

## Breast-Milk Sodium as a Predictor of Breastfeeding Patterns

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La présente étude reproduit en partie et poursuit une étude antérieure qui concluait que le taux élevé de sodium contenu dans le lait maternel (LM [Na<sup>+</sup>]) au début de la lactogénèse pouvait aider à prédire un allaitement maternel déficient. Du lait maternel extrait au jour 6 de la période postpartum a été utilisé pour la présente étude. En conformité avec les résultats de l'étude précédente, on a constaté que chez 80 % des femmes dont le lait affichait un taux de LM [Na<sup>+</sup>] de 16 mmol/L ou moins au jour 6, le taux de sécrétion lactée demeurait élevé à la quatrième semaine, comparé à 50 % chez celles pour qui le taux LM [Na<sup>+</sup>] était élevé ( $\chi^2=4,05$ ,  $df=1$ ,  $p=0,04$ ). Cette différence était encore plus marquée chez un sous-groupe de femmes pour lesquelles on avait prédit un risque de sécrétion lactée insuffisante, se fondant sur les variables de qualité du soutien reçu et de l'attitude éprouvée à l'égard de l'allaitement. Au sein de ce dernier groupe, chez 75 % des femmes pour qui le taux LM [Na<sup>+</sup>] était faible, on observait une sécrétion lactée élevée à la quatrième semaine de la période postpartum, alors que ce pourcentage n'était que de 22 % chez celles affichant un taux LM [Na<sup>+</sup>] élevé ( $\chi^2=0,65$ ,  $df=1$ ,  $p=0,01$ ). Par contraste, chez les femmes à faible risque, les taux de LM [Na<sup>+</sup>] n'ont pas été associés à une variation du taux de sécrétion lactée (allaitement soutenu dans 89 % des cas pour le groupe au taux de sodium faible et dans 82 % des cas pour le groupe au taux de sodium élevé). Par conséquent, une baisse normale du taux de LM [Na<sup>+</sup>] laisse prévoir de meilleures chances d'allaitement soutenu. Or, la valeur de prédiction de cet indice semble s'accroître lorsque celui-ci est combiné aux variables psychosociales que sont la qualité du soutien reçu et l'attitude de la mère à l'égard de l'allaitement.

This study partially replicates and extends a study reporting that elevated breast-milk sodium BM [Na<sup>+</sup>] during early lactogenesis was predictive of poor breastfeeding outcomes. The present study used 6-day postpartum breast milk. Consistent with the findings of the earlier study, 80% of those with a BM [Na<sup>+</sup>] of 16 mmol/L or lower at day 6 sustained a high level of breastfeeding at week 4, compared to only 50% of those with an elevated BM [Na<sup>+</sup>] ( $\chi^2 = 4.05$ ,  $df = 1$ ,  $p = .04$ ). This difference was even greater in a subgroup of mothers predicted to be at high risk for insufficient milk supply on the basis of support density and self-perception variables. Of the latter group, 75% with low BM [Na<sup>+</sup>] sustained a high level of breastfeeding at 4 weeks postpartum, compared to only 22% with an elevated BM [Na<sup>+</sup>] ( $\chi^2 = .65$ ,  $df = 1$ ,  $p = .01$ ). In contrast, among the low-risk

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mothers BM [Na<sup>+</sup>] levels were not associated with any difference in breast-milk sustainment (89% and 82% sustainment for low- and high-sodium groups, respectively). Thus a normal drop in BM [Na<sup>+</sup>] is predictive of higher sustainment of breastfeeding. However, the predictive validity of this marker appears to be enhanced by combining it with the psychosocial variables of support density and self-perception of breastfeeding by the mother.

Elevated sodium concentrations in human breast milk have been associated with insufficient milk supply and infant malnutrition. Little is known, however, about the usefulness of elevated sodium concentrations as a predictor of sustained breastfeeding.

### **Review of the Literature**

In her study of breast-milk sodium (BM [Na<sup>+</sup>]) and lactation, Morton (1994) summarizes what is generally known about BM [Na<sup>+</sup>] as follows: BM [Na<sup>+</sup>] is not influenced by a mother's diet and is similar in women of high and low socio-economic groups. BM [Na<sup>+</sup>] levels are generally high in colostrum but fall precipitously by day 3 and then continue to decline slowly for at least 6 months. BM [Na<sup>+</sup>] does not differ between foremilk and hindmilk (Ereman, Lonnerdal, & Dewey, 1987; Gillies & Neill, 1985; Neville et al., 1991; World Health Organization/UNICEF, 1989). Additionally, BM [Na<sup>+</sup>] levels are high during weaning when the volume of milk falls below 400 mL per day. The expected early postpartum drop in BM [Na<sup>+</sup>] usually precedes the increased volume experienced with the mother's milk "coming in" by day 1 (Neville et al., 1991). Thus while related, dilution is not considered to be the primary mechanism for the dramatic drop in BM [Na<sup>+</sup>], which typically occurs at about 60 hours postpartum.

Based on animal studies, Allen and Peltó (1985) propose a mechanism to relate sodium to milk production. They report that before lactation is established, and later during circumstances threatening the milk supply, the tight junctions between mammary epithelial cells leak, permitting pericellular Na<sup>+</sup> to influx into the milk. In contrast, when lactation is well established the junctions close and there is no exchange of Na<sup>+</sup> between the pericellular fluid and breast milk. When lactogenesis is diminishing and the junctures are again open, a resulting high Na:K ratio in both the milk and secretory cells may inhibit synthesis of the proteins necessary for milk formation, which would explain the downward spiral of milk production once weaning begins. The majority of studies in this area have focused on the conditions influencing the amount of sodium in breast milk. Little has been documented about how the long-term human breastfeeding process is related to BM [Na<sup>+</sup>]. Morton (1994) looked at the relationship between early BM [Na<sup>+</sup>] in the

first week and human lactation at 1 month and reports that an elevated BM  $[Na^+]$  between postpartum days 3 and 8 was associated with a drop in breastfeeding rates at 1 month postpartum. Thus BM  $[Na^+]$  level showed potential for being an important early clinical marker of the lactation process. Further development of such a marker would be potentially useful in early intensive support for mothers at risk of insufficient milk supply (IMS), which is the reason most frequently given by mothers for earlier than intended weaning (World Health Organization/UNICEF, 1989). While debate exists as to whether these mothers truly have insufficient milk supply or merely perceive that they do, mothers respond similarly in both cases. Early perceived IMS frequently leads to increased supplementation before lactation is established, followed by true IMS; thus for the purpose of nursing care the distinction may be a moot point.

It is important that mothers be assisted in continuing to breastfeed, because breast milk has been shown to benefit infants and mothers in ways that infant formulas cannot. Despite these relatively well-known benefits, many North American mothers wean their infants in the first few weeks and earlier than intended. Infant demand has been shown to be the main determinant of lactation performance after the first month (Dewey, Heinig, Nommsen, & Lonnerdal, 1986; Neville et al., 1989). However, the most rapid decline in the incidence of breastfeeding occurs in the first 2 weeks postpartum when maternal factors as well as infant demand — including maternal health, fatigue, comfort, and confidence (Hill & Humenick, 1989; Samuels, Margen, & Schoen, 1989) — may also affect the establishment of breast-milk production. Thus it is likely that a high level of BM  $[Na^+]$  at the end of the first week of breastfeeding is a result of poor lactation management and only secondarily an infant problem.

The purpose of the present study was to partially replicate Morton's (1994) research and to extend it to examine additional risk factors with mediating potential on the relationship of elevated BM  $[Na^+]$  to breastfeeding outcomes. For this study, mothers who reported breastfeeding at a level over 80% at 4 weeks were operationally defined as having sustained breastfeeding. Those who reported weaning or breastfeeding at a level 80% or below at 4 weeks were defined as having non-sustained breastfeeding.

We chose 80% as a cut point because our data analysis in a pilot study had shown that early in breastfeeding, once a mother decreased her breastfeeding to 80% and below, it was often a short time until the baby was weaned. Thus in these early weeks once feeding had reached

80% breast milk and below, supplemental feeding was substantial, and essentially the weaning process had begun.

### Research Questions

1. The primary question was: *Do elevated levels of BM [Na+] at postpartum day 6 by themselves serve as a marker to predict low frequency of breastfeeding at week 4?* Additional data were available to examine supplemental questions as to whether they also predict low attainment of mothers' breastfeeding goals, a more rapid decline of breastfeeding levels in the first 20 weeks, or higher weaning rates by week 20.
2. *Are the psychosocial risk factors of perceived IMS, support density, and self-perception of breastfeeding mediators of the relationship between elevated BM [Na+] and the above breastfeeding outcomes?*

### Methods

#### Primary Subjects

This analysis was performed as a secondary analysis. The subset of data was drawn from 340 subjects in a prospective, longitudinal, primary study of IMS. Mothers were recruited from 10 hospitals within 36 hours of giving birth. The original sample was stratified to recruit an equal number of first- and second-time mothers, with half of the latter group having breastfed previously for longer than 3 weeks. Subjects were retained if they fit into pre-selected categories designed so that two thirds were judged as high-risk for perceived IMS. Human-subject reviews were conducted by the two universities and 10 hospitals involved. The consent forms allowed for additional unspecified analyses of the milk samples.

Approximately 50% of the breastfeeding mothers who were approached agreed to participate in the study. This was also true in a similar pilot study conducted by Hill and Humenick (1996a). For the pilot group, almost all mothers not participating in the full study agreed to participate minimally. This consisted of selected demographic information at the time of the birth and a telephone call to ascertain breastfeeding outcome at week 20. There were no significant differences between mothers who fully and minimally participated in the study on either breastfeeding outcomes or demographics, with the exception of lower maternal education for the minimally participating mothers. Of those mothers who entered the present primary study, almost none



were lost to the planned follow-up, due to vigorous staff efforts and highly cooperative subjects.

Women in this primary study had single births, had begun breastfeeding within 36 hours, and, along with their infants, had been judged to be in good health. In addition, all the infants weighed at least 2,500 grams and had an estimated gestational age of 37 weeks or more. The mothers of the subsample in this secondary analysis averaged 28 years of age and lived in western Illinois or eastern Iowa in the United States; 85% were married; 89% were Caucasian. These demographic characteristics are consistent with those of the larger, primary sample.

### *Assessment of Risk*

On the first day postpartum, mothers reported the density of their breastfeeding support network by responding to the question of how many of their friends and family members who had had babies in the previous 3 years had breastfed ("most," "many," "few," or "none"). Subsequently mothers provided a Breastfeeding Satisfaction Scale (MIBSS) at 6 days postpartum. Based on these responses, mothers in the primary study were assigned to one of three groups relative to their risk for IMS: high risk were randomly assigned to either an intervention or control group, while low risk were assigned to a low-risk observational group. The risk assessment and outcomes of the nursing interventions are fully described elsewhere (Humenick & Hill, 1998). The MIBSS is a subscale of the H & H Lactation Scale (Hill & Humenick, 1996b). It is a 7-point Likert scale with the following five items: (1) I feel successful at breastfeeding my baby; (2) In general, I am satisfied with breastfeeding; (3) I become more relaxed as I sit and breastfeed; (4) My baby appears to enjoy breastfeeding; and (5) I believe my baby is satisfied with breastfeeding. Cronbach's alpha for this subscale was .92. Mothers in the high-risk intervention group received weekly home nursing visits that included counselling based on use of a current breastfeeding reference (Tully & Overfield, 1989). Mothers in the high-risk control and low-risk observational groups were queried during bi-weekly telephone calls from a non-nurse who offered no advice. The risk assessment is enumerated in Box 1.

These variables were the most potent at day 6 out of all the variables in the study conceptual framework (Hill & Humenick, 1989). In the primary study, IMS risk category was assigned by the end of the first postpartum week, because mothers who wean earlier than intended often do so by week 2 or 3; thus any planned intervention must be started early.

**Box 1    Risk Assessment**

The assessment of mothers for risk for breastfeeding outcomes was based on items culled from a Phase 1 observation of 120 mothers that immediately preceded this primary study. The items used did separate out a high-risk group as documented in this article. However, analyses of the Phase 2 data suggest that a portion of the items can parsimoniously be used to assign risk. The first is the Maternal Infant Breastfeeding Satisfaction Subscale (MIBSS) (Hill & Humenick, 1996), which was administered at 1 week postpartum. The scale is a 5-item Likert scale with 35 possible points at the extreme end of disagreement. A score of 16 or more points was the cut point for MIBSS risk. The second item was one of "support density" administered while the mother was in hospital. It read, "How many (best guess) of family, friends and co-workers having babies in the past three years have breastfed their babies?" Possible answers were "none," "few," "many," or "most." Answers of "none" or "few" constituted the cut point for supporting density risk.

Further analysis revealed that the following levels of risk were predictive of breastfeeding outcomes among Phase 2 subjects:

- Risk Level 1:** No risk on MIBSS and no risk on support density.
- Risk Level 2:** No risk on MIBSS but high risk on support density.
- Risk Level 3:** High risk on MIBSS and either high or low risk on support density.

	Level 1 Risk	Level 2 Risk	Level 3 Risk	Chi-Square	P Value
Mother met or exceeded her breastfeeding goals during her hospitalization	70.8% (n = 34)	60.0% (n = 40)	20.0% (n = 15)	12.2	.002
Week 4: Breastfeeding exclusively or >80%	95.6% (n = 45)	92.0% (n = 50)	35.7% (n = 14)	34.8	.000
Week 8: Breastfeeding exclusively or >80%	82.2% (n = 45)	72.9% (n = 48)	15.4% (n = 13)	21.7	.000
Week 12: Breastfeeding exclusively or >80%	72.0% (n = 43)	57.8% (n = 45)	15.4% (n = 13)	34.8	.000
Week 16: Breastfeeding exclusively or >80%	66.7% (n = 39)	47.7% (n = 44)	14.3% (n = 14)	11.55	.003
Week 20: Breastfeeding exclusively or >80%	57.5% (n = 40)	32.5% (n = 43)	13.3% (n = 15)	10.55	.003

### ***Assessment of Breastfeeding Level***

Breastfeeding levels were adapted from Labbok and Krasovec (1990). All mothers were asked to respond to the inquiry "How would you describe your breastfeeding pattern this week?" A set of choices was verbally administered at postpartum weeks 1, 2, 4, 6, 8, 12, 16, and 20. For the secondary analysis, mothers were categorized as feeding over 80% breast milk ("More than eight of every ten feedings is breast milk") or less.

***Breast milk sample collection.*** Mothers collected breast-milk samples on postpartum day 6. They were instructed to hand-express from each breast 1/2 to 1 teaspoon (2.5 to 5 mL) of breast milk. The sample was to be taken before and after the feeding nearest to 8 a.m. Mothers were instructed to refrigerate breast-milk samples until research assistants collected them the following day. Milk samples were tested for fat content and milk maturation progression from colostrum through mature milk (Humenick, Mederios, Wreschner, Walton, & Hill, 1994). The remainder of the milk samples were frozen for 1 to 2 weeks at -10 to 0°C and then frozen at -80°C in the event future analysis was required.

### ***Subjects and Samples***

Morton's (1994) study was published just after the aforementioned data collection had been completed. It became apparent that a partial replication was possible through secondary analysis of collected milk samples and maternal data. For this analysis, foremilk samples at day 6 postpartum were analyzed for Na<sup>+</sup>. Samples were conveniently chosen if adequate milk samples were on hand to carry out this post-hoc milk analysis, potentially introducing a sample bias of mothers with more ample milk production. The number of milk samples for this unanticipated analysis was based on budget constraint. To avoid the confounding variable of prior breastfeeding experience, only milk from primiparae was used. The milk samples used for the Na<sup>+</sup> analysis had been frozen for 2 to 3 years prior to the analysis. All samples were stored in 12 x 75 polystyrene capped 5 cc. tubes, which were then sealed in plastic bags to prevent dehydration. Of the 41 samples, 16 were from mothers in the low-risk observation group, 14 from the high-risk intervention group, and 11 from the high-risk observation group.

### *Milk Analysis*

The 41 milk samples used were re-labelled to conceal identification and control testing biases. Each sample was 1 to 2 mL in quantity. The samples were brought to room temperature, mixed, and centrifuged at 3,000 rpm for 10 minutes, and the substrate was analyzed for  $\text{Na}^+$  (ion-specific electrode method) on a Beckman Synchron CX7 at Medical Laboratory in Casper, Wyoming.

The Medical Laboratory in Casper is accredited (#21965-01) by the College of American Pathologists (CAP). The instrument was calibrated with two standards for maximum sensitivity, and the linearity correlation coefficient was 0.99995. Zero of five data points exceeded the 10% limit set for sodium using the ion-specific electrode methodology. All test samples were reported in whole numbers using mmol/L as the unit of measure. Assayed control samples were run parallel with the 41 breast-milk samples to ensure instrument function. For consistency with Morton's (1994) study, samples with BM  $[\text{Na}^+]$  levels of 16mmol/L and under were operationally defined as non-elevated; those above 16mmol/L were defined as elevated.

### *Breastfeeding Outcome Patterns*

In this study, mothers who reported breastfeeding at a level over 80% at 4 weeks were operationally defined as having sustained breastfeeding. Those who reported weaning or breastfeeding at a level 80% and under at 4 weeks were defined as having non-sustained breastfeeding. We chose 80% as a cut point because our primary data analysis had shown that early in breastfeeding, once a mother decreased her breastfeeding to 80% and below, it was usually a short time until the baby was weaned. Additional outcome variables used were: (1) the percentage of mothers who met their breastfeeding goals as stated during their childbirth hospitalization, (2) the number of weeks until breastfeeding decreased to below 80%, and (3) the percentage of mothers who had weaned at infant age of 20 weeks. These outcome variables were chosen because they were related outcomes and reflected the data available.

### *Limitations*

This sample had several limitations. Approximately two thirds of the subjects were selected because they were at risk for perceived IMS, a rate higher than found in the general population. Thus generalization of feeding and weaning rates to all mothers cannot be made. However, the comparison between in-study groups is appropriate and useful.



Other limitations to generalization to all breastfeeding mothers are that only primiparae were included, BM [Na<sup>+</sup>] was examined only at one time period, and the sample was small and from a circumscribed region of one country.

### ***Statistical Analysis***

Chi-square analysis or Fisher's Exact Tests were used to test the validity of BM [Na<sup>+</sup>] as a predictor of breastfeeding outcome patterns. *T*-tests were used to contrast duration of feeding in weeks between low and elevated BM [Na<sup>+</sup>]. A difference with a *p* value of .05 was considered significant.

### **Results**

For the 41 breast-milk samples, BM [Na<sup>+</sup>] ranged from 6 to 46 mmol/L. The median was 15. The mean was 17.4 with a standard deviation of 8.59. Of the 41 mothers, 61% (*n* = 25) had non-elevated BM [Na<sup>+</sup>] (16 mmol/L or lower) and 39% (*n* = 16) had elevated BM [Na<sup>+</sup>] levels.

#### ***BM [Na<sup>+</sup>] as a Predictor of Breastfeeding Outcomes***

Of the 41 mothers, 80% of those with low BM [Na<sup>+</sup>] had sustained breastfeeding at postpartum week 4 compared to 50% with elevated BM [Na<sup>+</sup>]. The difference was significant ( $\chi^2 = 4.05$ , *df* = 1, *p* = .04) (see Table 1). Thus day 6 BM [Na<sup>+</sup>] was predictive of sustained breastfeeding at week 4.

**Table 1** *Comparisons of Breast-Milk Sodium Level and Frequency of Sustained Breastfeeding: Patterns at 4 Weeks Postpartum*

	Low BM [Na <sup>+</sup> ]	High BM [Na <sup>+</sup> ]	$\chi^2$	Fisher's Exact Test	<i>P</i> Values
All Mothers ( <i>n</i> = 41)	80%	50%	4		.04
High-Risk Intervention ( <i>n</i> = 14)	67%	20%		.13	
High-Risk Control ( <i>n</i> = 11)	86%	25%		.08	
Low-Risk Comparison ( <i>n</i> = 16)	89%	86%		.70	
Combined High-Risk Groups ( <i>n</i> = 25)	75%	22%	65		.01

For the supplemental outcome measures: the percentage of mothers reaching their goal, the average time to decreasing breastfeeding to 80% or less, and the percentage of mothers weaning by 20 weeks were all in the direction of better outcomes for the low BM [Na<sup>+</sup>] for high-risk mothers. These differences did not reach significance.

### *Risk for IMS Outcomes*

The data were further analyzed by IMS risk group. By chance, all three groups had relatively even distribution of elevated BM [Na<sup>+</sup>]. This was 36% for the control group, 36% for the intervention group, and 44% for the low-risk observation group ( $p = .88$ ). Thus these samples could be compared across risk groups by BM [Na<sup>+</sup>].

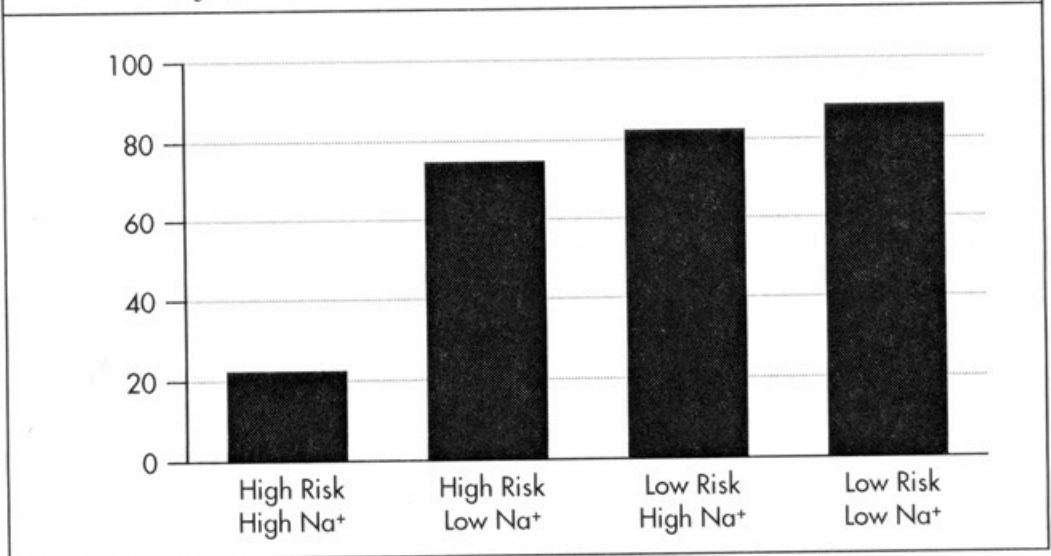
**Week 4 comparison.** Sustained breastfeeding rates at 4 weeks were compared. For mothers in the *high-risk control* group they were 86% and 25% for low- and elevated-BM [Na<sup>+</sup>] groups, respectively (Fisher's Exact Test, one-tailed,  $p = .08$ ). Similarly, for the *high-risk intervention* group the rates were 67% to 20%, respectively (Fisher's Exact Test, one-tailed,  $p = .09$ ). For the combined *high-risk* groups the differences in the percentage who sustained breastfeeding at 4 weeks were statistically significant at 75% and 22%, respectively ( $\chi^2 = .65$ ,  $df = 1$ ,  $p = .01$ ). In contrast, for the *low-risk* group nearly identical rates of sustained breastfeeding were 89% to 86%, respectively, for low- and elevated-BM [Na<sup>+</sup>] groups (Fisher's Exact Test, one-tailed,  $p = .70$ ) (see Table 1). In summary, elevated BM [Na<sup>+</sup>] at postpartum day 6 was shown to be predictive only for the mothers at high risk for IMS (Figure 1).

**Meeting breastfeeding goals.** For the *low-risk* group 55% and 57% of mothers with low and elevated BM [Na<sup>+</sup>] had met their breastfeeding goals at week 20. For all *high-risk* mothers 50%, contrasted with 22%, of low- and elevated-BM [Na<sup>+</sup>] mothers, respectively, met their breastfeeding goals ( $p = .42$ ).

**Weeks until breastfeeding decreased.** The average time for mothers in the *low-risk* group to decrease their level of breastfeeding to 80% or less was 14.1 weeks and 14.5 weeks for the low- and elevated-BM [Na<sup>+</sup>] groups, respectively. For all *high-risk* mothers decreased breastfeeding occurred at 10.3 and 5.6 weeks for the low- and elevated-BM [Na<sup>+</sup>] groups, respectively. Using two-way ANOVA, the differences in time to decreased breastfeeding was significant for risk grouping ( $p = .02$ ) but not for BM [Na<sup>+</sup>] level ( $p = .31$ ).

**Weaning rates.** When weaning rates (number of mothers breastfeeding) by 20 weeks were examined by IMS risk group, the mothers in the *low-risk* group continued to breastfeed at 20 weeks at a rate of 55.6% and 57.1% for low- and elevated-BM [Na<sup>+</sup>] groups, respectively. For all *high-risk* mothers, breastfeeding continued at a rate of 28.6% and 11.1% for mothers with low and elevated BM [Na<sup>+</sup>], respectively. This trend was also not statistically significant. However, it is notable that all the measures were in the direction of a difference by BM [Na<sup>+</sup>] level for high-risk mothers and nearly identical numbers for low-risk mothers.

**Figure 1** *Percentage of Mothers Breastfeeding >80% at Week 4 by Sodium Level and Risk Level*



### *Additional Variables*

Several other potentially influencing factors were examined. Correlations and *t*-tests were used as appropriate, and determined that BM [Na<sup>+</sup>] (as both a continuous variable and a grouping variable) was not significantly related to any of the following: mothers' reports of their age, height, and weight; mothers' responses to questions about their general health and nutrition levels, exercise level, or consumption of alcohol, caffeine, vitamins, and medications. None of the mothers reported smoking. BM [Na<sup>+</sup>] was also compared to an objective measure of breast-milk maturation (Humenick et al., 1994) at postpartum days 6 and 20 and was not found to be significantly related. BM [Na<sup>+</sup>] was compared to the MIBSS and no significant relationship was found in these two measures from data collected at postpartum days 6 and 7.

### **Summary**

In summary, answers to the research questions are that elevated levels of BM [Na<sup>+</sup>] at postpartum day 6 do predict a significant decrease in breastfeeding sustainment at week 4. When IMS risk groups was used as a mediating variable, high-risk mothers showed a striking decrease in sustained breastfeeding at week 4 (75% compared to 22%) for low- and elevated-BM [Na<sup>+</sup>] groups, respectively. For mothers who had been judged to be at low risk for IMS, level of BM [Na<sup>+</sup>] showed no prediction of future breastfeeding patterns. Thus BM [Na<sup>+</sup>] appears to be a marker predicting poor breastfeeding outcomes only for mothers at high risk for perceived IMS.

### **Discussion**

The answer to the first research questions is yes. A difference in sustained breastfeeding was predicted by early BM [Na<sup>+</sup>] levels. Morton (1994) reported diminished breastfeeding at 1 month for mothers whose milk was elevated above 16mmol/L sampled between postpartum days 3 and 8. There were a number of methodological differences between our study and the Morton investigation. In the Morton study the initial BM [Na<sup>+</sup>] was measured in samples collected from days 3 through 8, as compared to day 6 samples in the present study. Morton's criteria for success were exclusive breastfeeding and 454 grams above birthweight at 1 month, whereas in the present research "sustained breastfeeding" was defined as infant daily average intake of greater than 80% breast milk at 4 weeks. In the Morton study all mothers with an elevated BM [Na<sup>+</sup>] received intervention, whereas mothers with low BM [Na<sup>+</sup>] received no intervention. In comparison, in the present study approximately one third of mothers with both low and elevated BM [Na<sup>+</sup>] received intervention. Thus in Morton's study intervention was potentially confounded with BM [Na<sup>+</sup>] grouping, whereas in the present study intervention was limited to half the high-risk mothers but appeared to make no difference among those with elevated sodium levels. Another difference is that in the present study mothers were followed for 3 additional months; thus more is known about their breastfeeding outcomes up to 20 weeks. Morton reported a 1-month follow-up.

### **Consistency**

In spite of the recruitment and methodological differences, the similarity of the 1-month findings for the two studies is striking. This provides

support for the findings from both sets of data. Morton (1994) reported that of 60 women with high BM  $[Na^+]$  45% did not meet her criteria for success at 1 month. Similarly, in the present study 50% of all mothers with high BM  $[Na^+]$  did not meet our criteria for sustained breastfeeding at 4 weeks. Of the mothers in Morton's study who had low BM  $[Na^+]$  88% met her criteria for success, as compared to 80% of all mothers in the present study. Given our small sample and the multitude of variables that were not controlled, perhaps this similarity is a coincidence. Conversely, since the findings fit the earlier physiologic discussion of lactogenesis, it is likely that BM  $[Na^+]$  is a sufficiently powerful marker of the lactation process to override the influence of a variety of potentially intervening variables. The collective evidence calls for a more definitive study with more subjects than featured in our study and with a longer follow-up data-collection period than featured in Morton's study. A larger sample would allow for the examination of additional mediating variables such as labour anesthesia/analgesia, frequency of breastfeeding, use of supplements, newborn suckling behaviour, and maternal breastfeeding-associated problems such as sore nipples, engorgement, and mastitis.

### *Question 2: IMS Risk as a Mediating Variable*

An important finding of our study was that high levels of BM  $[Na^+]$  predicted a significant difference in breastfeeding at 4 weeks only for the groups at high risk for perceived IMS when this variable was considered. In the present analysis the high-risk mothers with low  $[Na^+]$  also showed a trend towards more weeks of breastfeeding before weaning and a greater likelihood of meeting their breastfeeding goals. While these trends were not significant in this small sample, they suggest that the influence of early BM  $[Na^+]$  may extend beyond the time frame documented in the Morton (1994) study. This, too, should be further studied in a larger sample.

Interestingly, the data also suggest that mothers' BM  $[Na^+]$  levels at 6 days are not significantly associated with mothers' reported MIBSS scores at 7 days. Thus although MIBSS scores played a large part in IMS risk-group assignment, they do not predict BM  $[Na^+]$  in this sample. One might hypothesize that mothers with elevated BM  $[Na^+]$  would be somewhat aware of experiencing breastfeeding difficulties and would express this as dissatisfaction on the MIBSS. This does not, however, appear to be the case based on this small sample. Thus the MIBSS scores and the BM  $[Na^+]$  scores, collected at about the same time (days 7 and 6), appear to be independent but additive predictors.



### *Implications for Nursing*

If the additive prediction of this combination of biological and psychosocial variables is supported by future studies, it will be of clinical significance. The better the predictive validity of risk measures, the more precision is possible in nursing interventions related to breastfeeding outcomes. Identification of those at highest risk for IMS (or any health condition) has potential for cost savings in the provision of care. Seldom are there adequate health-care resources to provide all mothers with intensive breastfeeding support. In the larger primary intervention study, Humenick and Hill (1998) found that intervention with their group of high-risk primiparae resulted in significantly more breastfeeding and less weaning due to perceived IMS. Continued perfecting of risk-assessment measures has the potential to allow nurses to efficiently direct their efforts towards the breastfeeding mothers who need them most.

### **References**

- Allen, L., & Peltó, G. (1985). Research on determinants of breast-feeding duration: Biocultural studies. *Medical Anthropology*, 9, 97-105.
- Dewey, K., Heinig, M., Nommsen, L., & Lonnerdal, G. (1986). Maternal versus infant factors related to breast milk intake and residual milk volume: The DARLING study. *Pediatrics*, 77, 357-365.
- Ereman, R., Lonnerdal, B., & Dewey, K. (1987). Maternal sodium intake does not affect postprandial sodium concentrations in human milk. *Journal of Nutrition*, 117, 1154-1157.
- Gillies, M., & Neill, A. (1985). Variations in the mineral concentration in breast milk during a single nursing, diurnally, and on consecutive days. *Human Nutrition, Applied Nutrition*, 39A, 370-375.
- Hill, P., & Humenick, S. (1989). Insufficient milk supply. *Image*, 21, 145-148.
- Hill, P., & Humenick, S. (1996a). Comparison of subjects who fully versus minimally participated in a breast-feeding study. *Western Journal of Nursing Research*, 17(3), 136-140.
- Hill, P., & Humenick, S. (1996b). Development of the H & H Lactation Scale. *Nursing Research*, 45(3), 136-140.
- Humenick, S., & Hill, P. (1998). *Assessment-based, individualized intervention and perceived insufficient milk supply*. Unpublished manuscript.
- Humenick, S., Mederios, D., Wreschner, T., Walton, M., & Hill, P. (1994). The maturation index of colostrum and milk (MICAM): A measurement of breast milk maturation. *Journal of Nursing Measurement*, 2, 169-186.
- Labbok, M., & Krasovec, K., (1990). Toward consistency in breastfeeding definition. *Studies in Family Planning*, 21, 226-230.

- Morton, J. (1994). The clinical usefulness of breast milk sodium in the assessment of lactogenesis. *Pediatrics*, 93, 802-806.
- Neville, M., Allen, J., Archer, P., Casey, C., Seacat, J., Keller, R., Lutes, V., Rasbad, J., & Neifert, M. (1991). Studies in human lactation: Milk volume and nutrient composition during weaning and lactogenesis. *American Journal of Clinical Nutrition*, 54, 81-92.
- Neville, M., Keller, R., Seacat, J., Lutes, U. Neifert M., Casey, C., Allen, J., & Archer, P. (1989). Studies in human lactation: Milk volume in lactating women during the onset of lactation and full lactation. *American Journal of Clinical Nutrition*, 48, 1375-1386.
- Samuels, S.E., Margen, S., & Schoen, E.J. (1989). Incidence and duration of breastfeeding in a health maintenance organization population. *American Journal of Clinical Nutrition*, 42, 504-510.
- Tully, M.R., & Overfield, M.L. (1989). *Breastfeeding Counseling Guide* (2nd ed.). Raleigh, NC: Lactation Consultants of North Carolina.
- World Health Organization/UNICEF. (1989). *WHO Collaborative Study of Breast Feeding. Protecting, promoting, and supporting breast feeding: The special role of maternity services*. Geneva: Author.

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