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Short Report

Dehydration Among Lactating Mothers in the Amazon: A Neglected Problem

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Objectives: The purpose of this study was to compare hydration status between lactating and non-lactating women in the hot-humid Amazon.

Methods: Fifty-four women (15–81 years) from two villages at different distances to the market provided urine samples, anthropometric measurements, and health recalls. Urine samples were analyzed for urine specific gravity (USG). Bivariate and multiple linear and logistic regressions tested differences in USG and dehydration (USG $>$ 1.020) between women of different lactating status.

Results: Lactating women (1.024 g/ml; 78% dehydrated) had significantly higher USG levels ($\beta = 0.004$; $P = 0.011$) than non-lactating women (1.020 g/ml; 50% dehydrated) and were significantly more likely to be dehydrated adjusting for covariates (OR: 4.05; 95% CI 1.1–14.7).

Conclusions: Women living in hot-humid rural environments with minimal access to clean water are at greater risk of dehydration when breastfeeding. Future research should examine lactating women longitudinally and assess whether chronic dehydration affects breast milk composition. Am. J. Hum. Biol. 00:000–000, 2014.

INTRODUCTION

In 1998, Bentley made a call that has gone largely unheeded for human biologists to study the relationship between lactation and hydration. Lactating women have higher water needs because they generate on average 750 ml/day in breast milk, which is composed of 87% water (Kleiner, 1999). While the Institute of Medicine (IOM, 2004) recognizes that lactating women have greater water needs with a recommendation of 3.8 l/day, 1.1 l above the recommendations for non-lactating, non-pregnant women, little research has examined whether breastfeeding women are at greater risk of dehydration (Bentley, 1998).

The topic of dehydration for lactating women remains overlooked (Wutich and Brewis, 2014), likely because recommendations come from industrialized countries where local ecological conditions are favorable for easy rehydration through clean water and food. Yet, in developing countries, lactating women are placed at a dilemma. Exclusive breastfeeding protects infants from diarrheal diseases (Morrow et al., 2005). However, to increase water intake places the mother at greater risk of diarrhea and dehydration because the water sources available to replenish losses are often unsafe.

The lactation–hydration relationship becomes more complex in hot environments where water requirements are higher still (Sawka et al., 2005). To tackle this issue, the present article examines hydration levels of breastfeeding women in a population with little access to clean water in a hot-humid environment and a high burden of infectious disease (Rosinger and Tanner, in press; Tanner et al., 2013). I predict that lactating status will be associated with worse hydration because of the challenging environmental conditions that make it difficult to meet high water requirements.

METHODS

Fieldsite

This study took place in the Beni department of Lowland Bolivia among Tsimane' forager-horticulturalists. Approximately, 15,000 Tsimane' live in ~100 villages. Part of a larger study, this phase of the research took place in two villages, during March 2014 in village A (traditional) and April 2014 in village B (market integrated) toward the end of the rainy season. The two research communities were selected to provide variation in distance to the main market town, market participation, and lifestyle. Village A is a two-day motorized canoe ride away from the main market town of San Borja year-round and only has access to the river and stream for water. Village B is an hour car ride from San Borja during the dry season or a 2–3 h motorized canoe ride, and has access to river, stream, pond, handpumps, and well sources. A discussion of water sources and water quality available to Tsimane' has been described elsewhere (Rosinger and Tanner, in press). Exhaustive sampling was attempted in both villages, yielding a sample of 54 women ages 15+ from 50 households (Table 1). T1

Permission was granted by the Grand Tsimane' Council, community leaders, and each participant gave oral consent before data collection. The Institutional Review Board at the University of Georgia approved the study protocol (IRB #2012-10290-0).

Independent variable: Urine specific gravity and dehydration

I used urine specific gravity (USG), or the density of urine compared to the density of water, to measure hydration status. USG was analyzed using a digital handheld refractometer (Atago, Measurement accuracy ±0.001), which was calibrated daily with bottled water. While

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there is no gold standard for assessing hydration status, USG is noted as the best indicator for field measurements (Armstrong, 2007). USG ranges between 1.000 and 1.040 g/ml, and values above 1.020 are an accepted cut-off point for clinical dehydration representing ~1–3% body mass loss (Oppliger et al., 2005).

Dependent variable: Lactating status

Lactating status and number of months lactating were determined by asking women during the interview if they were breastfeeding and the age of their baby, which was confirmed with birth certificates when available.

Covariates

I used health recall, followed by doctor examinations, to assess whether each woman was experiencing diarrhea in the past week (defined as 3+ instances of watery stool in 24 h). Age was measured by asking individuals their birthdate, how old they were, and verified with a government identity card or birth certificate when possible.

Ambient temperature was measured through an indoor/outdoor wall thermometer placed in the shade at the interview site (Springfield Precision #90116). Temperature was recorded at the time of the urine sample to the nearest 0.5°C.

The height of each individual was measured using a standing stadiometer, rounded to the nearest 0.1 cm (Seca 213), and weight was measured using a Tanita Bioimpedance scale (0.1 kg) following the work by Lohman et al. (1988). BMI was calculated as kg/m^2.

Statistical analysis

Data were analyzed in Stata 13.1 (College Station, TX). USG was normally distributed in the sample. Eight pregnant women were excluded, including three who were also lactating, because their hydration needs are different. Bivariate analyses with two-way *t*-tests were performed for descriptive characteristics. I then used ordinary least squares (OLS) multiple linear and logistic regression models to assess how lactating status was associated with USG and dehydration adjusting for covariates using the variance-covariance estimator to cluster robust standard errors by household. This method accounts for potential correlation between hydration status and environmental and dietary conditions within households. Sensitivity analysis was conducted in two ways: restricting the sample to women of peak reproductive ages (15–45) and including the excluded pregnant women.

TABLE 1. Tsimane' sample characteristics and descriptive statistics of lactating and non-lactating women

	Lactating (n = 32)		Non-lactating (n = 22)	
	Mean	SD (Range)	Mean	SD (Range)
Age (years)	26.1	7.0 (15–41)	49.6*	21.3 (15–81)
USG (g/ml)	1.024	0.005 (1.016–1.034)	1.020**	0.006 (1.008–1.030)
Temperature (°C)	28.2	2.3 (23–32)	28.2	2.9 (23–36)
Months lactating	10.2	0–40	0*	0
BMI (kg/m^2)	23.6	2.5 (20.4–30.2)	25.2	5.2 (19.1–35.3)
Dehydrated (%)	78%		50%**	
Diarrhea (%)	22%		18%	
Traditional village	22%		27%	
Market integrated village	78%		73%	

*P < 0.01, **P < 0.05, using two-tailed *t*-test.

RESULTS

Lactating women were breastfeeding for a median of 10 months, with 95% of women lactating 23 months or less. Lactating women's average USG (1.024 g/ml) was significantly higher than the USG of non-lactating women (1.020) (P = 0.01; t = −2.63; two-way *t*-test). USG also increased with ambient temperature for women regardless of lactating status (Supporting Information Fig. 1). Additionally, significantly more lactating women were dehydrated than non-lactating women (78% vs. 50%; P = 0.03; *t*-test = −2.21; two-way *t*-test) (Table 1).

Results from the OLS linear regression models illustrate that after adjusting for environmental, community, and other covariates, lactating status was associated with a significant increase of 0.004–0.005 g/ml compared to non-lactating women (Table 2, Models 1–2). Similarly, T2
when dichotomizing USG, results showed that lactating women were 4 to 6.4 times more likely to be dehydrated than non-lactating women (Models 4, 5). Women from the traditional village had significantly lower USG (P =

TABLE 2. Multiple linear and logistic regression of lactating status on urine specific gravity and odds of being dehydrated among Tsimane' women

	Dependent variable					
	Urine specific gravity			Dehydrated		
Variables	OLS coefficient (Standard error)			Odds ratio (95% confidence interval)		
	1	2	3	4	5	6
Lactating (yes)	0.0037* (0.0014)	0.0045* (0.0017)	0.0047* (0.0016)	4.05* (1.11–14.71)	6.35† (0.95–42.34)	9.88* (1.13–86.81)
Temperature (°C)	0.0006* (0.0002)	0.0006** (0.0002)	0.0007* (0.0003)	1.21 (0.93–1.58)	1.26† (0.96–1.66)	1.29 (0.95–1.75)
Trad. village A (Village B ref)	−0.0050** (0.0017)	−0.0056** (0.0016)	−0.0050** (0.0017)	0.14** (0.03–0.56)	0.09** (0.02–0.47)	0.07* (0.01–0.53)
Diarrhea (yes)	–	0.0021 (0.0015)	0.0014 (0.0019)	–	2.79 (0.40–19.43)	0.76 (0.07–8.07)
Age (years)	–	0.0000 (0.0000)	0.0000 (0.0001)	–	1.02 (0.97–1.08)	1.10 (0.96–1.26)
BMI (kg/m^2)	–	−0.0001 (0.0002)	−0.0001 (0.0002)	–	0.93 (0.77–1.13)	0.79 (0.53–1.15)
Observations	54	54	42	54	54	42
R-squared	0.28	0.32	0.30	0.18[a]	0.22[a]	0.26[a]

[a]Psuedo R-squared; all models include a constant term with robust standard errors clustered by household; models 3 and 6 restrict ages to 15–45 to include peak reproductive years.
Trad: traditional; ref: reference.
*P < 0.05; $^{\dagger}P$ < 0.1; **P < 0.01.

0.005) and were 86–93% less likely to be dehydrated than women from the market integrated village (Models 1, 4–6).

When restricting the sample to women of reproductive age (Models 3, 6), associations between lactating status and USG/dehydration were stronger (β = 0.005, P = 0.011; OR = 9.8, P = 0.038). When the excluded pregnant women were included in the sample, effect sizes were larger with higher significance than those reported here (results not shown).

DISCUSSION

As Bentley (1998) and more recently Wutich and Brewis (2014) note, human biologists have an important role to play in studying the connection between lactation and dehydration, especially among chronic poverty or in locations without access to safe water. The present study answers these calls by providing evidence that lactating women living in a stressful physical environment are significantly more likely to be dehydrated than non-lactating women.

While a staggering 78% of breastfeeding women in this sample were clinically dehydrated, half of non-lactating women were also dehydrated demonstrating the difficulty of meeting the high water demands of this environment. The average USG of 1.024 for breastfeeding women in this study is higher than reports from a US sample of women before exercise (1.017) (Stover et al., 2006). Interestingly, environmental conditions had a mixed effect on hydration status: diarrhea in the previous week was not associated while hotter temperatures were related to hydration status. The village-effects were strong and indicate that certain lifestyle practices in traditional villages, such as breastfeeding intensity, may be influencing hydration levels. This result is consistent with the finding that Tsimane' women in market integrated villages breastfeed more intensively than women in traditional villages (Veile et al., 2014).

The present study is subject to two main limitations: it does not report water intake or activity patterns, which affect hydration levels. Previous research shows that a sample of Tsimane' women (not distinguishing between lactating status) consumed on average 4.4 l of water daily (Rosinger and Tanner, in press), which is higher than the 3.8 l IOM (2004) recommendation for lactating women. Therefore, while Tsimane' women on average consume more water than the IOM recommends, it still appears that in a hot-humid environment, the water intake is not sufficient for lactating women to remain well-hydrated. A year of participant observation during fieldwork suggested lactating women's activity patterns are not systematically different from non-lactating women except for the immediate weeks following pregnancy. Since the majority of women in this sample were breastfeeding more than 2 months, their activity levels would be similar to non-lactating women.

Previous research suggests breast milk composition may be buffered from maternal diet (Quinn et al., 2012). Tsimane' women's breast milk is significantly higher in $n - 3$ and $n - 6$ long-chain polyunsaturated fatty acids than US women's (Martin et al., 2012). Yet, it remains unclear whether chronic dehydration dilutes breast milk in humans as reported in cows and camels (Bentley, 1998). Future research should examine longitudinally whether lactating status creates an additive dehydrating effect over the course of breastfeeding and if it affects breast milk composition. These findings warrant further study in multiple environments and re-evaluation of water intake recommendations for this sub-population. Public health interventions should focus on providing access to clean water for lactating women.

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