; Insufficient postpartum milk secretion; Randomized controlled trial; Milk yield; Breastfeeding outcomes; State of mind

Online publication: November 25, 2026

1. Introduction

Breastfeeding is the cornerstone of ensuring the healthy growth of infants and young children and plays an irreplaceable role in promoting the short- and long-term health of both mothers and infants [1]. The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) jointly recommend

exclusive breastfeeding for the first 6 months after birth [2-3]. China's "National Nutrition Plan (2017-2030)" also clearly sets specific goals for increasing the exclusive breastfeeding rate of infants within 6 months. However, insufficient postpartum milk secretion is one of the most common clinical problems leading to early interruption of breastfeeding and difficulty in achieving the exclusive breastfeeding target. It not only affects infants' short-term nutrition and development but also brings considerable psychological stress and feeding frustration to postpartum women.

In clinical practice, the management of postpartum insufficient lactation mostly remains at the level of scattered education and empirical guidance, and cannot be considered systematic. Milk secretion is regulated by multiple factors: nutrition and water are only the foundation, while emotional stability, adequate breastfeeding stimulation, and correct latch-on also affect lactation [4-5]. Integrating assessment, health education, skill guidance, and psychological counseling into a fixed process is more likely to be effective than isolated efforts. Based on this, this study constructed a "structured lactation promotion program" and compared it with routine obstetric care to observe whether it could increase milk volume [6-8] (including actual milk volume and serum prolactin), enhance mothers' breastfeeding self-efficacy, and ultimately increase the exclusive breastfeeding rate and promote infant weight gain.

2. Materials and methods

2.1. Study subjects

This study was a prospective randomized controlled trial. Postpartum women with insufficient milk secretion who visited the Breastfeeding Clinic and Obstetric Ward of Xiangyang No.1 People's Hospital between February and December 2024 were conveniently selected as study subjects. According to preliminary experimental results or previous literature, the expected between-group mean difference for the primary outcome indicator (e.g., 24-hour milk volume on day 28 after intervention) was set as d, and the pooled standard deviation was SD. Using the sample size calculation formula for comparison of two independent sample means, with a significance level of $\alpha=0.05$ (two-sided) and power $1-\beta=0.80$, PASS software was used to calculate the minimum required sample size for each group as n*n*. Considering an approximately 20% loss to follow-up rate, the final planned total sample size was 100 cases (50 cases per group). The actual included sample size met the calculation requirements. This study protocol was reviewed and approved by the Medical Ethics Committee of Xiangyang No.1 People's Hospital (approval number: 2026KY079). All participants signed informed consent, and the research process followed the principles of the Declaration of Helsinki.

2.1.1. Inclusion criteria

(1) Primiparous women with singleton, full-term delivery (gestational age ≥37 weeks);
(2) 3–7 days postpartum, diagnosed with insufficient postpartum milk secretion after assessment (definition: 24-hour milk volume <500 mL, and the infant showing hunger crying, weight loss exceeding 7% of birth weight, or unsatisfactory weight gain);
(3) Age 20–35 years;
(4) Clear intention to exclusively breastfeed;
(5) Clear consciousness and no communication barriers.

2.1.2. Exclusion criteria

(1) Severe pregnancy complications or comorbidities (such as severe preeclampsia, heart disease, etc.);
(2) Mothers with organic diseases that may affect lactation, such as thyroid dysfunction, breast hypoplasia, severe nipple inversion, or mastitis;
(3) Infants with congenital diseases or requiring admission to the neonatal intensive care unit;
(4) Postpartum women with a history of mental illness or cognitive impairment. A computer-generated block randomization sequence (block length of 4) was completed by independent researchers not involved in recruitment. The generated random allocation plan was placed in sequentially numbered, sealed, opaque envelopes. When eligible subjects were enrolled, members of the research team opened the envelopes in sequence and assigned them to the intervention group or control group according to the allocation result inside the envelope.

2.2. Intervention methods

2.2.1. Control group (Routine care group)

The control group received standard obstetric postpartum care and breastfeeding guidance, including:

(1) verbal education once daily in the postpartum ward on breastfeeding positions and latch-on techniques;
(2) distribution of a unified breastfeeding health handbook;
(3) answering postpartum women's questions about breastfeeding as needed.

This part of nursing was performed by the duty primary nurse, and the content and frequency followed departmental routines.

2.2.2. Intervention group (Structured lactation promotion program group)

In addition to routine care, the intervention group received a 4-week structured lactation promotion program intervention. The program was based on evidence-based guidelines, expert consensus, and traditional Chinese medicine lactation promotion theory and was jointly developed by a multidisciplinary team (obstetricians, senior breastfeeding instructors, dietitians, and psychological counselors). It aimed to correct insufficient milk secretion through systematic and multidimensional intervention. All intervention personnel received unified program training and passed an assessment to ensure homogeneous implementation. The core content of the program is shown in **Table 1**.

Table 1. Core content and implementation framework of the structured lactation promotion program

Implementation stage	Implementation item	Specific implementation content
Stimulating the milk ejection reflex (Days 1–2)	Breast and milk volume assessment	① Breast appearance: observe breast redness, swelling, induration, nipple inversion/cracking, accessory breast, and other manifestations; ② Breast palpation: clarify the location and degree of tenderness, size/location of masses, and milk stasis; ③ Lactation initiation: record postpartum lactation time and colostrum/transitional milk/mature milk stage; ④ Milk volume monitoring: record single milk expression volume and residual milk volume after neonatal sucking; ⑤ Neonatal intake assessment: judge feeding effectiveness by urine output, weight gain, and soothing state after sucking
	Efficient lactation behavioral intervention (increasing prolactin levels)	① Feeding strategy: on-demand breastfeeding is preferred, with direct breastfeeding/pumping once every 2–3 hours, ≥8 times per day (10–12 times per 24 hours), preserving the nocturnal lactation peak and adhering to regular milk expression; ② Latch-on and sucking guidance: standardize breastfeeding positions and nipple latch-on techniques, ensure effective sucking, observe neonatal swallowing, and avoid shallow sucking/ineffective sucking; ③ Breast stimulation: follow the principle of breast emptying, use massage patterns to stimulate the breast, combine pressing, kneading, rubbing, and pushing techniques to dredge mammary ducts, and achieve deep breast emptying

Implementation stage	Implementation item	Specific implementation content
Activating lactation potential + integrated physical and mental conditioning (Days 2–5)	Integrated traditional Chinese medicine lactation conditioning technique (dredging mammary duct nodules, regulating qi and blood, calming the mind and relieving depression)	① Auricular acupressure with seeds (5 min): select liver, gallbladder, Shenmen, and endocrine points; instruct postpartum women to press by themselves 3–5 times daily, with soreness, numbness, and distension as the degree. In the early intervention period, it calms the mind and soothes the liver, regulates the endocrine system, and lays the foundation for subsequent nursing; ② Acupoint massage and meridian dredging (about 30 min): first knead and press the bladder meridian and Jianjing area to dredge whole-body qi movement, then sequentially press Taichong (soothing the liver and relieving depression), Qimen (soothing the liver and strengthening the spleen), Rugen (dredging collaterals and promoting lactation), and other chest and abdominal acupoints; stimulate the breast and nipple through pushing, pulling, pressing, and kneading techniques, and use nipple sensory signals to transmit to the hypothalamus to inhibit the secretion of dopamine and other prolactin-inhibiting factors, promote prolactin release, and soften the breast; ③ Moxibustion warming and tonification (about 25 min): select Danzhong (qi meeting point, promotes lactation), Shenque (reinforces primordial qi and consolidates the foundation), Guanyuan (replenishes primordial qi), Zusanli (strengthens the spleen and harmonizes the stomach, strengthens health) and other acupoints; moxibustion warms and nourishes the spleen and stomach, replenishes qi and blood, provides raw materials for milk production, and also assists in regulating liver qi to avoid milk stasis or reduced secretion caused by liver qi stagnation
	Refined fluid management (maintaining optimal hydration status and providing a foundation for milk production)	① Drinking guidance: follow the principle of "small sips, slow drinking, frequent intake," with water temperature controlled at about 50°C; emphasize drinking 150–200 mL of warm water after each breastfeeding/pumping; ② Total volume control: set the daily total fluid intake target at 2000–3000 mL (including soup, milk, etc.), mainly warm water; ③ Adherence management: instruct postpartum women to issue a "Daily Water Intake and Breastfeeding Diary" to record fluid intake, type, and time, facilitating self-observation and management
	Scientific nutritional support (balanced, high-quality, easy to digest, avoiding milk-reducing foods)	① Dietary combination: recommend balanced intake of high-quality protein (fish, poultry, eggs, soy products), dark vegetables/fruits, and minerals (nuts, seafood); ② Dietary contraindications: clearly instruct avoidance of foods that may reduce milk production (such as large doses of Chinese chives, malt, etc.) and spicy, greasy, raw, and cold foods
	Sleep-emotion management	① Sleep guarantee: jointly develop a child-rearing plan with family members, with family members sharing tasks such as diaper changing and soothing to sleep, ensuring postpartum women sleep ≥8 hours daily; encourage synchronized rest during the infant's daytime naps; ② Emotional regulation: conduct postpartum emotional assessment (using the Edinburgh Postnatal Depression Scale), provide psychological support such as listening and encouragement, and teach relaxation techniques such as deep breathing and meditation; ③ Family support: mobilize family members to participate in health education and clarify their supporting roles in meal preparation, ensuring postpartum women's rest, and providing positive feedback

2.3. Outcome indicators

2.3.1. Primary outcomes

The primary outcomes included 24-hour milk volume and serum prolactin level. The 24-hour milk volume was measured before intervention (T0), on day 7 after intervention (T1), on day 14 (T2), and on day 28 (T3). During measurement, the infant weight difference method combined with cumulative recorded expressed milk volume was used. Weighing before and after breastfeeding was completed using a calibrated electronic infant scale, and records were made by uniformly trained researchers to reduce measurement bias. Serum prolactin was collected from elbow venous blood in the morning on an empty stomach at T0, T1, T2, and T3, and serum was separated by centrifugation and uniformly tested to reflect lactation-related endocrine changes.

2.3.2. Secondary outcomes

(1) Breastfeeding self-efficacy: assessed using the Chinese version of the Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF). The scale contains 14 items and uses a 5-point Likert scale (1 = not at all confident, 5 = completely confident), with a total score range of 14–70; higher scores indicate stronger self-efficacy. This study confirmed that the Cronbach's α coefficient in this study population was 0.92, showing good reliability. It was self-administered by the study subjects at T0 and T3.

(2) Risk of maternal depressive symptoms: assessed using the Edinburgh Postnatal Depression Scale (EPDS). The scale contains 10 items, with a total score range of 0–30. According to the Chinese population norm, a total score ≥13 is defined as a relatively high risk of postpartum depressive symptoms. It was assessed at T0 and T3.

(3) Infant weight gain: infant birth weight was recorded (extracted from obstetric medical records), and weight was measured at T3 using the same calibrated electronic infant scale. The weight gain during the intervention period (T3 weight − birth weight) was calculated as an objective indicator for evaluating infant nutritional status.

(4) Exclusive breastfeeding rate: assessed at 6 weeks postpartum (about day 42 after intervention) through standardized telephone follow-up. It was judged according to the World Health Organization (WHO) definition: "exclusive breastfeeding" means that in the past 24 hours, the infant did not consume any other liquids (including water and formula milk) or solid foods except necessary medicines and vitamin/mineral supplements. According to this definition, the exclusive breastfeeding success rate of each group was calculated.

2.4. Statistical methods

Statistical analysis was conducted using SPSS 25.0. Normally distributed continuous data were expressed as mean ± standard deviation (SD), and baseline between-group comparisons were performed using independent-samples *t*-tests. Categorical variables were expressed as numbers (percentages), and χ^2 tests or Fisher's exact probability method were used. For the dynamic changes in 24-hour milk volume and serum prolactin, mixed-design analysis of variance was used to examine time effects, group effects, and interaction effects; between-group comparisons were then performed at specific time points, and mean differences, 95% confidence intervals, and P values were reported. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of baseline data

A total of 100 postpartum women were ultimately included in this study, including 50 in the intervention group and 50 in the control group. As shown in Table 2, there were no statistically significant differences between the two groups in age, postpartum days, gravidity, parity, pre-pregnancy BMI, baseline 24-hour milk volume, baseline serum prolactin, baseline BSES-SF score, baseline EPDS score, or birth weight (all $P > 0.05$), indicating that the baseline characteristics of the two groups were balanced and comparable. The composition of delivery modes also showed no significant difference between the two groups ($P = 0.689$).

Table 2. Comparison of baseline data between the two groups

Variable	Intervention group (n=50)	Control group (n=50)	Statistical value	*P* value
Age	30.34±3.50	30.56±3.59	-0.319	0.751

Variable	Intervention group (n=50)	Control group (n=50)	Statistical value	*P* value
Postpartum days	2.88±1.08	2.64±1.08	1.109	0.270
Gravidity	2.10±0.95	2.10±0.95	0.000	1.000
Parity	1.36±0.48	1.44±0.50	-0.811	0.419
Pre-pregnancy BMI	23.61±2.66	23.62±2.64	-0.023	0.982
T0_milk volume	237.40±52.52	234.60±54.67	0.261	0.795
T0_prolactin	184.44±13.82	184.34±14.96	0.037	0.970
T0_BSES	37.90±3.29	37.16±3.35	1.115	0.268
T0_EPDS	10.80±2.14	11.34±2.26	-1.229	0.222
Birth weight_g	3248.82±266.29	3249.12±252.50	-0.006	0.995
Delivery mode: cesarean section	26 (52.0%)	23 (46.0%)	χ^2	0.689
Delivery mode: vaginal delivery	24 (48.0%)	27 (54.0%)	—	—

3.2. Primary outcome indicators

3.2.1. 24-Hour milk volume

The changing trends of 24-hour milk volume in the two groups are shown in **Figure 1**. Mixed-design analysis of variance showed that the group main effect, time main effect, and time × group interaction effect were all statistically significant, with F = 100.55, F = 931.73, and F = 160.48, respectively, all $P < 0.001$. At each time point, the baseline 24-hour milk volumes of the intervention group and control group were similar, at (237.40 ± 52.52) mL and (234.60 ± 54.67) mL, respectively ($P = 0.795$). By day 7 after intervention, the gap between the two groups began to widen; the intervention group increased to (407.00 ± 75.36) mL, while the control group was (303.40 ± 58.85) mL. On day 14 after intervention, the intervention group further increased to (532.40 ± 86.39) mL, while the control group was (350.20 ± 63.07) mL. By day 28, the intervention group reached (641.80 ± 116.00) mL, while the control group was (404.20 ± 65.93) mL; the between-group mean difference was 237.60 mL, 95% CI [200.03, 275.17], $P < 0.001$. This result suggests that the structured lactation promotion program can not only accelerate the growth rate of milk volume but also form a more stable and considerable milk volume advantage in the later intervention period.

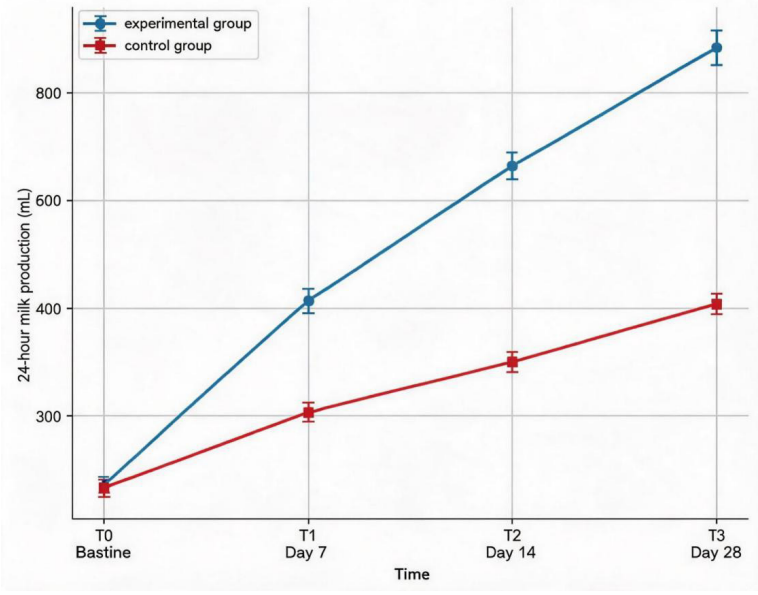

Figure 1. Dynamic changes in 24-hour milk volume in the two groups.

3.2.2. Serum prolactin level

The changing trends of serum prolactin levels are shown in **Figure 2**. Mixed-design analysis of variance showed that the group main effect, time main effect, and interaction effect were all statistically significant, with F = 34.00, F = 92.19, and F = 5.66, respectively, all $P \leq 0.001$. At baseline, the prolactin levels of the intervention group and control group were close, at (184.44 ± 13.82) μIU/mL and (184.34 ± 14.96) μIU/mL, respectively ($P = 0.970$). At T1, the intervention group increased to (200.24 ± 14.26) μIU/mL, while the control group was (191.97 ± 12.44) μIU/mL ($P = 0.003$). At T2, the intervention group was (210.98 ± 14.59) μIU/mL, while the control group was (199.12 ± 17.84) μIU/mL ($P < 0.001$). At T3, the intervention group was (227.93 ± 17.87) μIU/mL, while the control group was (210.45 ± 17.42) μIU/mL; the between-group difference was 17.48 μIU/mL, 95% CI [10.48, 24.48], $P < 0.001$. Combined with the milk volume curve, the continuous increase in prolactin level was in the same direction as the improvement in milk secretion, indicating that the program may have a positive effect on lactation-related endocrine regulation.

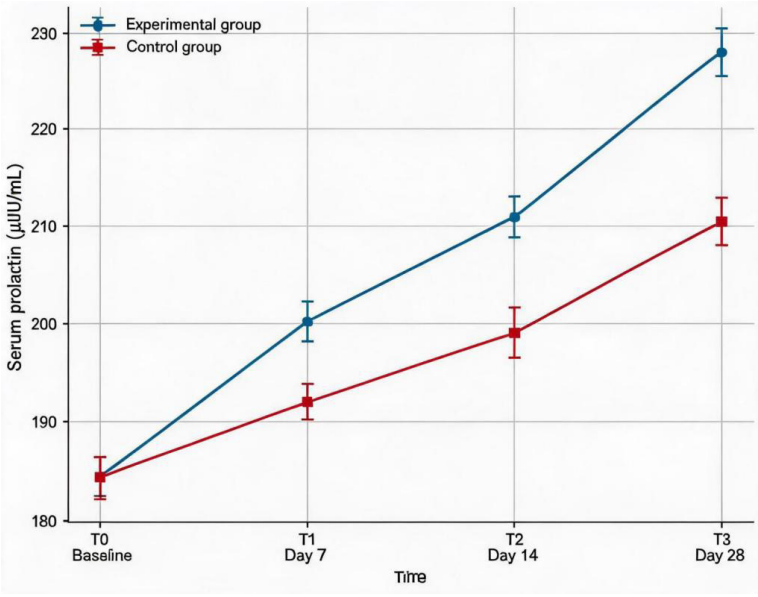

Figure 2. Dynamic changes in serum prolactin in the two groups.

3.3. Secondary outcome indicators

The comparison results of secondary outcomes are shown in **Table 2**. On day 28 after intervention, the BSES-SF score in the intervention group increased from (37.90 ± 3.29) to (46.18 ± 3.98), while that in the control group increased from (37.16 ± 3.35) to (40.94 ± 3.78). The final comparison between the two groups showed that the intervention group was 5.24 points higher than the control group (95% CI 3.70–6.78, $P < 0.001$), suggesting that the structured lactation promotion program helps enhance postpartum women's feeding confidence and coping ability. In terms of psychological outcomes, the EPDS score in the intervention group decreased from (10.80 ± 2.14) to (7.78 ± 2.79), while that in the control group decreased from (11.34 ± 2.26) to (10.68±2.40). At the end of the intervention, the intervention group was 2.90 points lower than the control group (95% CI -3.93 to -1.87, $P < 0.001$), suggesting that the program has some benefit in alleviating early depression risk. In terms of infant weight gain, the intervention group was (867.16±90.42 g), while the control group was (772.26±85.96 g); the mean difference was 94.90 g (95% CI

59.88–129.92, $P < 0.001$). By 42 days postpartum, the exclusive breastfeeding rate in the intervention group was 64.0%, significantly higher than 32.0% in the control group, with relative risk RR=2.00 (95% CI 1.27–3.15, P=0.003). Taken together, the structured lactation promotion program not only improved lactation itself but also showed relatively consistent benefits in maternal behavior, psychological status, and infant nutrition-related outcomes.

Table 2. Comparison of secondary outcomes between the two groups

Indicator	Intervention group T0	Intervention group T3/42 days	Control group T0	Control group T3/42 days	Within-group P (intervention)	Within-group P (control)	Between-group effect size	95% CI	Between-group P
BSES-SF total score	37.90 ± 3.29	46.18 ± 3.98	37.16 ±3.35	40.94 ± 3.78	<0.001	<0.001	5.24	[3.70, 6.78]	<0.001
EPDS total score	10.80 ± 2.14	7.78 ± 2.79	11.34 ± 2.26	10.68 ± 2.40	<0.001	0.002	-2.90	[-3.93, -1.87]	<0.001
Infant weight gain (g)	—	867.16 ± 90.42	—	772.26 ± 85.96	—	—	94.90	[59.88, 129.92]	<0.001
42-day exclusive breastfeeding rate	—	32 (64.0%)	—	16 (32.0%)	—	—	RR=2.00	[1.27, 3.15]	0.003

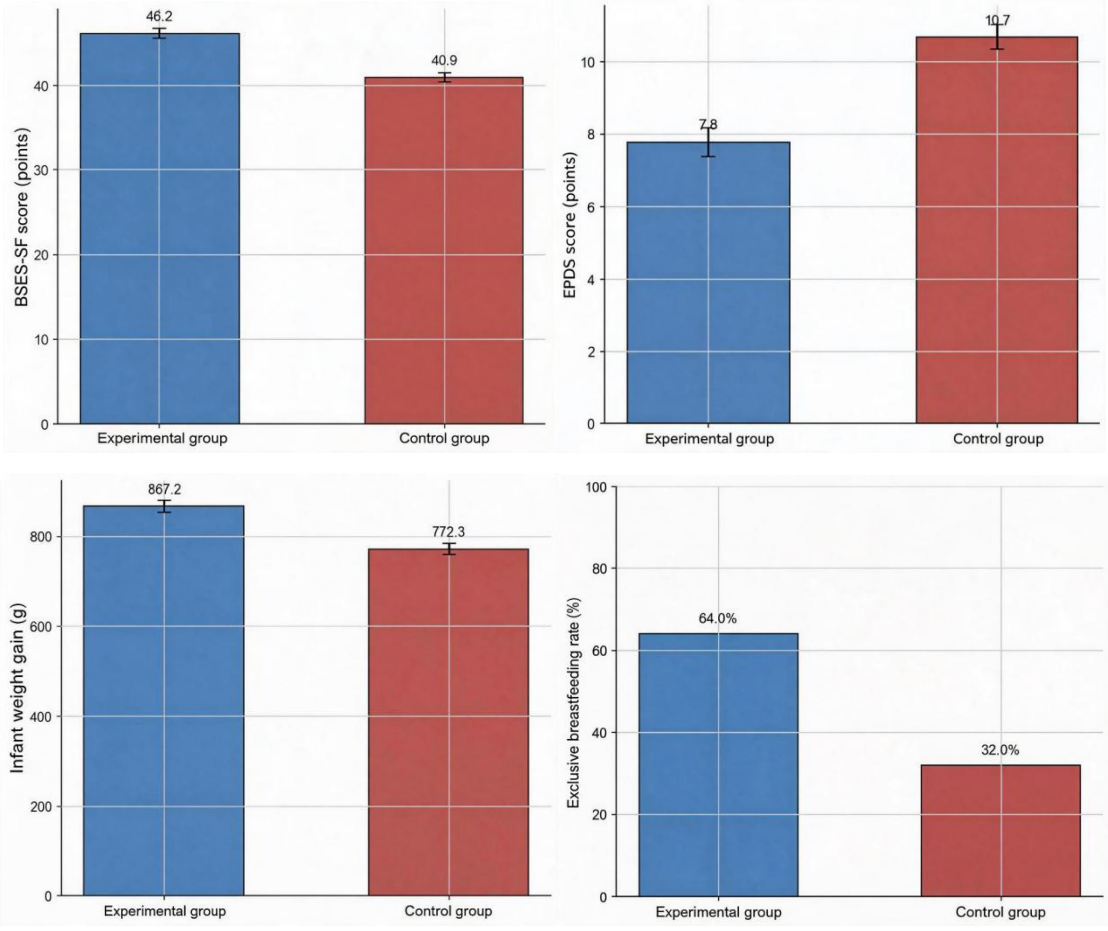

Figure 3. Graphical presentation of secondary outcomes (BSES-SF; EPDS; infant weight gain; 42-day exclusive breastfeeding rate).

4. Discussion

This study confirmed through a randomized controlled trial that, compared with routine care, the structured lactation promotion program can more effectively increase 24-hour milk volume and serum prolactin levels in postpartum women with insufficient milk secretion [9-10]. At the same time, the program significantly improved postpartum women's breastfeeding self-efficacy, alleviated postpartum depressive symptoms, and ultimately increased the exclusive breastfeeding success rate at 6 weeks postpartum and infant weight gain. These findings provide an operational integrated approach for addressing early postpartum insufficient lactation.

4.1. Analysis of the effectiveness of the structured program

Why is this program effective? The key is that it opens several pathways simultaneously rather than focusing on only one point as traditional approaches do [11]. Regular breastfeeding and emptying (8–12 times per day) directly trigger neuroendocrine reflexes, such as the milk ejection reflex, causing the pituitary to continuously release prolactin [12]; this is precisely the physiological basis for increased milk volume. Nutritional guidance and psychological support fill in another piece: sufficient energy and nutrients are the raw materials for lactation, while anxiety raises cortisol and in turn suppresses lactation [13]; reducing this suppression makes the internal environment more conducive to milk production. In addition, hands-on feeding training and repeated small successes give postpartum women more confidence [14], enabling them to persist more when difficulties arise. In the final analysis, linking physiological, nutritional, psychological, and behavioral factors together is the key to solving early insufficient lactation.

4.2. Comparison with existing evidence and positioning

The results of this study are consistent with some exploratory studies at home and abroad [15-16], all confirming that comprehensive intervention has a positive effect on promoting lactation. However, this study deepened and expanded the evidence in the following aspects:

(1) The quantified effect is clearer: the measured increase in milk volume (e.g., an average difference of 550 mL at day 28) and the increase in exclusive breastfeeding rate provide more precise effect values, which is helpful for clinical decision-making;

(2) Mechanistic evidence is more comprehensive: compared with most studies that only focus on milk volume or feeding rate, this study simultaneously monitored serum prolactin, a key physiological indicator, and psychological indicators such as BSES-SF and EPDS [17], providing direct evidence to explain the physiological and psychological pathways of intervention effects;

(3) The program is more structured and replicable: the program in this study has a clear structure, content, and implementation process. Compared with generalized "strengthened education" or "psychological support," it has a higher degree of standardization and is more conducive to promotion and application in different clinical settings.

4.3. Clinical and practical significance

At present, clinical support for postpartum insufficient lactation is often "fragmented" and lacks a systematic and sequential integrated program. The structured lactation promotion program proposed in this study fills this gap. Its feasibility is reflected in the following:

(1) Resource requirements are relatively modest: the core of the program relies on trained nurses or lactation consultants and does not require expensive equipment, making it suitable for obstetric wards, postpartum

clinics, and community health centers;

(2) It can be integrated into existing workflows: the program content can be decomposed and integrated into prenatal education [18-19], postpartum ward rounds, and follow-up. Potential challenges include the initial investment in unified training of healthcare personnel, strategies to ensure intervention adherence, and adaptive adjustments in institutions with different medical resource allocations. It is suggested that standardized training manuals and patient education materials based on this program could be developed in the future to promote its wider dissemination.

4.4. Study strengths and limitations

The main strengths of this study are: it adopted a prospective randomized controlled trial design, effectively controlling confounding bias; it conducted dynamic assessment at multiple time points, clearly depicting the trajectories of outcome indicators; and it simultaneously focused on physiological and psychological multidimensional outcomes, making the evaluation more comprehensive.

This study also has shortcomings. First, it was a single-center study with a single sample source, so the conclusions should be extrapolated with caution; multicenter studies are best for further verification. Second, the intervention group inherently received longer attention and contact, so the Hawthorne effect—people performing better because they are being watched—cannot be completely ruled out. Third, follow-up only extended to 6 weeks postpartum, lacking longer-term outcomes (such as breastfeeding up to 6 months or 1 year), so the long-term effects of the program remain uncertain. Fourth, although the weighing method was used, breast milk intake measurement may still have measurement error.

4. Conclusion

For postpartum women with insufficient milk secretion, implementing a structured lactation promotion program is a comprehensive nursing measure that can effectively increase milk volume, improve breastfeeding outcomes, and improve postpartum women's psychological status. Future research can conduct multicenter, large-sample RCTs further to verify the efficacy and generalizability of the program; explore the adaptability and effects of the program in specific populations (such as mothers of preterm infants and postpartum women after cesarean section); and use mobile health technology to develop and validate digital support tools based on this program (such as apps) to achieve low-cost, scalable personalized guidance and benefit a broader maternal and infant population.

Funding

Hospital-Level Nursing Research Project of Xiangyang No. 1 People's Hospital (Project No.: XYY2023NB04)

Disclosure statement

The authors declare no conflict of interest.

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