Quantitative Analysis of Sex-Biased Variations in Human Milk Profile and Subsequent Growth Outcomes

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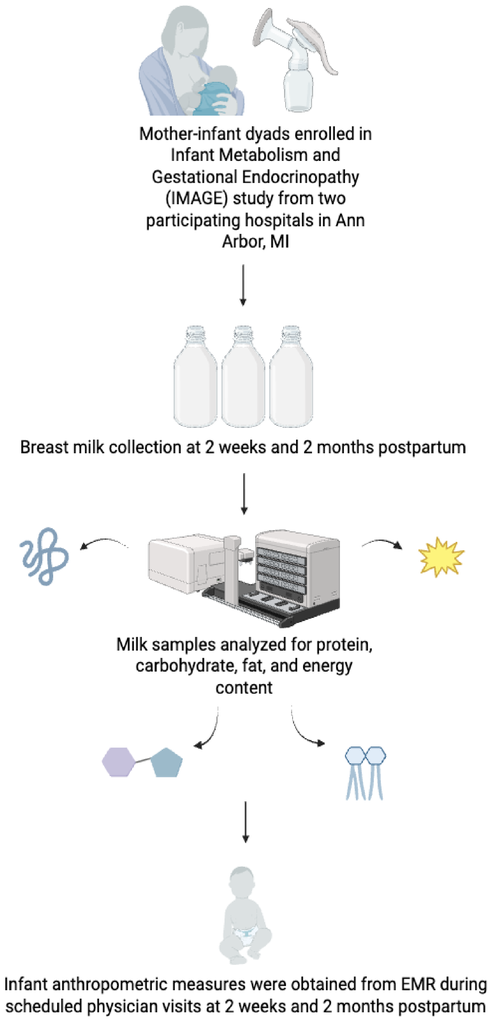
INTRODUCTION

- Human milk is an adaptive fluid that dynamically evolves alongside infant physiological demands.
- Early post-partum milk (colostrum) features high protein concentrations paired with lower fat and carbohydrate levels. As milk matures, protein and amino acid levels decline, while fat and carbohydrate contents rise to meet expanding growth requirements.
- Although maternal synthesis may adjust based on infant biological sex, empirical data remain sparse.
- This study evaluated sex-dependent variations in milk macronutrients and their impacts on infant growth.

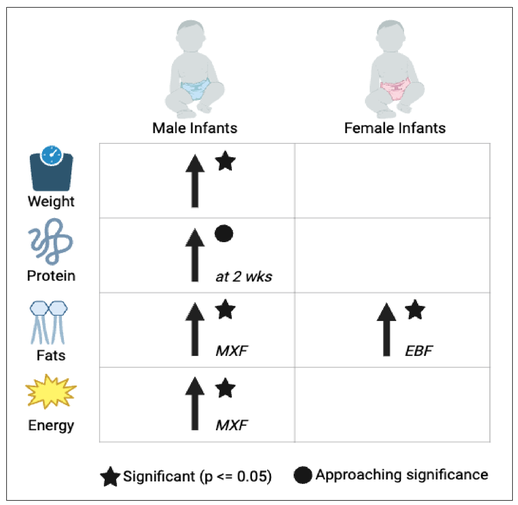
METHODS



RESULTS

Maternal Characteristics	Overall (n=112) Mean (SD) or n (%)	Female (n=62) Mean (SD) or n (%)	Male (n=50) Mean (SD) or n (%)
Race			
African American	14 (14)	11 (20)	3 (6.8)
Asian	8 (8.2)	4 (7.4)	4 (9.1)
Latino	7 (7.1)	3 (5.6)	4 (9.1)
White	67 (68)	35 (65)	32 (73)
Other	16 (14.2)	9 (14.2)	7 (0.14)
Gestational Age (weeks)	39.7 (1.0)	39.8 (1.0)	39.5 (0.1)
Health Condition			
Healthy	87 (77)	50 (79)	37 (74)
Gestational Diabetes	13 (12)	6 (9.5)	7 (14)
PCOS	13 (12)	7 (11)	6 (12)
Maternal Age (years)			
25-34	90 (80)	51 (81)	39 (78)
=>35	23 (20)	12 (19)	11 (22)
Body Mass Index (kg/m^2)	28.8 (6.7)	29.0 (6.7)	28.6 (6.7)
Infant Characteristics	Overall (n=112) Mean (SD) or n (%)	Female (n=62) Mean (SD) or n (%)	Male (n=50) Mean (SD) or n (%)
Birth Weight (kg)	3.5 (0.4)	3.4(0.4)	3.6 (0.5)
Feeding Status at 2 Weeks			
Exclusively Breastfed	74 (73)	40 (71)	34 (76)
Feeding Status at 2 Months			
Exclusively Breastfed	66 (67)	37 (70)	29 (63)

Table 1. Maternal and infant demographics



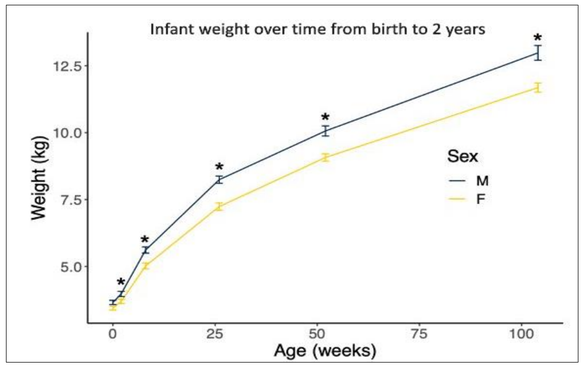


Figure 1. Average weight of infants from birth to 2 years of age by sex

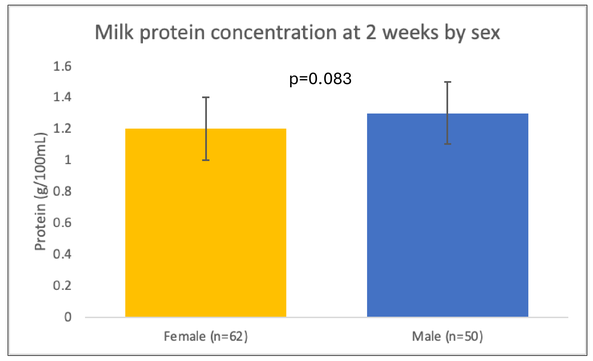


Figure 2. Differences in breast milk protein concentration at 2 weeks by sex.

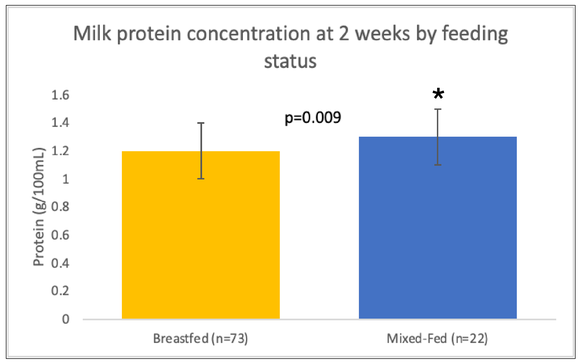


Figure 3. Differences in breast milk protein concentration at 2 weeks by feeding status

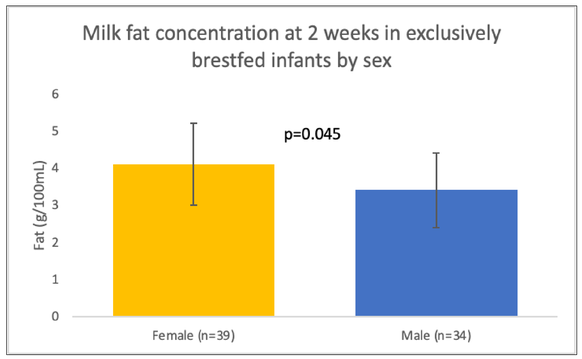


Figure 4. Differences in breast milk fat concentration in exclusively breastfed infants at 2 weeks by sex

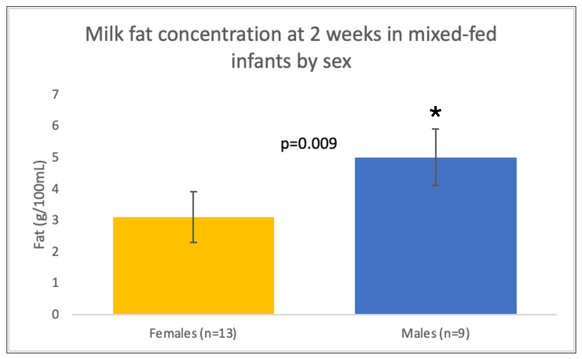


Figure 5. Differences in breast milk fat concentration in mixed-fed infants at 2 weeks by sex

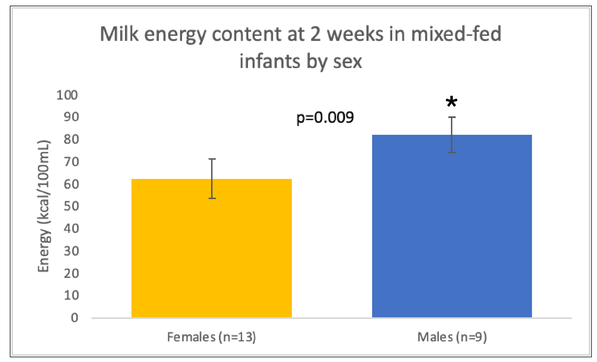


Figure 6. Differences in breast milk energy content in mixed-fed infants at 2 weeks by sex

DISCUSSION

- Breast milk macronutrient profiles differed significantly based on infant biological sex.
- Variations between exclusively breastfed and mixed-fed infants suggest potential maternal physiological adjustments or compensatory responses.
- These findings highlight early, sex-specific differences in human milk and point to dynamic, time- and feeding method–dependent impacts on infant growth.
- Further research is needed to isolate the interactive effects of infant sex and feeding modality on milk composition and clarifying the underlying biological mechanisms.

ACKNOWLEDGEMENTS

This study protocol was approved by the University of Michigan Institutional Review Board (HUM00107801).