Water-Soluble Vitamins in Human Milk: Factors Affecting Their Concentration and Their Physiological Significance

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Water-soluble vitamins are essential for the breastfed infant’s health and development, yet they are among the most susceptible to depletion in human milk when maternal status and/or intake is low. B vitamins play essential roles in cell metabolism, including DNA synthesis and regulation, fatty acid and amino acid metabolism, and gluconeogenesis, either as cofactors/coenzymes for or as precursors of these cofactors. Vitamin C serves as an antioxidant involved in tissue repair, immune system support, and interferon production. Inadequate supply of one or more water-soluble vitamins to breastfed infants can result in growth retardation, DNA damage, or metabolic defects, and affect the cardiovascular, muscular, gastrointestinal, and nervous systems. Typical deficiency syndromes in infants are beriberi (B₁), ariboflavinosis (B₂), pellagra (B₃), neural tube defects (folate), and megaloblastic anemia, growth retardation, and impaired development (B₁₂)[1].

There are natural changes in the concentrations of water-soluble vitamins in human milk over the course of lactation. While vitamins B₁ (thiamine), B₃ (niacin), and B₅ (pantothenic acid) increase throughout the course of lactation, concentrations of vitamin B₆, B₁₂, and C decrease. In contrast, vitamin B₂ (riboflavin) remains constant, as does choline after an initial increase during the first months of lactation. Folate has a unique pattern with increasing and decreasing concentrations until stabilization in late lactation.

The concentrations of most of the water-soluble vitamins are influenced by maternal status and/or supplementation. While vitamins B₁, B₂, B₃, B₅, B₆, B₁₂, choline, and vitamin C in milk are quite strongly correlated with maternal status, folate is not. A low maternal intake of animal source foods causes depletion of B₁₂ in the milk although milk B₁₂ appears to be more dependent on maternal liver stores and accumulation in the liver of the fetus. Low intake of riboflavin will also rapidly reduce
its concentration in milk since humans do not have excessive stores of this vitamin. Maternal supplementation positively affects milk concentrations of vitamins B₁, B₂, B₃, B₆, and B₁₂ (Fig. 1) but has no effect on folate. However, the efficacy of maternal supplementation postpartum is somewhat limited [2]. Other factors affecting concentrations of some water-soluble vitamin concentrations in human milk include parity, preterm delivery, diurnal variation, smoking, medication, and maternal illness.

Existing data on the concentrations of water-soluble vitamins in human milk are very limited. Most studies had few participants, some analytical methods were invalid, the vitamin status or intake of the mother was often unknown, and few studies measured concentrations longitudinally during lactation. As a result, there is substantial variation in the reported concentrations that were used to set the adequate intakes for infants and recommended intakes for lactating women. We have developed more efficient, validated methods that can now measure most of the B vitamins and their vitamers simultaneously in small volumes of milk [3]. These have revealed the large differences in concentrations among population groups around the world and enabled the efficient determination of the effects of multiple micronutrient supplements on milk vitamins. This raises the question of how to define a “low” value and is

**Fig. 1.** Percent changes in the concentrations (means ± SEM) of water-soluble vitamins in human milk after maternal supplementation compared to nonsupplemented women (100% value) at 2, 6, and 24 weeks [2]. *p < 0.05, ***p < 0.001, control vs. supplemented groups.
the goal of our ongoing study to evaluate the concentrations of vitamins (and other nutrients) in milk from well-nourished but unsupplemented women in 4 countries during the first 9 months of lactation. This Mothers, Infants and Lactation Quality (MILQ) study will establish reference values that will improve estimates of the nutrient requirements of infants and lactating women and enable the adequacy of milk nutrient concentrations to be evaluated and compared across populations.

References