Combining hand techniques with electric pumping increases the caloric content of milk in mothers of preterm infants

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Objective: We previously reported that preterm mothers’ milk production can exceed levels of term mothers by using early hand expression and hands-on pumping (HOP) with the highest production (955 ml per day) in frequent users of hand expression. In this study, we compared milk composition between mothers stratified by early hand expression frequency.

Study Design: A total of 67 mothers of infants <31 weeks gestation were instructed on hand expression and HOP. Subjects submitted expression records and 1-ml samples from each pumping session over 24 h once weekly for 8 weeks.

Result: 78% (52/67) of mothers completed the study. But for Week 1, no compositional differences (despite production differences) were noted between the three groups. Protein and lactose tracked reported norms, but fat and energy of mature milk (Weeks 2–8) exceeded norms, 62.5 g l⁻¹ (26.4 cal oz⁻¹), respectively.

Conclusions: Mothers combining manual techniques with pumping express high levels of fat-rich, calorie-dense milk, unrelated to production differences.

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Keywords: hand expression; breastmilk; breastfeeding; lactation; preterm infants; milk composition

Introduction

Although human milk is the preferred nutrition for premature infants, the major limitations have been inadequate supply and suboptimal nutrients for the infant to achieve optimal growth. More effective milk expression techniques may address both issues by removing a larger fraction of nutrient-dense ‘hindmilk’.

We previously reported that mothers of preterm infants can attain and sustain high milk production levels by combining the use of electrical pumps with two manual techniques, hand expression and hands-on pumping (HOP) (Figure 1). Mothers who initiated expression by using frequent hand expression (>5 per day × 3 days) produced the highest subsequent volumes. The influence of hand expression in the first 3 days was independent of pumping frequency and affected production up to Week 8. We concluded that early hand expression may have removed viscous colostrum more effectively than pump suction alone, and thereby influenced the percentage of alveoli (milk secretory units) recruited for subsequent milk production.

Once milk volume increased, all mothers received instruction on the second manual technique, HOP, at 20.6 ± 9.6 days postpartum. This technique combines electric pumping with breast compression, stripping and, if needed, hand expression. The use of HOP did not increase pumping time and was associated with longer uninterrupted sleeping time.

This was the first report of mothers of preterm infants with a steady increase in production over 8 weeks, which surpassed reference levels for mothers of term infants. Recently, a pump with a newer suction pattern was shown to improve volume over earlier pumps, and yet subjects did not achieve production levels on a par with those we reported for mothers using frequent early hand expression. This pump was designed to mimic the suction pattern of the breastfeeding baby, but there is no feature to match the infant’s oral compression and milking action. We speculate that combining electric pumping with manual techniques (which include breast compression and a milking action) results in more effective breast emptying, thereby increasing milk production. If correct, one would expect compositional changes to include a higher percentage of hindmilk fat, possibly improving the nutritional adequacy of human milk for the preterm infant.

Milk fat, but not other macronutrients increases significantly in relation to breast emptying. Special attributes of human milk fat for preterm infants have included the benefits of polyunsaturated fatty acids on neuronal development, the superiority of absorption of human milk fat versus cow milk formula fat, the improved caloric value of high fat feeding, and increased availability of fat-soluble vitamins. Concerns about the nutritional inadequacies of human milk for the preterm infant have led to routine multi-nutrient fortification of human milk both pre- and
initiating expression using hand expression >5 times per day). We compare milk composition in high production mothers (those initiating expression using hand expression). Furthermore, using two techniques, which influence production (early hand massage and breast massage on milk composition was proposed by Foda et al.,12 who reported total solids, lipids, casein and gross energy increase in milk hand expressed after using a Japanese method of breast massage on milk composition was proposed by Foda et al.,12 who reported total solids, lipids, casein and gross energy increase in milk hand expressed after using a Japanese method of breast massage. Currently, reports on the composition of milk of mothers of preterm infants and donor milk are primarily based on samples expressed using passive pump suction.9–11 A possible influence of breast massage on milk composition was proposed by Foda et al.,12 who reported total solids, lipids, casein and gross energy increase in milk hand expressed after using a Japanese method of breast massage.

The composition of milk expressed by combining pump suction with manual techniques has not previously been reported. Our objective was to investigate the constituents of milk in mothers using two techniques, which influence production (early hand expression of colostrum and HOP of mature milk). Furthermore, we compare milk composition in high production mothers (those initiating expression using hand expression >5 × day) to that in lower production mothers (those initiating expression using hand expression <2 × day, yet pumped with the same frequency).

Methods

Study population

From 2004 to 2006, a convenience sample of eligible mothers of preterm infants (<1500 g infants, <31 weeks gestation) were invited to participate. Exclusion criteria included a moribund infant, breast surgery, substance abuse, severe maternal illness and known plans to transfer the infant to another facility. Written informed consent was obtained from all participants. The study was approved by the Stanford University Institutional Review Board and the Human Research Ethics Committee, The University of Western Australia.

Study design

Mothers were provided Symphony pumps (Medela, McHenry, IL, USA) for either the duration of the study or the hospitalization of the infant, which ever was longer. Maternal perinatal information and histories were obtained through chart review, questionnaires and interviews. Mothers recorded their own milk expression information, including date, time, duration and volume removed from each breast for 8 weeks.

Manual techniques (hand expression and HOP) combined with electric pumping

Participants were instructed to begin pumping within 6 h following delivery. Before the onset of copious milk production, they were instructed to ‘double pump’ (pump both breasts simultaneously) eight times per day for 15 min, and to hand-express colostrum as frequently as possible in the first three postpartum days. Once milk volume increased, mothers were advised to pump eight times per day until they could express only drops. As the capability of mothers varied, partners and family members were invited to learn the techniques to help with hand expression.

Once discharged, mothers returned for monitored pumping sessions where they were instructed on ‘HOP’. In contrast to relying only on pump suction for milk removal, this technique combined both electric pumping with manual maneuvers, which included breast massage, compression, stripping and, if needed, hand expression. Instructions for hand expression and ‘HOP’ can be viewed at http://newborns.stanford.edu/Breastfeeding/HandExpression.html and http://newborns.stanford.edu/Breastfeeding/MaxProduction.html.

Sample collection

Mothers were asked to donate milk samples once they felt doing so would not deprive their infants. They were given pre-labeled 1-ml cryogenic vials (Econo-lab, Chambly, QC, Canada) and asked to contribute right and left breastmilk samples after completing expression by swirling the bottles of pooled milk collected from each breast and pouring mixed milk into the vials. Subjects labeled the vials with time and date. They were asked to provide right and left breastmilk samples from one expression on postpartum days 1 to 14 and similarly, right and left breastmilk samples after every pumping for a 24-h period once a week, beginning week 2. They were instructed to freeze the samples immediately, transport them in cold storage and give them to staff for placement in a freezer. They were logged in, shipped in frozen storage to Perth, Australia for analyses at The University of Western Australia.
Table 1 Composition values (mean ± s.d. in g l⁻¹ and cal l⁻¹) of milk expressed using hand techniques and electric pumping

<table>
<thead>
<tr>
<th>Week</th>
<th>Lactose (g l⁻¹)</th>
<th>Lactose (cal l⁻¹)</th>
<th>Protein (g l⁻¹)</th>
<th>Protein (cal l⁻¹)</th>
<th>Fat (g l⁻¹)</th>
<th>Fat (cal l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>60.7 ± 9.3 (48)</td>
<td>67.1 ± 6.8 (43)</td>
<td>26.6 ± 7.0 (51)</td>
<td>70.6 ± 7.8 (61)</td>
<td>71.7 ± 6.9 (54)</td>
<td>73.5 ± 7.6 (50)</td>
</tr>
<tr>
<td>3</td>
<td>67.1 ± 6.8 (43)</td>
<td>26.6 ± 7.0 (51)</td>
<td>70.6 ± 7.8 (61)</td>
<td>71.7 ± 6.9 (54)</td>
<td>73.5 ± 7.6 (50)</td>
<td>73.6 ± 7.2 (46)</td>
</tr>
<tr>
<td>4</td>
<td>70.6 ± 7.8 (61)</td>
<td>71.7 ± 6.9 (54)</td>
<td>73.5 ± 7.6 (50)</td>
<td>73.6 ± 7.2 (46)</td>
<td>75.3 ± 7.8 (45)</td>
<td></td>
</tr>
</tbody>
</table>

Sample analyses

Esterified fat assay. Esterified fat assay was determined by a method described by Atwood and Hartmann. Triolein was used as a standard and the recovery of a known amount of fat added to milk samples was 98.4 ± 5.5% (n = 15). The detection limit of this assay was 0.27 ± 0.03 g l⁻¹ (n = 15) and the interassay coefficient of variation (CV) was 7.3% (n = 15).

Lactose. Lactose was determined by an enzymatic method described by Arthur and Hartmann. The recovery of a known amount of lactose added to defatted milk samples was 99.5 ± 2.3% (n = 10). The detection limit of this assay was 11.3 ± 0.3 g l⁻¹ (n = 10) and the interassay CV was 5.3% (n = 10).

Proteins. The protein assay was performed on defatted milk samples using the Bio-Rad Protein Assay (Hercules, CA, USA) according to manufacturer’s instructions. Kjelldahl’s method was used to determine the protein concentration of a defatted human milk sample. The defatted milk sample was then diluted and used as a protein standard for the Bio-Rad Protein Assay. The recovery of a known amount of protein added to defatted milk samples was 100.5 ± 3.8% (n = 7). The detection limit of this assay was 0.14 ± 0.02 g/l (n = 10) and the interassay CV was 6.6% (n = 10).

Energy. For mature milk, energy values based on bomb calorimetry agree with calculations based on conversion formulas, summing the contribution to total energy from each of the major components of milk. Energy conversion calculations are based on the specific Atwater conversion factors: proteins × 4.27 kcal g⁻¹; fats × 8.79 kcal g⁻¹; lactose × 3.87 kcal g⁻¹⁻¹.

Statistical analyses. Laboratory investigators were masked as to breakdown of subjects in the hand expression groups. Statistical analyses were performed using SAS v9.2 Software (SAS Institute, Cary, NC, USA). The factors affecting changes in milk production for an individual mother were analyzed using analysis of variance and with Student’s paired t-tests. Comparisons of milk production volumes for any given timeframe were done using unpaired t-tests.

The level of significance was set at P ≤ 0.05. All data are expressed as mean ± s.d.

Results

Demographics

A total of 71 mothers were recruited. Three refused and one was ineligible because of breast implants. As described previously, of the 67 enrolled mothers, 52 remained in the study for the entire 8 weeks. No significant demographic differences among the three groups were found.

Hand expression

In all 49 reported their frequency of use of hand expression in days 1 to 3. Based on the frequency of hand expression, these participants were stratified into three self-selected groups: Group I (no/low, <2 times per day, n = 15); Group II (medium, 2 to 5 times per day, n = 18); and Group III (high, >5 times per day, n = 16). Up until Week 8, significant production differences were reported between the three groups, with Group III maintaining the highest levels. By Week 8, mean production in all Groups was 658 ± 267, 859 ± 430, and 955 ± 667 ml per day, respectively, as we have previously reported. No statistical differences in mean pumping frequency in Groups I, II, and III over the first 3 days postpartum or over days 1 to 14 were found.

Sample collection and analyses

Overall, 5684 samples were analyzed. Table 1 and Figure 2 presents the average values for fat, lactose and protein concentrations for study mothers from Week 1 to 8. Fat, lactose and protein concentrations represent the averages of samples from the last day of that week for all study mothers.
cal l\(^{-1}\) are calculated by summing the contribution to metabolizable energy from each of the major components of milk, that is, fats, lactose and total proteins. Primarily weighted by the fat contribution, energy values of mature milk (Weeks 2–8) averaged 892.7 cal l\(^{-1}\) or 26.4 cal oz\(^{-1}\).

We evaluated the values of fat, protein, lactose and energy in breastmilk over an 8-week study period from the three groups of mothers categorized by frequency of early hand expression: Group I (<2 times per day), Group II (2 to 5 times per day), and Group III (>5 times per day). Despite production differences between groups up to Week 8, there are no significant compositional or energy differences between groups after Week 1 (\(P = 0.05\)).

**Discussion**

Many of the immediate and long-term benefits of breastfeeding for both the infant and mother depend on exclusivity and duration, with the strongest determinant being the volume of milk produced by the pump-dependent mother.\(^{19}\) By combining manual techniques with electric pumping, sufficient production can be achieved by preterm mothers who have been reported to be 2.8 times more likely to have insufficient production compared with term mothers.\(^{1,2}\)

Despite significant differences in subsequent milk production between subjects who used early hand expression with varying frequency, there were no significant differences in the composition of their milk after Week 1, demonstrating that subsequent volume, but not milk composition, was impacted by the early use of hand expression. Our findings on the changes in the concentration of lactose and protein in milk up to Week 8 of lactation are consistent with those reported for preterm mothers by other investigators.\(^{10}\)

The most striking observation is the high fat content of milk (>60 g l\(^{-1}\)) expressed using the combination of electric pump and manual techniques. Although a wide range of values in fat concentration has been reported in both preterm and term milk, the typical range is between 25–45 g l\(^{-1}\).\(^{19,20}\) Reports of high fat content of milk have been associated with late lactation and a decline in milk production. An increase of 50% in fat content from early to late lactation has been observed with crematocrit values rising as high as 28%.\(^{21}\) Before electric pumps were in common use, Dewey et al\(^{15}\) reported high fat content in milk of mothers who used either hand expression and/or a manual pump. Mean values of 51.6 ± 27.3 and 62.2 ± 28.7 g l\(^{-1}\) were found in mothers with infants 7–11 months and 12–20 months of age, respectively. These investigators suggested that the duration of lactation influences the fat content of milk.

We hypothesize that both high production levels and fat content are related to effective removal of viscous milk, (colostrum early on and the ‘hindmilk’ fraction of mature milk) enhanced by combining hand techniques with electric pumping. The triple combination of external breast compression, pump suction and the milk ejection reflex possibly removes a greater fraction of milk from individual alveoli than pump suction alone. Breast compression may increase intramammary and intraductile pressure, thereby improving the removal of more viscous, fat-rich milk, especially from the periphery of the breasts. Yet a near doubling of fat content as compared with reported norms was unexpected and calls for examination of collection, sampling, transportation and analyses.

**Figure 2** Compositional (g l\(^{-1}\)) and caloric (cal l\(^{-1}\)) values of milk expressed using hand techniques and electric pumping over the 8-week study period. Fat, lactose and protein concentrations represent the averages of samples from the last day of that week for each study mother (see also Table 1).
During the collection process, variables that affect fat concentration are the interval between pumping sessions and the percent of available milk removal. With a long versus brief interval between expressions, more foremilk (fat-poor milk) may be collected. By collecting milk from each expression over a 24-h period once a week for each subject, differences related to expression schedules should be insignificant. For each subject, the 24-h mean from week to week varied minimally, suggesting consistency in her collection technique.

Sampling unmixed milk could lead to errors. Therefore, subjects were specifically cautioned not to provide samples from the tail end of the collection or from unmixed milk. If these instructions were inconsistently followed by some subjects, one would expect larger standard deviations than those reported in studies of comparable size, which is not the case.

If transportation processes exposed samples to evaporation, one would expect the lactose and protein content to be higher than reported norms. Instead, lactose is similar to norms (70 g l$^{-1}$),\textsuperscript{10,22} and the protein is somewhat lower, (13–18 g l$^{-1}$).\textsuperscript{5,10}

The investigators performing the analyses of samples in this report followed the same technique used in their previously published reports on milk composition. In addition, they have recently compared the esterified fat analysis with infrared spectrophotometric analysis and found good agreement between the two methods.\textsuperscript{23} Furthermore, noting that fat content rises with breast emptying, these investigators have proposed formulas for calculating breast emptying based on pre- and post-fat content.\textsuperscript{24} Although they have reported values above 60 g l$^{-1}$ for breastfeeding and the protein is somewhat lower, (13–18 g l$^{-1}$) other laboratories.\textsuperscript{25}

We propose that a simple, no-cost, risk-free intervention, combining electric pumping with two manual techniques has a beneficial influence on milk production, as well as composition, by removing fat-rich hindmilk more effectively than pump suction alone.

Conflict of interest
The authors declare no conflict of interest.

Acknowledgments
We thank Medela for project facilitation, with particular thanks to Leon Mitoulas, Director of Research. Also, we acknowledge the study mothers both for their contributions to this study and for generously volunteering to participate in videos to demonstrate manual pumping techniques. Thanks also to Ronald S Cohen, MD for project support. This work was supported, in part, by the Clinical and Translational Science Award 1UL1 RR025744 for the Stanford Center for Clinical and Translational Education and Research (Spectrum) from the National Center for Research Resources, National Institutes of Health and in part by Medela AG, Medical Research, Switzerland.

References
Randomised trial comparing hand expression with breast pumping for mothers of term newborns feeding poorly

Valerie J Flaherman,1 Barbara Gay,2 Cheryl Scott,3 Andrew Avins,4 Kathryn A Lee,5 Thomas B Newman1,6

ABSTRACT

Objective Breast pumping or hand expression may be recommended when newborns latch or suck poorly. A recent trial found worse outcomes among mothers who used a breast pump in the early postpartum period. The objective of this study was to compare bilateral electric breast pumping to hand expression among mothers of healthy term infants feeding poorly at 12–36 h after birth.

Design Randomised controlled trial.

Setting Well-baby nursery and postpartum unit.

Patients 68 mothers of newborns 12–36 h old who were latching or sucking poorly were randomly assigned to either 15 min of bilateral electric pumping or 15 min of hand expression.

Main outcome measures Milk transfer, maternal pain, breastfeeding confidence and breast milk expression experience (BMEE) immediately after the intervention, and breastfeeding rates at 2 months after birth.

Results The median volume of expressed milk (range) was 0.5 (0–5) ml for hand expressing mothers and 1 (0–40) ml for pumping mothers (p=0.07). Maternal pain, breastfeeding confidence and BMEE did not differ by intervention. At 2 months, mothers assigned to hand expression were more likely to be breastfeeding (96.1%) than mothers assigned to breast pumping (72.7%) (p=0.02).

Conclusions Hand expression in the early postpartum period appears to improve eventual breastfeeding rates at 2 months after birth compared with breast pumping, but further research is needed to confirm this. However, in circumstances where either pumping or hand expression would be appropriate for healthy term infants 12–36 h old feeding poorly, providers should consider recommending hand expression.

INTRODUCTION

The many benefits of breastfeeding1–8 have encouraged the establishment of Healthy People breastfeeding goals.9, 10 Although rates of initiation have risen and are now close to target, rates of breastfeeding at time points after initiation are still well below target.5, 9 Paediatricians, obstetricians, lactation consultants, nurses and peer counsellors have all been shown to promote breastfeeding.11–19 However, few specific provider recommendations have been examined in clinical trials for their effect on eventual breastfeeding duration.

One common provider recommendation is early milk expression, either using a breast pump or using hand expression.20, 21 Chapman et al22 conducted a randomised trial comparing breast pumping to no intervention for mothers after Caesarean delivery and found a trend toward decreased breastfeeding duration in the pumping group. Other investigators, including Schwartz et al23, Morton et al24 and Win et al25 have conducted observational studies on the association between breast pumping and/or hand expression and eventual breastfeeding duration. The results of these studies have been mixed, and due to their observational design, they may have some confounding by varying reasons for early expression practices. Milk expression may provide additional breast stimulation to increase milk production, but the hormonal response to expression is not identical to infant sucking.26 and expression may have other important differences from sucking as well. Nevertheless, because the degree to which an infant empties a breast influences the future rate of milk synthesis (at least during mature milk production),27 experts often recommend milk expression for mothers with breastfeeding challenges.21, 28 Because some studies have shown that breast pumping removes more
milk than hand expression, breastfeeding may be seen as superior to hand expression. However, some experts have observed that hand expression may result in larger milk volumes immediately after birth. The difference between the effect of early breast pumping and the effect of early hand expression on eventual breastfeeding prevalence is unknown.

Infants who are not latching well or not sucking well when latched are at increased risk of early breastfeeding discontinuation. Excessive newborn weight loss, initiation of formula, maternal pain, maternal frustration and lower milk production due to inadequate breast stimulation may all contribute to breastfeeding discontinuation in this group, and milk expression is often recommended to improve breast stimulation and milk production. However, no studies have examined the effect of the method of early milk expression on breastfeeding outcomes for such newborns. We conducted a randomised controlled trial comparing the effect of breast pumping to that of hand expression for mothers of healthy term infants 12–36 h old who were not latching well or not sucking well when latched.

PATIENTS AND METHODS

We enrolled mother–infant pairs 12–36 h after birth where the infants were not latching well or not sucking well when latched. Pairs were excluded if mothers were <18 years old, did not speak English or had a history of low milk supply or breast surgery other than cyst removal, or if infants were <37 weeks gestation, <2000 g birth weight or received level II or III care. Poor latch and/or poor suck was determined by a study doctor or nurse by maternal interview and review of any lactation consultation at the time of recruitment. The study sample was drawn in 2007–2009 from the population of the well-baby nurseries and postpartum units at the University of California San Francisco (UCSF) Medical Center, Kaiser Permanente South Sacramento Medical Center and Stanford University Medical Center. Informed consent was obtained from all subjects by the study doctor or nurse. This study was approved by the UCSF Committee on Human Research, the Kaiser Permanente Institutional Review Board and the Stanford University Administrative Panel on Human Subjects in Medical Research.

We randomly assigned 68 mother–infant pairs to either breast pumping or hand expression using blocked randomisation, stratified by site and delivery method. Sample size was determined to allow 80% power to detect a 5 ml difference in expressed milk volume between the two study groups with an α of 0.05. The allocation sequence for randomisation was generated by an independent biostatistician; assignments were placed into sealed opaque envelopes by an independent administrative assistant. Immediately following enrolment, the study investigator opened sequential envelopes in the presence of a second clinician and revealed the randomisation arm. Thus we had complete allocation concealment, although no blinding was possible. Infants were then weighed on a Babyweigh scale (Medela, McHenry, Illinois, USA) for 15 min in a single session under supervision of the study doctor or nurse. The breast pump vacuum setting was initially begun at the lowest level (30 mm Hg) and then gradually increased as tolerated by the mother. Mothers assigned to hand expression were taught hand expression by a study doctor or nurse and then performed hand expression for 15 min in a single session under supervision of the study doctor or nurse. After milk expression, the entire expressed milk volume was measured by syringe and mothers in both groups fed their babies any expressed milk using a syringe, cup or spoon. Infants were subsequently reweighed on the same scale.

Immediately following these procedures, the study investigator verbally administered three questionnaires. First, in order to measure breastfeeding confidence, mothers were asked questions from a slightly modified version of the Breastfeeding Self-Efficacy Scale–Short Form (BSES-SF), rating each item on a scale from 1 (‘strongly disagree’) to 5 (‘strongly agree’). Second, mothers were asked questions from a modified Holdcroft scale of breastfeeding-related pain, which assessed pain in the breast, lower abdomen, back and perineum on a scale of 0–10. Third, mothers were asked questions from a newly developed breast milk expression experience (BMEE) measure, which included questions about social support for milk expression and personal and learning experience of milk expression. Mothers were then reminded that they could continue to use their method of milk expression if desired but were not under an obligation to do so. Phone follow-up by various investigators at 1 week, 1 month and 2 months assessed breastfeeding, milk expression and formula use. See box 1 for survey questions used to assess breastfeeding, milk expression and formula use. After 3 months of enrolment, due to low follow-up rates, study procedures were revised to include the collection of at least two phone numbers for follow-up, and were further revised after 9 months to include the collection of at least three phone numbers for follow-up. Completion rate rose from 30% to 81.6% following these changes.

We compared the effect of method of expression on the dichotomous outcomes of breastfeeding and breast pumping using χ² tests. We compared the effect of method of expression on our primary outcome of expressed milk volume and maternal pain using the Mann–Whitney test. We compared the effect of method of expression on continuous outcomes of BSES-SF scores and BMEE scores using the Student t test.

Box 1 Survey questions on breastfeeding, milk expression and formula use at 1 week, 1 month and 2 months

1. Within the past 24 h, since yesterday at this time, has the infant received any breast milk?
2. Within the past 24 h, has the infant received any breast milk directly from nursing?
3. Within the past 24 h, has the infant received any expressed breast milk?
4. Within the past 24 h, has the infant received any formula?
5. In the past 24 h, has the infant received any water, juice or tea?
6. Are you expressing breast milk?
All analyses were conducted using Stata 9.2 (Stata, College Station, Texas, USA).

RESULTS
Overall, 35 (51.5%) mothers were assigned to the hand expression group and 33 (48.5%) to the pumping group. The two study groups were similar at baseline (table 1).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Breast pump group (N=33)</th>
<th>Hand expression group (N=35)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant age (h), mean±SD</td>
<td>20.9±7.8</td>
<td>20.9±6.7</td>
<td>0.95</td>
</tr>
<tr>
<td>Male gender</td>
<td>23 (69.7%)</td>
<td>17 (48.6%)</td>
<td>0.08</td>
</tr>
<tr>
<td>Birth weight (kg), mean±SD</td>
<td>3.31±0.5</td>
<td>3.50±0.5</td>
<td>0.23</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>39.1±1.3</td>
<td>39.4±1.1</td>
<td>0.27</td>
</tr>
<tr>
<td>Vaginal delivery</td>
<td>27 (77%)</td>
<td>24 (72.7%)</td>
<td>0.67</td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td>30.2±6.6</td>
<td>30.2±6.3</td>
<td>0.98</td>
</tr>
</tbody>
</table>

The median volume of expressed milk (25th–75th percentile) was 0.5 ml (0–1) for hand expressing mothers (range 0–5 ml), and 1 ml (0–5) for pumping mothers (range 0–40 ml) (p=0.07). The median change in weight of infants before and after feeding (including breastfeeding and feeding of expressed milk) was 0 g (−3 to 5) for the pumping group (range −8 to 98 g), and 0 g (−1 to 2) for the hand expression group (range −4 to 14 g) (p=0.72).

There were no significant differences between the groups for any of the individual items in the BSES-SF or for the full scale (table 2). The BMEE differed for two questions whose wordings necessarily varied with treatment group. Mothers assigned to pumping had more agreement with the statement ‘I don’t want anyone to see me pumping’ (6.0±1.2) than mothers who hand expressed did with the statement ‘I don’t want anyone to see me hand expressing’ (2.3±1.1) (p<0.05). Mothers who were assigned to pumping had lower agreement with the statement ‘The instructions for using the pump are clear’ (4.1±0.9) than mothers who hand expressed did with the statement ‘The instructions for hand expressing are clear’ (4.5±0.5) (p<0.05). In our cohort, 33 (48.5%) mothers reported a pain score of 5 (of 10) or greater in one or more areas (either breast, lower abdomen, back or perineum). Pain scores during and after the milk expression intervention differed little by study group. However, breast pain scores measured during the feeding before the intervention were significantly higher in the hand expression group than in the breast pump group (22.9% vs 6.1% with breast pain scores ≥5), so it is possible that this pre-existing difference between the groups masked an effect of the intervention. For additional results on pain, see table 3.

At 1 week, 35 (57.4%) babies had received formula, including 17 (58.6%) in the pump group and 18 (56.3%) in the hand expression group. The 57 (62.7%) mothers expressing milk at 1 week included 18 (66.7%) from the group originally assigned to pumping and 19 (59.4%) from the group originally assigned to hand expression; one mother from each group reported using hand expression at 1 week. The 40 (78.4%) mothers expressing milk at 1 month included 16 (66.7%) from the group originally assigned to pumping and 24 (82.8%) from the group originally assigned to hand expression; two mothers from each group reported using hand expression at 1 month.

Final outcome assessment at 2 months was obtained for 48 mothers (70.6%). Absence of outcome ascertainment at

Table 1 Cohort characteristics

<table>
<thead>
<tr>
<th>BMEE items and scale</th>
<th>Breast pump group</th>
<th>Hand expression group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can always comfortably breastfeed with my family members present</td>
<td>3.2±1.3</td>
<td>3.8±1.2</td>
<td>0.058</td>
</tr>
<tr>
<td>I can always know when to switch from one breast to the other</td>
<td>3.2±1.2</td>
<td>2.6±1.3</td>
<td>0.080</td>
</tr>
<tr>
<td>Total BSES</td>
<td>3.4±0.8</td>
<td>3.4±0.7</td>
<td>0.994</td>
</tr>
</tbody>
</table>

*Items scored on a 1–5 scale, from 1, strongly disagree to 5, strongly agree. p Values are for randomised assignment to breast pump compared to hand expression.

BSES, Breastfeeding Self-Efficacy Scale;

Table 2 Outcomes immediately following intervention: item scores* for items differing by group

<table>
<thead>
<tr>
<th>BSES items and scale</th>
<th>Breast pump group</th>
<th>Hand expression group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don't want anyone to see me (hand expressing)</td>
<td>3.0±1.2</td>
<td>2.3±1.1</td>
<td>0.021</td>
</tr>
<tr>
<td>The instructions for (using the pump/hand expressing) are clear</td>
<td>4.1±0.9</td>
<td>4.5±0.5</td>
<td>0.036</td>
</tr>
<tr>
<td>Total score, 11-item BMEE</td>
<td>3.4±0.4</td>
<td>3.4±0.6</td>
<td>0.901</td>
</tr>
<tr>
<td>Expressed milk volume (ml)</td>
<td>2.9±7.7</td>
<td>0.8±1.4</td>
<td>0.136</td>
</tr>
<tr>
<td>Weight change before feed to after feed (g)</td>
<td>0.8±3.5</td>
<td>4.2±19.4</td>
<td>0.334</td>
</tr>
</tbody>
</table>

*Items scored on a 1–5 scale, from 1, strongly disagree to 5, strongly agree. p Values are for randomised assignment to breast pump compared to hand expression.

BMEE, breast milk expression experience; BSES, Breastfeeding Self-Efficacy Scale.

Table 3 Number of subjects with a pain score ≥5 (out of 10) in the hand expression (n=35) and pumping (n=33) groups

<table>
<thead>
<tr>
<th>During feeding, prior to the expression intervention</th>
<th>During the expression intervention</th>
<th>After expression intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand</td>
<td>Pump</td>
<td>Hand</td>
</tr>
<tr>
<td>Breast</td>
<td>8 (22.9) **</td>
<td>2 (6.1) **</td>
</tr>
<tr>
<td>Abdomen</td>
<td>10 (34.5) *</td>
<td>4 (15.4) *</td>
</tr>
<tr>
<td>Back</td>
<td>3 (8.6)</td>
<td>3 (9.1)</td>
</tr>
<tr>
<td>Perineum</td>
<td>5 (14.3)</td>
<td>5 (15.2)</td>
</tr>
<tr>
<td>Any location</td>
<td>18 (51.4)</td>
<td>13 (39.4)</td>
</tr>
</tbody>
</table>

Values are N (%). *p<0.10, **p<0.05.
2 months did not differ by study group, with nine mothers in the hand expression group and 11 mothers in the pump group lost to follow-up for 2-month outcomes (p=0.49). Mothers assigned to the hand expression group were more likely to be breastfeeding at 2 months (97.1%) than mothers assigned to the breast pump group (72.7%) (p=0.02). The relative risk for breastfeeding at 2 months was 1.32 (1.01–1.73) for the hand expression group compared to the breast pump group.

At 2 months, 41 (85.4%) mothers were still breastfeeding and seven had stopped breastfeeding. Mothers who stopped breastfeeding by 2 months had lower scores in the immediate postpartum period for the modified BSES-SF, with a mean score of 2.7±0.74 compared with mothers who continued breastfeeding at 2 months, with a mean BSES-SF score of 3.5±0.66 immediately after birth (p=0.02). See table 4 for additional differences between mothers who eventually breastfed through 2 months.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Breastfeeding at 2 months</th>
<th>No breastfeeding at 2 months</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can always comfortably breastfeed with my family members present</td>
<td>3.7±1.2</td>
<td>2.7±1.4</td>
<td>0.055</td>
</tr>
<tr>
<td>I can always know when to switch from one breast to the other</td>
<td>3.0±1.3</td>
<td>2.9±0.9</td>
<td>0.859</td>
</tr>
<tr>
<td>Total BSES</td>
<td>3.5±0.7</td>
<td>2.7±0.7</td>
<td>0.019</td>
</tr>
<tr>
<td>I don’t want anyone to see me (pumping/hand expressing)</td>
<td>2.5±1.1</td>
<td>3.4±1.1</td>
<td>0.062</td>
</tr>
<tr>
<td>I had no problems figuring out how to</td>
<td>3.8±1.0</td>
<td>3.0±0.6</td>
<td>0.048</td>
</tr>
<tr>
<td>use the pump/hand express colostrum/milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructions for using the pump/hand expressing</td>
<td>4.2±0.6</td>
<td>3.4±1.0</td>
<td>0.002</td>
</tr>
<tr>
<td>Total score, 11-item BMEE</td>
<td>3.5±0.5</td>
<td>3.2±0.3</td>
<td>0.134</td>
</tr>
</tbody>
</table>

*Items scored on a 1–5 scale, from 1, strongly disagree to 5, strongly agree. p Values are for eventual outcome of breastfeeding at 2 months compared to no breastfeeding at 2 months.

BMEE, breast milk expression experience; BSES, Breastfeeding Self-Efficacy Scale.

DISCUSSION

Our randomised study found that mothers of healthy, term, poorly feeding infants randomly assigned to hand expression at 12–36 h were more likely to be breastfeeding at 2 months than mothers randomly assigned to breast pumping. Our results could not be explained by milk volume, breastfeeding self-efficacy, pain or BMEE, which all differed little between the groups. However, the hand expression group reported increased comfort expressing milk with others present compared to the breast pump group, and the hand expression group also showed a trend towards increased comfort breastfeeding with others present. It is possible that hand expressing made mothers feel more comfortable breastfeeding and/or expressing with others present, or that pumping made mothers feel less comfortable breastfeeding and/or expressing with others present. This trend may have contributed to the success of the intervention, since we also found a trend towards increased rates of breastfeeding at 2 months among mothers who reported increased comfort breastfeeding with others present during the birth hospitalisation.

Since few mothers in our study used hand expression after the first week, we believe our results may be potentially attributable to two important differences between pumping and hand expression that are specific to the immediate postpartum period. First, mothers in the hand expression group reported greater comfort expressing milk with others present than mothers in the breast pump group. Feeling awkward or embarrassed in the presence of others might be an important barrier to continued successful breastfeeding in the immediate postpartum period. Second, milk volumes in this study cohort were very small, with median volumes of 1 ml in both groups. It is possible that the small volume of colostrum expressed by both groups appeared ‘normal’ in the hand expression group but appeared ‘insufficient’ for the mothers in the pump group, who used the large collecting system of the pump.

Potential additional causes for our results include bias or chance. A potential source of bias for this study could be that follow-up at 2 months was completed for 70.6% of subjects. If mothers in the hand expression group had lower rates of follow-up than those in the pump group, and if mothers who were not breastfeeding at 2 months were more likely to be lost to follow-up than mothers who were breastfeeding at 2 months, this might introduce bias to account for our results. However, there was no difference between the study arms in loss to follow-up. Furthermore, most loss to follow-up occurred in the early study participants, prior to establishment of improved follow-up procedures. Since our randomisation occurred in randomly permuted blocks of two and four, we had an even distribution to both randomisation arms throughout the time period of our study, and therefore loss to follow-up from early subjects due to suboptimal follow-up procedures is unlikely to account for any difference found between study groups.

Our study has several important limitations. First, we included only mothers of healthy term infants 12–36 h old who were not latching well or not sucking well when latched. While this is a large and important group, our findings may not apply to mothers of younger or older infants, or to mothers expressing milk for other reasons, such as engorgement or maternal–infant separation. Second, our study did not include a group randomised to receive no intervention. Therefore, we cannot report how either hand expression or breast pumping would compare to no intervention for our study population.

Third, our study attempted to identify potential reasons for...
an effect of method of expression on eventual breastfeeding prevalence, including breastfeeding confidence as measured by breastfeeding self-efficacy, expression experience and pain. However, few differences in these measures reached statistical significance when we compared the two groups. It is possible that a larger sample size would have provided the statistical power to better identify the factors contributing to the effect of method of milk expression, but it is also possible that other, unmeasured factors were significant contributors to or mediators of the effect. The indication of no significant difference between the two groups on enrolment (table 1), however, suggests that the randomisation procedure was effective in controlling for confounders. Fourth, we do not have data on LATCH score, incidence of ankyloglossia, maternal body mass index or other predictors of breastfeeding rates. However, we would expect these factors to have been approximately evenly distributed by the randomisation, so bias from this source appears to be unlikely.

Our results need to be confirmed by other studies. If confirmed, further research is needed to determine how method of expression affects eventual breastfeeding rates, for example, by impacting maternal embarrassment, by impacting maternal perception of milk supply, or by some other mechanism. A recent systematic review found that the literature on maternal experience associated with milk expression is limited.32 Our study revealed overall low volumes of expressed milk, high background levels of postpartum pain, and high overall concern about expressing and/or breastfeeding in front of others. The impact of these factors on maternal experience requires further study.

Although breast pumping is a fast and efficient method of milk expression once mature milk supply is established, there has been little previous study of breast pumping in the immediate postpartum period. One previous trial suggested that breast pumping in the immediate postpartum period may have a negative effect on breastfeeding duration, and no previous research has demonstrated either that pumping is beneficial for mothers at 12–36 h or that hand expression is harmful. Therefore, based on the previous literature and our results, we believe that in circumstances where either pumping or hand expression would be appropriate for healthy term infants 12–36 h old feeding poorly, teaching hand expression rather than breast pumping might improve breastfeeding rates at 2 months.

CONCLUSION
Mothers who were randomly assigned to hand expression shortly after birth were more likely to be breastfeeding at 2 months than those assigned to breast pumping shortly after birth. The mechanism for the association between early method of expression and later breastfeeding prevalence is unknown, and further research is needed to confirm our results and explore the reasons for an association between early expression practice and later breastfeeding outcomes. However, given the lack of previous evidence to support breast pumping in this population and the results of our study, providers should consider teaching hand expression instead of pumping to mothers of healthy term newborns feeding poorly after birth in cases where either method of expression might be appropriate.

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Competing interests None.

Ethics approval This study was conducted with the approval of the UCSF Committee on Human Research, the Kaiser Permanente Institutional Review Board and the Stanford University Administrative Panel on Human Subjects in Medical Research.

Provenance and peer review Not commissioned; externally peer reviewed.

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Randomised trial comparing hand expression with breast pumping for mothers of term newborns feeding poorly

Valerie J Flaherman, Barbara Gay, Cheryl Scott, Andrew Avins, Kathryn A Lee and Thomas B Newman

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Hand expression is a handy skill to have whenever you need to empty your breasts and you are not with your baby or your baby is temporarily unable to breastfeed. In the first few days after birth hand expression can be more effective at removing colostrum than using a breast pump. If your baby needs a supplement in the first few, use hand expression to provide the milk he needs!

**Hand expression routine:**

1. Apply heat, massage and stroke breasts
2. Position fingers behind areola
3. Press back towards chest
4. Compress fingers together to express milk
5. Relax and repeat getting a rhythm going
6. Express for 5-7 minutes
7. Move fingers to a different position
8. Massage and stroke the breast
9. Press back towards chest
10. Compress fingers together to express milk
11. Express milk for 3-5 minutes
12. Massage and stroke breasts
13. Move fingers to a different position
14. Express milk for 1-2 minutes
15. Complete cycle takes 20-30 minutes

*Watch this video while you are hand expressing to see the technique in action!*


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**Hands on Pumping**

Using a breast pump is important if your baby is ill, premature or unable to breastfeed for any reason. You will obtain more milk from the pumping session if you use breast massage at the same time. You will have more milk to save for feedings and your milk supply will increase.

**Hands on pumping routine:**

- Begin breast pumping within 6 hours of delivery
- Use a hospital grand breast pump with a double pump kit 8 times or more per 24 hours
  - Does not need to be a regular schedule, do when ever convenient
- Assure the flanges are appropriate size
  - Nipple moves freely in and out during suction cycle
  - Breasts are emptied completely, no areas of lumps
  - No pain while pumping
  - No white ring around areola
- Wear a bra or bustier that will hold the flanges in place while you pump so your hands can be free for massaging
- Start with slow massage to stimulate let-down
- Apply the breast pump and use the maximum suction level that is comfortable, not painful
- Watch the sprays of milk and adjust hand position to where milk flows the most easily
- When the sprays of milk subside, switch to single pumping so you can be more vigorous with the massage
- When the sprays of milk subside again, turn off the pump and hand massage into the pump flange. Some mothers can double their output this way. This is hind milk so the richest milk for the baby.
- Pay special attention to the outer margins of the breast

**Watch this video while you are pumping!**

http://newborns.stanford.edu/Breastfeeding/MaxProduction.html
Is use of breast pumps out of hand?  
Mothers who use ‘hands-on’ technique see increase in milk production

by Jane A. Morton, M.D., FAAP

Over-reliance on electric breast pumps may be associated with underproduction of breast milk, according to a study to be published in the *Journal of Perinatology*.

In the article titled “Combining Hand Techniques with Electric Pumping Increases Milk Production in Mothers of Preterm Infants,” Stanford researchers report the effect on milk production of two manual techniques used by mothers of infants younger than 30 weeks’ gestation. These mothers typically remain pump-dependent for weeks to months before they can rely on the breastfeeding infant to maintain their supply. This is the first report to show a steady increase in production over eight weeks, which surpassed reference levels for mothers of term infants.

Mothers first were taught hand expression of colostrum ([http://newborns.stanford.edu/Breastfeeding/HandExpression.html](http://newborns.stanford.edu/Breastfeeding/HandExpression.html)). Once milk came in, they were instructed on the second technique, “hands-on pumping” ([http://newborns.stanford.edu/Breastfeeding/MaxProduction.html](http://newborns.stanford.edu/Breastfeeding/MaxProduction.html)). During instructional sessions, milk was collected in bottles that were placed on electric scales, which were computer-linked to record milk removal. While simultaneously compressing their breasts and massaging firmer areas, mothers would observe sprays of milk into the tunnel of the breast shield, guiding them as to where and how to use their hands. Additionally, they could watch the computer screen display milk removal from each breast in real-time (see graph below). If study mothers were dependent solely on pump suction, stopping when the flow ended, available milk would have remained unexpressed.

Production among these preterm infant mothers, who are considered to be at high risk for impaired milk production, steadily rose over eight weeks, exceeding published averages for mothers of term infants.

Frequency of hand expression in the first three postpartum days correlated with subsequent production. The self-selected mothers who used frequent hand expression (over five times per day) and then hands-on pumping once milk came in produced an average of 955 milliliters per day (about 32 ounces) by two months. The average intake for a healthy 3-month-old breastfed term baby is approximately 27 ounces per day.

By the eighth week, mothers pumped an average of six times a day with a seven-hour uninterrupted interval for sleep.

The study underscores the long-term importance of the first three days when frequent and effective removal of colostrum is critical. Factors speculated to compromise production such as advanced maternal age, preterm delivery, high body mass index, Caesarean section delivery, *in vitro* fertilization and primiparity had no impact. Acceptance was so positive that mothers volunteered to demonstrate these techniques and share their impressions on the Stanford University Web site, [http://newborns.stanford.edu/Breastfeeding/](http://newborns.stanford.edu/Breastfeeding/).

The researchers do not challenge the importance of pumps but suggest that suction alone may remove only a fraction of available milk, thus compromising production. Eighty-five percent of mothers of infants younger than 4.5 months rely on an electric pump...

Insufficient milk supply is the most common reason mothers give for discontinuing their efforts to breastfeed during the first year (Ruowei Li, et al. *Pediatrics*. 2008;122:S69-S76). The most common reason for re-hospitalization of newborns relates to insufficient breast milk intake. Compromised production is three times more common in mothers of preterm vs. term infants.

There are many unforeseeable scenarios in which reliance on the baby or the baby plus the pump may not be enough to stimulate or maintain a robust supply. Ideally, expectant mothers could watch the videos on the Stanford Web site to learn about the importance of the first three days and an effective technique that may prevent subsequent production problems.

Whether these preliminary findings can be duplicated to the advantage of a wider spectrum of mothers remains to be studied. Yet the solution at hand (literally) may be learning a simple skill that involves no cost, no paraphernalia, no discomfort, no drugs and no risk.

Dr. Morton is a member of the AAP Section on Breastfeeding executive committee and co-author of the study to be published in the *Journal of Perinatology*.