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Infant Stunting Is Associated With Short Maternal Stature

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Abstract

The objectives were to determine the range of maternal height associated with growth velocity of older infants and the magnitude of this association in an indigent population. Maternal height and infant length-for-age *z* scores (LAZ) were positively correlated at both 6 (*n*=412, *r*=0.324) and 12 (*n*=388, *r*=0.335) months (*P*<0.0001) and for maternal heights from 131 to 164 cm. Maternal height is independently associated with infant LAZ and stunting (LAZ <−2) at both 6 and 12 months (*P*<0.001) and with linear growth velocity from 6 to 12 months (*P*=0.0023).

Keywords

infant growth; maternal height; stunting

The poor indigenous population of the western highlands of Guatemala is notable for the high rate of stunting in infancy (1). Also notable in the Mayan population is the severity of the maternal short stature (2). The association between low maternal height and impaired linear growth in early childhood has been well documented (3), but there are more limited data for infancy, an age that is relevant to long-term growth (4). Data derived from a study of the Mayan population in the western highlands of Guatemala, the primary outcome of which has already been reported (1), has provided the opportunity to examine the association between maternal stature and linear growth, including incidence of stunting of offspring during mid- and late infancy; determine whether an association between maternal stature and linear growth velocity is detectable in late infancy; and evaluate the range of maternal heights over which there is an association with the length of older infants.

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SUBJECTS AND METHODS

Study Design

The infant growth data for this report were the primary outcome measure of a randomized controlled trial (2). The maternal height data were obtained during the course of the trial. For convenience, a brief overview of the study design of this trial is included here.

A total of 412 infants were randomized to receive low-phytate or control maize as a complementary food from age 6 to 12 months. Within each maize group, infants were further randomized to receive a zinc supplement or placebo between 6 and 12 months. Recumbent length and weight at age 6 and 12 months were not significantly different for the 4 treatment groups (Table 1); therefore, the anthropometric data of the infants who completed the study were combined into a single group for analyses.

Subjects

The subjects were residents of the small rural town of San Juan Comalapa in the western highlands of Guatemala. Ninety-three percent were pure Maya and the remainder were of Maya-European descent (Ladino). The participants were a convenience sample of apparently healthy infants ages 6 months who were primarily breast-fed at recruitment. The parent protocol was approved by the interinstitutional ethics committee of Guatemala, the Colorado multiple institutional review board, and the ethics board at Research Triangle International. Written informed consent was obtained from all of the participants.

Length and Height Measurements

Length measurements were obtained according to World Health Organization guidelines with a calibrated Harpenden Infant-ometer (Holtain Ltd, Crosswell, Crymych, UK) and recorded to the nearest 0.1 cm. Linear growth data were converted to *z* scores using the World Health Organization Infant Growth Standards. Maternal heights (barefoot) and weights were obtained at the project headquarters from a single calibrated mechanical column scale with integrated measuring rod (model 700, Seca Corp, Hanover, MD) and recorded to the nearest 0.5 cm.

Data Analyses

Mean ($\pm$ standard deviation), median, and range of maternal heights were determined. To examine the relation between maternal height and infant length measurements at 6 and 12 months, 3 outcome variables were derived: length-for-age *z* score (LAZ); stunting, a dichotomous variable defined by LAZ < -2 ; and linear growth velocity from 6 to 12 months determined from the difference in length measurements at 6 and 12 months expressed as millimeters per month. LAZ and stunting were calculated at both 6 and 12 months. First, correlations between each of these 3 variables and maternal height were calculated. Also, for illustrative purposes, *t* tests were used to determine the difference in maternal height for subjects who were stunted (at 6 and 12 months) and subjects who were not stunted. Simple linear and logistic regression models (with LAZ and linear growth velocity as the outcomes of the former and stunting as the outcome of the latter) were then run with maternal height as the explanatory variable and sex and maternal weight (kilogram) as covariates (6-month LAZ was an additional covariate in the linear growth velocity model). Odds ratios were derived from the parameter estimates of the stunting model. All of the analyses were performed using SAS version 9.0 software (SAS Institute, Cary, NC) and significance was determined at $\alpha = 0.05$.

RESULTS

All of the 412 infants (n=101–106/treatment group) provided 6-month data; 388 of these (92–100/group) completed the 12-month data. There were no differences in anthropometric measurements between groups. The mothers had a mean ($\pm$ SD) height of 144.3 (5.1) cm and a median of 144.0 cm, ranging from 131.5 to 164.0 cm. Overall, combined-sex mean infant LAZ at 6 and 12 months were -2.09 (1.09) and -2.54 (1.12), respectively (1). Corresponding data for weight-for-age z scores were -0.95 (1.13) and -1.34 (1.09); for weight-for-length z scores were -0.66 (0.97) and 0.00 (0.92); and for body mass index z scores were 0.39 (1.02) and 0.25 (0.93). Maternal height and infant LAZ were positively correlated at both 6 ($r=0.324$) and 12 ($r=0.335$) months ($P<0.0001$). The regression model comparing infant LAZ at 6 and 12 months with maternal height showed that the positive association between infant LAZ and maternal height persisted after controlling for infant sex, maternal weight, and infant BMI (Table 1). Adjusting for these covariates, infant LAZ increased by 0.06 and 0.07 at 6 and 12 months, respectively. Boys, on average, have lower LAZs (-0.86) than girls after adjusting for maternal height at 6 and 12 months ($P<0.0001$).

The average maternal height for subjects who were stunted at 6 months (143.2 cm) was significantly less ($P<0.0001$) than the average maternal height for subjects who were not stunted (145.5 cm). The relation was similar at 12 months ($P<0.0001$).

Table 2 shows that maternal height has a significant negative association with infant stunting rates after controlling for the same covariates. As maternal height increases, the odds ratio (95% CI) for infant stunting is 0.91 (0.87–0.96) and 0.88 (0.83–0.93) at 6 and 12 months, respectively.

Linear growth velocity between 6 and 12 months was also significantly associated with maternal height, after controlling for the covariates sex, maternal weight, and 6-month LAZ in a linear regression ($P=0.002$; Table 3).

DISCUSSION AND CONCLUSIONS

The incentive for examining these data retrospectively was the high rate of stunting as early as age 6 months in the San Juan Comalapa study population (1). The mean stunting rates were 64.7% for boys and 33.5% for girls. The correlation between maternal height and offspring infant length was modest but nevertheless makes a discernible contribution to our understanding of the early onset of linear growth failure in this indigenous population. That the remarkably short statures reported here are attributable at least primarily to environmental factors is suggested strongly by the differences in stature within 1 generation observed in Mayan Guatemalan families who have immigrated into the United States (5). The 4-village Orient studies in eastern Guatemala indicate that suboptimal nutrition is a major environmental factor determining the growth of young indigenous children in Guatemala (6).

In conclusion, the present report focuses specifically on mid-to-late infancy. Further to the outstanding data at age 6 months, the positive association between LAZ at 6 and 12 months, linear growth velocity between 6 and 12 months, and maternal height, independent of infant length at 6 months, suggest that the uncertain biological pathways linking maternal stature and offspring's linear growth continue to affect the latter through late infancy. The present study also emphasizes the broad range of maternal heights that affect infant length.

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TABLE 1

Results of regression model comparing length-for-age z score to maternal height controlling for sex, maternal weight, and infant BMI by infant age

	Infant age, mo			
	6		12	
	Estimate	P *	Estimate	P *
Intercept	−11.33	<0.0001	−15.23	<0.0001
Maternal height, cm	0.06	<0.0001	0.07	<0.0001
Sex				
Male	−0.86	<0.0001	−0.88	<0.0001
Female	0		0	
Maternal weight, kg	0.01	0.0848	0.01	0.1100
Infant BMI, kg/m ²	0.13	<0.0001	0.16	<0.0001

BMI = body mass index.

* F test tests null hypothesis that regression estimate = 0.

TABLE 2

Results of logistic regression model comparing stunting to maternal height controlling for sex, BMI, and maternal weight by infant age

	Infant age, mo			
	6		12	
	Odds ratio (95% CI)	$P(\chi^2)^*$	Odds ratio (95% CI)	$P(\chi^2)^*$
Intercept	—	—	—	—
Maternal height, cm	0.91 (0.87–0.96)	0.0003	0.88 (0.83–0.93)	<0.0001
Sex				
Male	4.23 (2.73–6.57)	<0.0001	3.80 (2.33–6.20)	<0.0001
Female	—	—	—	—
Maternal weight, kg	0.98 (0.95–1.00)	0.0917	0.98 (0.95–1.00)	0.0931
Infant BMI, kg/m ²	0.80	0.0015	0.68	<0.0001

BMI = body mass index; CI = confidence interval.

* χ^2 , F test tests null hypothesis that regression estimate = 0.

TABLE 3

Results of regression model comparing linear growth velocity (millimeter/month) to maternal height controlling for sex, length-for-age z score, BMI, and maternal weight

	6–12 Mo	
	Estimate	P *
Intercept	−2.308	0.4894
Maternal height, cm	0.072	0.0012
LAZ at 6 mo	−0.063	0.5531
Sex		
Male	−0.234	0.2731
Female	—	—
Maternal weight, kg	−0.005	0.6576
Infant BMI at 6 mo, kg/m ²	0.182	0.0039

BMI = body mass index.

* F test tests null hypothesis that regression estimate = 0.