

Effect of A Structured Psychophysiological Intervention on Breast Milk Secretion among Post-Caesarean Mothers: A Quasi-Experimental Study with Mediation Analysis

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Abstract Background: Physiological stress and psychological distress after caesarean section can lead to poor early breast milk secretion and thereby impact lactation of mothers who had a caesarean. **Objective:** To evaluate the impact of a structured psychophysiological intervention on breast milk production in post-caesarean women and to evaluate if the change in the psychological status of the mother was intervening in this effect. **Methods:** Quasi-experimental two group pretest-posttest study with 220 post-caesarean mothers. The intervention consisted of 12 in total sessions of back massage and affirmation based relaxation four times a day for three days. Breast milk output was quantified and psychological factors were evaluated using well-developed scales. Data were analysed with t-tests and adjusted linear regression with control of baseline milk secretion and covariates. The bootstrapping (5000 samples) PROCESS Model 4 was used to test mediation. **Results:** The intervention group had significantly higher increases in breast milk secretion: 2.95 ml (95% CI: 2.53-3.38, $p < 0.001$). The adjusted effect remained significant ($B = 2.90$, 95% CI: 2.19-3.61; $p < 0.001$). Psychological distress significantly decreased in the intervention group (depression: mean difference -1.29, 95% CI: -2.03 to -0.55; anxiety: -1.95, 95% CI: -2.58 to -1.31; stress: -3.49, 95% CI: -4.34 to -2.64; all $p < 0.001$). **Results:** The intervention was linked with a higher output of breast milk. Results are consistent with a cumulative psychophysiological pathway between the psychological changes in the mother and lactation outcomes which warrants consideration of such strategies in the postpartum care.

Key Words Breast Milk Secretion, Caesarean Section, Stress, Anxiety, Depression, Mediation, Psychophysiological Intervention

INTRODUCTION

Early breast milk secretion is one important determinant of neonatal health, especially the immediate postnatal period, where infants are solely dependent on their mothers' breast milk which provides nutrition and immunological protection [1]. Prominent findings regarding adequate milk production and its relationship to neonatal morbidity, growth patterns and maternal-infant bond all indicate the need for adequate milk production at the right time [2,3]. Women who had cesarean section, however, frequently suffer from late onset of lactation and from poor establishment of lactation. Surgical delivery is often associated with complication of pain after surgery, having limited mobility, taking longer to achieve skin-to-skin contact and heightened

psychological stress [4,5]. Such challenges are especially acute in low and middle income countries and in areas with less than optimal postnatal care, where these barriers can also affect postnatal care. Therefore, interventions that may help to promote early milk production in post-caesarean mothers are still a great clinical and public health priority [3].

Lactation is under the control of a complex neuroendocrine system in which the combined activities of PRL and OT are involved. Oxytocin is more centrally involved in milk ejection via the let down reflex than is prolactin, which is mainly involved in milk synthesis [6]. The release of Oxytocin is very responsive to the mother's psychological state. The Hypothalamic Pituitary Adrenal (HPA) axis is activated during stress and cortisol is

released which can inhibit oxytocin; this can impair milk ejection [7-9]. On the other hand, positive emotions and relaxation can promote an increase in oxytocin production, which can aid milk letdown [8].

Maternal psychological factors, such as stress, anxiety and depression, have emerged as important factors affecting lactation outcomes. Stress has been shown to be a risk factor for slow onset of lactogenesis and for decreasing milk production [10,11]. Anxiety and depressive symptoms after giving birth can result in detrimental effects on maternal self-confidence, hormonal balance and breastfeeding duration [12,13]. While existing literature has examined breastfeeding behaviour, education and support systems, comparatively less was examined related to the pathways of how psychological states can affect milk secretion. This is a key gap as far as understanding how modifiable psychological factors can be used to enhance outcomes during lactation is concerned.

Psychophysiological intervention such as back massage has been shown to induce parasympathetic activity, decrease sympathetic arousal and increase relaxation, thus potentially making it easier to release oxytocin. Similarly, affirmation-based relaxation techniques can enhance emotional regulation and lower stress levels of mothers. [17]. These strategies when used in combination could provide a positive neuroendocrine milieu for lactation. Thus it is reasonable to suggest that psychological changes are a mechanism of breast milk secretion besides any direct relaxation effect and that such interventions may elicit a relaxation response. This is what underlies the hypothesized psychophysiological mechanism of intervention to better lactation response.

A few studies have studied the effects of massage or relaxation on breastfeeding but none have specifically looked beyond the mode of action of how massage or relaxation works. Empirical studies using a mediation approach to determine whether changes in psychological variables mediate improvements in milk secretion, however, are lacking and are especially limited in their focus on psychological variables. Furthermore, most of the research to date considers physiological and psychological processes as independent rather than interembedded aspects of an integrated process. This important gap needs to be filled with an analytical perspective that integrates intervention effects, psychological change and physiological outcomes into a single model.

The purpose of this study is to evaluate the impact of a structured psychophysiological intervention upon the secretion of breast milk in mothers who have just had a caesarean section and to explore the potential mediating pathways between psychological changes in mothers and their response to the intervention and breast milk secretion. Specifically, the study aims to: (1) Compare changes in breast milk secretion between intervention and control groups, (2) Estimate the adjusted effect of the intervention controlling for baseline and clinical covariates and (3) Examine whether the changes in stress, anxiety and depression of the post caesarean women mediate the link between the intervention and changes in breast milk secretion.

METHODS

Study Design and Setting

In this study, a quasi-experimental two group pre-test and post-test design was used. This study was carried out in the department of Obstetrics and Gynaecology of Fatima hospital, Mau, Uttar Pradesh, a secondary level health care institution with an average of 70 in-patients every day. To avoid contamination of subjects across groups in the same clinical environment, an allocation by ward was used [18]. The setting of the intervention was deemed appropriate, because after caesarean section the hospital stay is relatively long with mothers usually going home on the seventh post-operative day, providing enough time for the delivery of the intervention and evaluation of its outcomes.

Participants and Sample Size

Enrolled in the study were 220 post-caesarean mothers-110 in each group. In order to see a difference of 10% in milk secretion between groups (SD 20%), the sample was calculated for 90% power and a 5% significance. This was then rounded to 86 and then an additional 20% attrition was added to that number to result in 110 per group ($n = 220$) (using SigmaPlot version 14.5).

Eligibility Criteria

Clinically stable mothers after a cesarean delivery and who started to breastfeed were included. Mothers who have severe obstetric dilemmas, neonatal feeds issues or contraindications to breastfeeding were excluded. Consecutive sampling (group allocation was non-randomised based on ward-level feasibility).

Intervention

The intervention was a combination of back massage and affirmation based relaxation in a structured manner. From the fourth postoperative day the mothers were placed in a supported seated position and they were instructed to perform short breathing exercises as slow inhalation, short breath-holding (2-5 seconds) and controlled exhalation. Moderate rhythmic massage was then performed using para spinal muscles with massage in between the shoulder blades [14]. Mothers used positive affirmations during the procedure to help them relax and build confidence in breastfeeding. Breastfeeding immediately followed each session which lasted between 10-15 minutes. Four daily sessions of the intervention were conducted over 3 days (07:00, 11:00, 15:00, 19:00 hours). Caregivers received training on how to help with the written instructions. Standardisation was achieved by protocol-based training of nursing personnel (6-8 hours including supervised practices) and by conducting supervision and checklists to guarantee adherence and uniformity of the interventions.

Measures

Breast milk secretion was measured as the main outcome by a standard weighing method, which consisted of infant weight taken immediately prior and after latching-on on an electronic baby weighing machine. The difference in weight was converted to volume with the assumption of a density factor of 1.031 g/ml for breast milk, which is consistent with established

lactation measurement protocols [19]. The mediators, namely maternal psychological status, were measured by validated instruments, depression, anxiety and stress, (DASS 21) and scores were used in accordance with the normalization procedure and higher scores represented more psychological distress [20]. Breast milk secretion at baseline was taken as an important covariate to control for initial variation in lactation and the other ones included were: maternal parity (primiparous vs. multiparous), type of caesarean (elective vs. emergency) and maternal age. Let down reflex and breastfeeding behaviour were also measured with structured observers' notes to record functional aspects of lactation but were not used in the primary analytical models and were treated as additional measurements.

Data Collection Procedure

Participants were then recruited consecutively from the post caesarean wards and the experimental group from one ward while the control group was from other wards to minimise contamination and keep the procedure blinded. After informed consent, baseline data were gathered on the third day after surgery for socio-demographic, obstetric, neonatal, psychological and breastfeeding measures. The experimental group were provided with back massage along with affirmation-based relaxation four times a day at the same time each day for three days. These sessions were all around 10 minutes in duration and were conducted using a standardised protocol [14]. The normal (control) group had their regular postnatal care. Structured instruments and observation checklists were used to determine the completion on a sixth postoperative day and were filled by specially trained staff to ensure consistency and reliability of the post-test items.

Statistical Analysis

Characteristics of participants and outcome measures were summarized using descriptive statistics. Independent samples t-test was used to compare between groups. Linear regression analysis of milk secretion at baseline and selected covariates was used to estimate the adjusted association between the intervention and change in milk secretion. The Hayes [21] mediation procedure (Model 4) was used to conduct the mediation analysis, where depression, anxiety and stress were modeled as parallel mediators.

Bias-corrected bootstrapping with 5000 resample was used to estimate indirect effects and 95% confidence intervals were used to determine statistical significance

criteria. The p-value <0.05 was regarded as statistically significant [21]. Variance Inflation Factors (VIF) of the predictors were used to check for multicollinearity and the values were <5, indicating acceptable levels.

Ethical Considerations

The study has been approved by the Institutional Ethics Committee, Saveetha Medical College Hospital, Chennai (No. 004/02/2022/IEC/SMCH) with date 14/02/2022. Care was taken to ensure confidentiality and anonymity during the study and participants were made aware that they could withdraw at any time without this having any impact on the care they were receiving.

RESULTS

The baseline socio-demographic, obstetric and neonatal data are presented in Table 1. Huge number of mothers aged 18-30 in both groups. There was also an even distribution of parity status, with about 2/3 of the participants being primiparous in either group. The majority of the women in both groups had elective caesarean sections, although there were slightly more in the control group. The majority of the babies in both groups were in the 2500-3000 g range. The proportion of mothers who started to breastfeed within the first four hours was greater than 90% in both groups. Mothers who started to breastfeed after 4 hours exceeded 90% in both groups.

Table 2 shows the comparison of breastfeeding and psychological outcome between experimental and control groups. The amount of breast milk secreted in the experimental group was significantly greater (2.95 ml; 95% CI: 2.53-3.38; $p < 0.001$) after the intervention. There was a significantly greater reduction in depression, anxiety and stress scores in the experimental group compared to the control group (all $p < 0.001$).

The intervention remained associated with increased breast milk output after adjustment for baseline breast milk output and maternal and obstetric factors as shown in table 3 ($B = 2.90$, 95% CI: 2.19-3.61; $p < 0.001$). Only negative values for baseline milk secretion were significantly correlated with subsequent change ($B = -0.33$; $p < 0.001$), with no significance for parity, type of caesarean section or maternal age. The model explained 56.1% of the variance ($R^2 = 0.561$; adjusted $R^2 = 0.502$).

The mediation analyses are shown in Table 4 and Figure 1. The total effect of the intervention was significant

Table 1: Covariates Included in Adjusted and Mediation Analyses

Variable	Category	Experimental (n (%))	Control (n (%))
Age of the mother (years)	18-25	53 (48.2)	48 (43.6)
	26-30	43 (39.1)	46 (41.8)
	31-35	14 (12.7)	14 (12.7)
	≥36	0 (0.0)	2 (1.8)
Parity status	Primipara	67 (60.9)	70 (63.6)
	Multipara	43 (39.1)	40 (36.4)
Type of caesarean section	Elective	72 (65.5)	82 (74.5)
	Emergency	38 (34.5)	28 (25.5)
Neonatal birth weight (g)	2500-3000	81 (73.6)	87 (79.1)
	3001-3500	26 (23.6)	22 (20.0)
	>3500	3 (2.7)	1 (0.9)
Timing of breastfeeding initiation	≤4 hours	9 (8.2)	12 (10.9)
	>4 hours	101 (91.8)	98 (89.1)

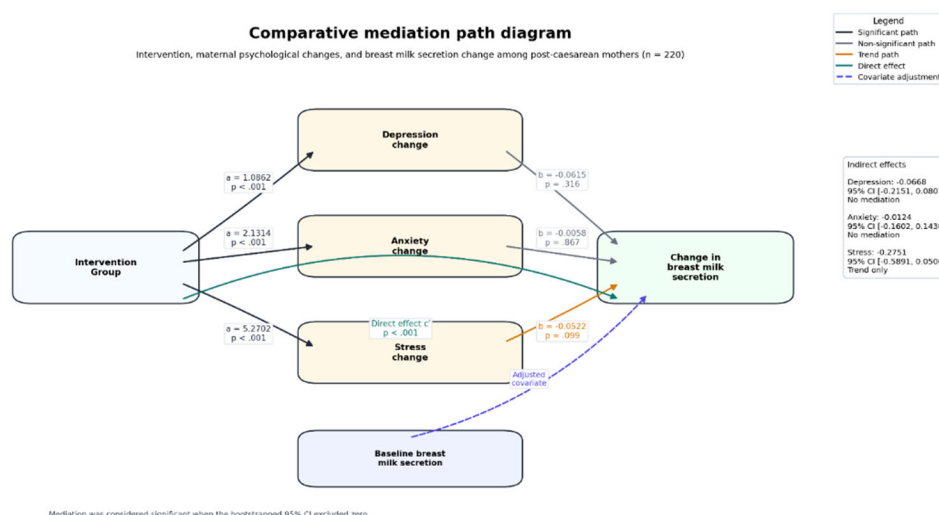


Figure 1: Parallel Mediation Path Diagram of the Association Between Intervention and Change in Breast Milk Secretion among Post-Caesarean Mothers

Table 2: Comparison of Breastfeeding and Psychological Outcomes Between Groups

Outcome	Group	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Change	Between-group difference (95% CI)	p-value
Breast milk secretion (ml)	Experimental	3.82 (1.08)	9.63 (1.56)	5.81	2.95 (2.53-3.38)	<0.001
	Control	3.66 (1.13)	6.67 (1.63)	3.01		
Depression score	Experimental	9.45 (3.56)	7.27 (2.68)	-2.18	-1.29 (-2.03 to -0.55)	<0.001
	Control	9.64 (3.75)	8.56 (2.91)	-1.07		
Anxiety score	Experimental	11.13 (4.11)	6.47 (2.04)	-4.66	-1.95 (-2.58 to -1.31)	<0.001
	Control	10.95 (3.89)	8.42 (2.67)	-2.53		
Stress score	Experimental	19.38 (4.29)	10.42 (2.83)	-8.96	-3.49 (-4.34 to -2.64)	<0.001
	Control	17.58 (4.43)	13.91 (3.51)	-3.67		

Values are presented as mean (SD). Between-group differences are based on independent t-tests. Negative values indicate reduction in psychological scores

Table 3: Adjusted Association Between Intervention and Change in Breast Milk Secretion among Post-Caesarean Mothers (n = 220)

Predictor	B (SE)	β	95% CI	p-value
Intervention group (Experimental vs Control)	2.90 (0.36)	0.63	2.19 to 3.61	<0.001
Baseline breast milk secretion	-0.33 (0.09)	-0.22	-0.51 to -0.15	<0.001
Parity (Multipara vs Primipara)	0.23 (2.78)	0.01	-5.26 to 5.72	0.933
Type of LSCS (Emergency vs Elective)	-0.63 (1.51)	-0.04	-3.61 to 2.36	0.680
Age (categorical, overall effect)	-	-	-	0.278*

Table 4: Parallel Mediation Analysis of the Association Between Intervention and Change in Breast Milk Secretion via Psychological Variables Among Post-Caesarean Mothers (n = 220)

Section A: Total and Direct Effects					
Pathway	Effect (B)	SE	t	p-value	95% CI
Total effect (c): Intervention → Milk change	2.8438	0.188	15.13	<0.001	2.4733 to 3.2142
Direct effect (c'): Intervention → Milk change (adjusted)	3.1691	0.2629	12.06	<0.001	2.6509 to 3.6873
Section B: Indirect Effects (Bootstrapped)					
Mediator	Indirect Effect (a x b)	BootSE	95% Boot CI	Interpretation	
Stress change	-0.2729	0.1619	-0.5901 to 0.0504	Not significant	
Anxiety change	0.015	0.0864	-0.1542 to 0.1880	Not significant	
Depression change	-0.0674	0.0811	-0.2296 to 0.0978	Not significant	
Total indirect effect	-0.3253	0.1619	-0.6425 to -0.0053	Significant (combined effect)	

(B = 2.84, SE = 0.19; p<0.001) and the direct effect remained significant after adjustment (B = 3.17, SE = 0.26; p<0.001). The intervention effect was not mediated by stress, anxiety or depression when these variables were analyzed separately (zero was included in the confidence intervals). The model suggested a significant indirect effect were present when the effects of the mediators were combined (B = -0.3253; 95% CI: -0.6425 to -0.0053).

DISCUSSION

Breastfeeding is essential for infant health and previous studies have explored interventions such as maternal iron supplementation, mobile health applications and ultrasound-based management of breast engorgement [22-24]. The present study demonstrated that a structured psychophysiological intervention significantly increased breast milk secretion among post-caesarean mothers, with

the effect remaining significant after adjustment for baseline milk secretion and maternal and obstetric variables. Although depression, anxiety and stress improved significantly, none independently mediated the intervention effect. However, the significant total indirect effect suggests a cumulative psychophysiological pathway through which these factors may collectively influence lactation.

The significant combined indirect effect, despite non-significant individual pathways, suggests that depression, anxiety and stress may represent complementary pathways rather than independent mediators. Multicollinearity diagnostics showed no problematic overlap among the mediators, indicating that the findings were unlikely to result from statistical suppression. The results may therefore reflect the cumulative contribution of several modest psychological pathways to changes in milk secretion.

These findings can be explained through a psychophysiological mechanism linking maternal emotional state with lactation. Psychological stress may activate the HPA axis and increase cortisol, which can interfere with oxytocin release and the milk ejection reflex [6,8]. Massage and relaxation may enhance parasympathetic activity and facilitate oxytocin-mediated lactation. The absence of significant individual mediation may also reflect measurement limitations of self-reported psychological scales and the complex neuroendocrine regulation of lactation, in which psychological factors may operate synergistically [20].

The findings are consistent with previous studies reporting beneficial effects of massage and relaxation-based interventions on maternal relaxation, stress reduction, milk production and breastfeeding outcomes [11,14,16]. The association between reduced psychological distress and improved lactation is also consistent with evidence linking maternal stress and anxiety with adverse breastfeeding physiology [7,13]. Importantly, the present study used objective milk volume rather than only behavioural breastfeeding outcomes, strengthening the physiological relevance of the findings.

Overall, this study supports a biopsychosocial perspective of lactation in which psychological and physiological factors interact. The significant combined mediation suggests that multiple psychological factors may collectively influence milk secretion rather than acting as isolated pathways. As a low-cost, non-invasive and feasible intervention, structured back massage with affirmation-based relaxation could be incorporated into routine postnatal nursing care, particularly in resource-limited settings.

Strength of This Study

- Objective measure of breast milk secretion enhances the validity of the findings compared to self-reported breastfeeding outcomes
- Multiple analytical approaches, including descriptive, adjusted and mediation analyses, providing a comprehensive understanding of the intervention effect

- The application of a mediation framework further strengthens the study by exploring underlying mechanisms rather than limiting interpretation to association alone

CONCLUSIONS

The results of this study showed that there was significant association between the application of the structured psychophysiological intervention and increased secretion of breast milk in the mothers who had caesarean section. The results emphasise the need to assess the combined effect of various psychological factors, instead of focusing on only one variable, when studying lactation physiology. In general, the findings are supportive of a biopsychosocial view of the secretion of breast milk, in which, psychological wellbeing plays a role in the physiological processes of lactation. Clinically, these results affirm the relevance of psychological and relaxation-based structured interventions in postnatal care. These strategies could be effectively incorporated into the standard nursing and lactation care procedures and may provide a potentially useful and scalable method for improving breastfeeding outcomes, especially in post-caesarean women.

Limitations

- The quasi-experimental design introduces the possibility of residual confounding despite statistical adjustment
- Psychological variables were assessed using self-reported scales
- Direct biomarkers (oxytocin or cortisol) are excluded for the evaluation of effects

Recommendations

- Future research should focus on conducting randomised controlled trials to strengthen causal inference
- Incorporating hormonal influence on lactation would provide deeper insight into underlying mechanisms

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