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Zinc Supplementation Affects the Activity Patterns of Rural Guatemalan Infants[1,2,3]

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ABSTRACT Zinc deficiency has been associated with growth deficits, reduced dietary intake and appetite, and has been hypothesized to result in reduced activity. This randomized, double-blind, placebo-controlled study examined whether 10 mg of oral zinc as zinc sulfate, given daily for up to 7 mo, affected activity patterns of 85 Guatemalan infants recruited at 6–9 mo of age. Infant activity was assessed by time sampling-observation method at 10-min intervals during a 12-h data collection period, at base line, 3 and 7 mo follow-up. Motor development and the percentage of time infants were observed in various positions (being carried, lying down, sitting, crawling, standing or walking) and engaged in various activities (eating, sleeping, resting, crying/whining or playing) were compared by treatment group. No differences in motor development were observed by treatment group. However, at follow-up 2 (after 7 mo of supplementation), zinc-supplemented infants were significantly more frequently observed sitting up compared with lying down, and were playing during 4.18 ± 1.95% ($P < 0.05$) more observations than unsupplemented infants. They were also somewhat less likely to be observed crying or whining ($P < 0.10$) compared with those receiving the placebo. These effects are independent of other factors including infant age, motor development, sex, maternal education, family socioeconomic status and nutritional status at base line. Further research must be conducted to determine the long-term developmental importance of these differences in activity patterns associated with zinc supplementation in this setting. J. Nutr. 127: 1333–1338, 1997.

KEY WORDS: • *zinc* • *activity* • *motor activity* • *infant development* • *growth* • *humans*

In rural Guatemala, the best sources of zinc in the food supply (meat and animal products) are often prohibitively expensive, and absorption of zinc from foods of plant origin is inhibited because of their high phytate content (Solomons et al. 1979a and 1979b). It is highly likely, therefore, that at least mild zinc deficiency is a problem among infants and young children in Guatemala.

The association of zinc deficiency with poor growth is supported by a large number of animal studies and a smaller number of human studies (Allen 1994, Walsh et al. 1994). Trials of zinc supplementation have shown that rates of growth can be enhanced (Dirren et al. 1994, Gibson et al. 1989, Golden and Golden 1981, Walravens et al. 1989, Xue-Cun et al. 1985). Further, zinc plays a role in nutritional rehabilitation from severe malnutrition (Khanum et al. 1988, Simmer et al. 1988).

Zinc deficiency has been associated with poor appetite and reduced dietary intake among infants (Hambidge et al. 1972), but few human experimental studies have assessed the effect of zinc supplementation on behavioral outcomes (Golub et al. 1995). Two experimental studies of moderate zinc deficiency in infant and juvenile rhesus monkeys showed reduced motor activity over a 15-wk period (Golub et al. 1984 and 1985). Friel et al. (1993) assessed infant motor development in very low birth weight infants and found higher developmental scores among those fed a zinc-fortified formula compared with those fed a nonfortified formula. Reduced exploration and motor activity have been hypothesized to be directly related to cognitive and developmental delays (Pollitt 1969), but the role of zinc in this process is unknown. Recently Sazawal et al. (1995) reported higher activity scores associated with zinc supplementation in children 12–24 mo of age living in a periurban community of north India.

As part of a randomized controlled trial of zinc supplementation among 6- to 9-mo-old infants in Guatemala, we assessed whether zinc supplementation would improve the activity levels of infants. In this study, zinc supplementation reduced the incidence of diarrheal morbidity by 22%, with stronger effects among males and among infants with low weight-for-height at base line (Ruel et al. 1997). Overall, there was no effect of

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zinc supplementation on infant growth over the 7-mo study period; however, among infants who were stunted at base line, those receiving zinc grew 1.4 cm more on average than control infants (Rivera et al. 1995).

MATERIALS AND METHODS

The study was conducted in Santa María de Jesús, Guatemala. Following a census of the community, 108 children aged 6–9 mo were recruited to participate in the study. Each child was randomized at enrollment to receive a 4-mL supplement containing either 10 mg zinc as zinc sulfate or placebo. These were delivered orally by a fieldworker during daily home visits over the 7-mo follow-up period. The supplements were indistinguishable, and neither the families nor the study staff were aware of the treatment group to which the infants belonged. At enrollment, and after 3 and 7 mo of supplementation, child activity patterns were assessed. Informed consent was obtained from a parent of the study infant, and the study design and protocol were approved by the Institutional Review Boards of The Johns Hopkins University, the Institute of Nutrition for Central America and Panama, and the University of California, Davis.

A total of 108 infants were enrolled in the study. There were 19 drop-outs, due to migration out of the village, mothers' work constraints or refusal. Two children did not complete the study because of late enrollment, and two more children were found to have unreliable data and are not included in the analyses. Therefore, the analytic sample consisted of 85 children, with 43 in the zinc group, and 42 in the placebo group. The sample size of this study was fixed by the sample size of the main study, which was designed to assess the effect of zinc supplementation on infant growth. With this sample size and conducting child-level analyses as presented here, we would be able to detect as statistically significant differences in activity patterns between the treatment groups of about 0.5 SD.

Infant activity was assessed by time sampling-observation method over a 12-h, in-home data collection period (Torún 1984). The full-day observation was conducted at base line (before zinc supplementation) and at each of the two follow-up visits, when the infants were 6.9 ± 0.9, 10.1 ± 1.3 and 14.5 ± 1.7 mo old, respectively. The activity patterns of the infants were observed on days when they were free of symptoms of diarrhea or acute respiratory infections. Five observers were trained in the observation method over the course of 1 mo, and data collection did not begin until interobserver agreement was >90% for all paired observations. Previous use of the instrument in this setting suggested that reliability did not diminish over time. Data collectors were unaware of the household randomization. Ongoing supervision and monitoring throughout the data collection period assured reliability of the measures for the duration of the study.

Each observer recorded specific, precoded activities on a datasheet at 10-min intervals, resulting in ~72 activity observations per 12-h d per infant, for a total of >6000 observations per follow-up visit. The exact activity and position observed at each 10-min interval were coded. The first observation occurred at the moment the data collector arrived at the household (~0600 h) and was able to observe the infant. Thereafter, preset wristwatch alarms alerted the data collector to record infant position and activity data every 10 min. Positions included the following: being carried, lying down, sitting, crawling, standing, walking and running/jumping, whereas activities included the following: playing, sleeping, resting (or doing nothing), crying/whining, breastfeeding/eating and dressing/bathing. Play was operationalized as an infant interacting with his or her environment, such as playing with objects, people or with self (e.g., moving hands in play, singing or touching), and could occur in any position. Play was coded by the observer, depending on the level of physical exertion of the child (little or much); because we were interested in play as a developmental behavior, we combined the two levels of play into one category for analyses. To describe the levels and patterns of daily activities of infants in the study, we summarized the percentage of observations over the 12-h period that each infant spent in each of the positions and activities listed above.

Because activity patterns in this age group are dependent on motor development, we also classified infants at each time point as to whether or not they had achieved specific motor milestones (sitting, crawling, standing and walking). To do this, we determined whether they were ever observed to be sitting, crawling, standing or walking over the 12-h observation period. We also considered children to have achieved specific milestones if *1*) they had achieved them in a previous time point or *2*) they had achieved a more advanced motor milestone. Thus, a child observed sitting was presumed to be able to sit at subsequent time periods, a child observed walking was presumed to be capable of sitting, crawling, and standing even if we did not directly observe them sitting, crawling or standing over the follow-up period, and a child who was observed either crawling or standing was presumed capable of sitting.

During analyses, the effects of zinc supplementation on motor development and child activity levels and patterns were evaluated. The proportions of children in each treatment group achieving each motor milestone were compared, as were the distributions of the percentage of observations devoted to each position and activity at each time point. For position variables that were not normally distributed, statistical tests were performed after transforming the data using a square root function. The distributions of each activity were compared after stratifying at each time point depending on the level of infant motor development (e.g., can stand, yes or no). Characteristics of the children by treatment group were also compared at each time point. Analysis of co-variance techniques were then used to examine the effects of zinc supplementation on child activity levels after adjusting for other covariates. The covariates considered during analyses included exact age at follow-up (mo), sex (1 = male), nutritional status at base line (height-for-age Z-score; stunted (< −2 SD) vs. not stunted), child activity level at base line (%), level of compliance with treatment over the study period (<85% days supplemented vs. ≥85%), time in study (mo), percentage of observations recorded inside the house, percentage of observations in which the child was cared for by each of three groups of caretakers (self or another child; mother, other adult), percentage of observations infant was carried, maternal years of schooling category and family socioeconomic status (SES) category. Characteristics of the family's household were combined using Guttman scale techniques to form an SES index, which consisted of three dichotomous items describing the floor and wall construction of the house and whether or not the family had access to electricity. The functional forms of all variables were determined on the basis of subject matter and performance during exploratory analyses.

Because other zinc supplementation studies have found treatment effects to vary depending on specific characteristics of children, such as greater effects among males compared with females (Krebs et al. 1984, Walravens et al. 1983) and among more malnourished infants (Rivera et al. 1995, Sazawal et al. 1995), specific characteristic × treatment group product terms (e.g., sex × treatment) were tested for inclusion in the multivariate models to determine whether the effects of zinc supplementation on child activity scores were stronger or weaker among specific subgroups of children. Specifically, we tested whether the effects of supplementation varied depending on the sex of the child, their initial age, activity level and nutritional status [stunted (< −2 SD) vs. nonstunted] at base line, their level of compliance with treatment (<85% days in study supplemented vs. ≥85%), the duration of the study (mo), and their exact age (mo) and level of motor development at follow-up (sit, crawl, stand or walk). Main effects were considered significant at the 0.05 level, but because we were interested in identifying interaction terms if they were present and because of limitations in sample size, interaction terms were considered significant at a 0.15 level.

RESULTS

Infant characteristics at enrollment were compared by treatment group (Table 1). Age, length, weight and breastfeeding status did not differ between the two groups. The zinc-supplemented group tended to have more boys ($P < 0.10$) and to have mothers with more years of schooling than the placebo group ($P < 0.10$). Because of these trends, we explicitly included these factors in the multivariate models.

The distributions of infants observed achieving specific motor milestones at the three time intervals did not differ by

TABLE 1

Characteristics of infants by treatment group

Characteristic	Placebo (n = 42)	Zinc (n = 43)
Age, *mo*	6.9 ± 0.9	6.9 ± 0.9
Length, *cm*	62.5 ± 3.1	63.1 ± 3.2
Weight, *kg*	7.0 ± 1.0	7.0 ± 0.8
Height-for-age Z-score	−2.1 ± 1.1	−2.0 ± 1.0
Weight-for-height Z-score	.09 ± 1.0	0.6 ± 0.9
Weight-for-age Z-score	−1.0 ± 1.1	−1.1 ± 0.8
Male, %	42.9	62.8
SES[1], %		
0	14.3	11.6
1	40.5	53.5
2	28.6	11.6
3	16.7	23.3
Breast fed, %	100.0	100.0
Maternal education, %		
0 y	76.2	53.4
1–4 y	16.7	32.6
5+ y	7.1	14.0
Time in study, *mo*	7.5 ± 1.4	7.7 ± 1.2
Compliance, %	95.2 ± 4.5	93.5 ± 5.4

[1] Socioeconomic status was defined by characterizing household items and using Guttman scale techniques to form an SES index.

treatment group (Table 2), with the exception of whether the infants could crawl at base line. More infants in the placebo group were observed crawling at base line, compared with the zinc group (P = 0.06), but this difference disappeared by follow-up 1.

Presented in Table 3 and Table 4 are the distributions of percentage of times infants were observed in selected activities and positions, by treatment group and follow-up interval. These activities and positions account for >90% of the observations at each time point. As shown, these Guatemalan infants were observed playing one quarter to one third of the time. Over the study period, the infants were less frequently observed sleeping and resting (or doing nothing), but at follow-up 2, when they were 14.5 ± 1.7 mo of age, they were still observed to be sleeping or resting one third of the time. Strikingly, the infants were observed being carried nearly two thirds of the time at base line and still carried nearly 45% of the time at follow-up 2.

There were no observed differences in activities associated with treatment group at base line or follow-up 1; however, at

TABLE 2

Distributions of motor milestones at each time point in Guatemalan infants administered zinc or placebo for 7 mo[1]

Milestone	Time point	Zinc (%)	Placebo (%)	P value[2]
Sit[3]	Base line	65.1	73.8	0.38
	F1	97.7	92.9	0.29
	F2	100.0	100.0	—
Crawl[4]	Base line	7.0	21.4	0.06
	F1	62.8	69.1	0.54
	F2	93.0	90.5	0.67
Stand[5]	Base line	44.2	33.3	0.31
	F1	88.4	78.6	0.22
	F2	97.7	90.5	0.16
Walk	Base line	4.7	2.4	0.57
	F1	32.6	33.3	0.94
	F2	69.8	66.7	0.76

[1] Children were 6.9 ± 0.9, 10.1 ± 1.3 and 14.5 ± 1.7 mo at baseline, first follow-up (F1) and second follow-up (F2), respectively.

[2] P value comparing zinc vs. placebo group, using a chi-square test.

[3] Children ever observed (over the 12-h period) sitting, crawling, standing, or walking.

[4] Children ever observed (over the 12-h period) crawling or walking.

[5] Children ever observed (over the 12-h period) standing or walking.

TABLE 3

Distributions of percentage of observations over each 12-h time period attributed to selected activities in infants administered zinc or a placebo for 7 mo[1]

Variable	Time period	% of Observations		P value[2]
		Zinc	Placebo	
Playing	Base line	26.3 ± 11.8	25.8 ± 9.3	0.84
	F1[3]	33.2 ± 10.5	31.6 ± 10.1	0.48
	F2	37.3 ± 9.1	33.8 ± 10.8	0.10
Eating	Base line	14.0 ± 5.2	13.3 ± 5.2	0.53
	F1	15.1 ± 5.0	16.1 ± 4.5	0.34
	F2	14.9 ± 4.1	15.2 ± 4.7	0.77
Sleeping	Base line	25.5 ± 9.4	25.1 ± 9.7	0.83
	F1	21.1 ± 7.2	22.1 ± 7.4	0.51
	F2	18.3 ± 8.1	19.6 ± 7.9	0.48
Resting or doing nothing	Base line	24.2 ± 11.4	26.5 ± 7.9	0.27
	F1	20.8 ± 9.6	20.5 ± 7.4	0.88
	F2	18.5 ± 8.5	18.8 ± 9.7	0.88
Crying or whining	Base line	8.4 ± 5.2	8.2 ± 5.3	0.86
	F1	7.2 ± 4.3	7.7 ± 4.3	0.58
	F2	7.4 ± 3.9	8.7 ± 4.4	0.14

[1] Values are means ± SD.

[2] P value comparing zinc vs. placebo group, using a t test.

[3] F, follow-up.

TABLE 4

Distribution of percentage of observations over each 12-h time period attributed to selected positions in Guatemalan infants administered zinc or placebo for 7 mo[1]

Variable	Time period	% of Observations		P value[2]
		Zinc	Placebo	
Being carried	Base line	68.3 ± 18.7	64.5 ± 21.8	0.39
	F1[3]	59.8 ± 21.8	64.2 ± 18.6	0.32
	F2	42.3 ± 19.7	44.2 ± 22.6	0.67
Lying down[4]	Base line	23.1 ± 16.9	21.4 ± 19.6	0.45
	F1	10.6 ± 9.2	10.6 ± 12.8	0.81
	F2	9.4 ± 8.6	12.8 ± 10.7	0.10
Sitting[4]	Base line	5.3 ± 7.4	9.3 ± 12.2	0.16
	F1	17.0 ± 12.7	14.5 ± 9.1	0.65
	F2	24.8 ± 11.5	19.0 ± 11.4	0.02
Standing[4,5]	Base line	6.7 ± 8.4	12.7 ± 11.7	0.09
	F1	10.2 ± 9.3	9.8 ± 9.9	0.85
	F2	14.6 ± 9.2	15.5 ± 12.4	0.98

[1] Values are means ± SD.

[2] P value comparing zinc vs. placebo group, using a t test.

[3] F, follow-up.

[4] The t test was performed following a square-root transformation of the data.

[5] Among those observed standing at each time point: 33, 65 and 80 children at base line, F1 and F2, respectively.

TABLE 5

Adjusted effects on selected activities and positions of Guatemalan infants after 7 mo of administration of zinc or placebo

	% Observations spent			
Variable	Playing B (SEM)	Crying[1] B (SEM)	Sitting[2] B (SEM)	Lying down[2] B (SEM)
Intercept	53.14* (9.21)	9.49* (0.83)	6.98* (0.64)	2.86 (0.67)
Male infant	3.57 (1.91)	−1.18 (0.95)	0.20 (0.27)	−0.24 (0.30)
Maternal education[4]				
1–4 y	1.18 (2.28)	0.29 (1.12)	−0.51 (0.31)	0.86* (0.33)
5+ y	−2.66 (3.21)	0.01 (1.57)	−1.20* (0.43)	0.42 (0.46)
Being carried, (%)	−0.23* (0.05)	—	−0.04* (0.01)	−0.05* (0.01)
In house, (%)	—	—	−0.02 (0.01)	−0.03* (0.01)
Zinc supplement	4.18* (1.95)	−1.58 (0.95)	0.83* (0.26)	−0.81* (0.27)

1 Crying or whining.
2 Analyses performed following square root transformation of variable.
3 Abbreviations used: B, beta coefficient; SEM, standard error.
4 Zero years of schooling treated as reference group.
* $P < 0.05$.

follow-up 2, zinc-supplemented infants were somewhat more frequently observed in play ($P = 0.10$), and less frequently observed crying or whining ($P = 0.14$). At base line, infants in the placebo group were somewhat more frequently observed sitting and standing than those in the treatment group. The differences in percentage of observations standing were no longer evident at follow-up 1 and 2. At follow-up 2, zinc-supplemented infants were more frequently observed sitting ($P = 0.02$), and, congruent with this finding, were somewhat less likely to be observed lying down than infants receiving the placebo ($P = 0.10$). There were no differences in the percentage of observations of infants crawling or walking (not shown).

To examine the effect of zinc supplementation after adjusting for infant sex and maternal years of schooling and other potentially confounding factors, we developed multiple linear regression models to describe variation in time spent playing, crying, sitting and lying down. There were no effects of zinc supplementation at follow-up 1, after 3 mo of supplementation. Presented in **Table 5** are the results for follow-up 2, after 7 mo of supplementation. After adjusting for multiple covariates, zinc-supplemented infants were estimated to spend 4.18 ± 1.95% more time in play than infants receiving the placebo. Zinc-supplemented infants tended to be observed crying less frequently at follow-up 2 compared with those receiving the placebo ($P < 0.10$). Treatment differences in observed frequency of sitting and lying down were statistically stronger after adjustment. Zinc-supplemented infants were more frequently observed sitting up and less frequently observed lying down at follow-up 2 than infants receiving the placebo. No significant treatment × covariate interactions were observed in any of these models, indicating that the effects of zinc supplementation on activity patterns were not dependent on infant age, sex, initial nutritional level or level of motor development at follow-up 2.

DISCUSSION

The results of this study indicate differences in activity patterns among 6- to 9-mo old infants who were supplemented daily with 10 mg zinc as zinc sulfate over 7 mo. After supplementation, zinc-treated infants were more likely to be observed sitting up and involved in play and less likely to be observed lying down than infants receiving the placebo. No other differences in activities between groups were observed except that zinc-supplemented infants were somewhat less likely to be observed crying ($P < 0.08$). These differences remained after adjusting for covariates and confounding factors, including infant sex and motor development, exact age at follow-up, nutritional status at base line, identity of caretaker, percentage of time the infant was carried, percentage of time spent inside the house, level of maternal education and family SES.

The present study has several strengths that provide confidence in the results, including the following: *1*) the randomized and double-blind design; 2) the natural environment within which the observations took place to assess activity patterns; 3) the use of highly trained observers and multiple checks on data quality; 4) the use of an instrument to assess infant activity that was previously developed for use in Guatemala; and 5) a thorough analysis that controlled for a number of possible confounders and considered whether effects were present only among specific subgroups within the study sample or dependent upon subject-specific characteristics.

Findings of this study are consistent with a small number of previous studies that have shown increases in activity levels or motor development associated with zinc supplementation. In a study of infant locomotor activity among rhesus monkeys whose pregnant and lactating mothers were marginally zinc deprived through dietary manipulation (4 μg/g diet compared with 100 μg/g diet), Golub et al. (1985) found that the males in the zinc-deprived group had lower plasma zinc and lower activity scores compared with monkeys whose mothers had adequate zinc nutriture. However, this relationship was also associated with an initial rapid linear growth among the zinc-deprived group, who grew in length nearly five times as much as the control group during the first month of life. Over the following 5 mo, both males and females in the zinc-deprived group grew at the same rate. In our study sample, zinc supplementation was associated with increased growth only among those infants who were stunted at base line (Rivera et al. 1995); however, we found no suggestion that our observed effects of zinc supplementation on activity patterns were dependent on level of stunting at base line. Because of the literature suggesting that males respond more favorably to zinc supplementation (Golub et al. 1984, 1985 and 1995), we also tested for sex differences, and although males were more frequently observed in play, we found no differences in treatment effects on activity patterns between males and females. In a study of low birth weight infants, Friel et al. (1993) found that, in addition to higher plasma zinc levels and increased linear growth, zinc-supplemented infants scored higher on the locomotor development portion of the Griffiths Mental Development Scales (Griffiths 1976) at 3, 6, 9 and 12 mo of age.

Sazawal et al. (1996) reported a positive effect of zinc supplementation on activity scores among infants 12–24 mo of age in a periurban community of north India. In this randomized trial, a 6 d/wk oral dose of 5 mL of zinc gluconate (10 mg elemental zinc) was administered for 6 mo with double doses given during diarrheal episodes. The instrument used to assess activity was identical to our Guatemalan instrument; however, infants were observed every 10 min for 5 h/d on two consecutive weekdays, and the data from 2 d were combined to compute activity level scores. The scores were based on the Children's Activity Rating Score (CARS) (Puhl et al. 1990) and on the estimated energy cost of each category of activity (Torún 1984). Zinc-supplemented children were observed to spend, on average, 3.4% more time in "high movement" activities. Further, the CARS score was 14.6% higher and the energy expenditure score was 8.3% higher, compared with the placebo group. The effects were greater among male infants and among stunted infants, although the latter was not significant (data not shown). Sazawal's analysis reflects an assessment of changes in motor activity due to zinc supplementation, whereas our study examined activity patterns of the infants, focusing on specific activities and positions, thus combining aspects of both infant motor and behavioral development. The scoring system used by Sazawal is not appropriate for our younger age group. However, there are other differences between the two studies that should be noted. In the north Indian study, infants were less active and were carried much less often than the Guatemalan infants. Although stunting among infants was similar (about 50%), nearly 12% of Indian infants were wasted, reflecting a higher degree of malnutrition than in the Guatemalan infants.

We were also able to examine whether zinc-supplemented infants were observed achieving specific motor milestones at earlier ages and whether they were more frequently observed performing them, compared with the placebo group. We found no effects of zinc supplementation on either the timing of achievement of motor milestones or on the amount of time infants spent on these specific motor activities with the exception of sitting at follow-up 2 as already discussed.

One limitation of the present study is the lack of data on biochemical indicators of zinc status at base line and during follow-up. Because of cultural constraints, it was not possible to collect blood from this age group in this rural setting. In a study of periurban Guatemalan elementary schoolchildren, Cavan et al. (1993) found suboptimal zinc status (<1.68 μmol zinc/g hair) among 55% of the children, and low plasma zinc (<10.71 μmol/L) among 12.3% of males. Further, the early growth faltering among infants in our study (half falling below −2 Z-scores at base line), combined with the known low zinc availability in the Guatemalan diet (Solomons 1979a and 1979b), suggests that these rural Guatemalan infants were zinc deficient to some degree. However, the best evidence we have that infants in our study were zinc deficient initially are the other results reported from the trial, which showed an improvement in growth (Rivera et al. 1995) and a reduction in morbidity (Ruel et al. 1997) with zinc supplementation.

It is interesting to note just how inactive these infants appeared to be. Even at follow-up 2, when the infants were 14.5 ± 1.7 mo old at the time of the 12-h observation period, they spent one third of their time sleeping or resting, and another third of their time playing. Further, they were observed to be carried nearly 45% of the time, which likely restricts their movement, because in this setting, infants are strapped to the backs of their mothers or caretakers. Our results verified that the percentage of observations during which an infant was carried negatively influenced the amount of time they spent in play ($P < 0.05$). Our study infants were less active and were carried more than those in a study reported by Engle and Zeitlin (1994) among 12- to 18-mo-old Nicaraguan children, although the stunting within their sample was only 28%. Our results suggest that 7 mo of zinc supplementation had a positive and significant effect on observed infant activity patterns. The relationships were observed only at the second follow-up (7 mo), suggesting either that they are the result of longer duration supplementation or that our measures of infant activity are not sufficiently sensitive to pick up differences at the first follow-up. An absolute increase in the frequency of play of 4% may seem small, but it signifies a 0.40 SD shift in activity patterns associated with zinc supplementation. Because this is one of the first human studies of zinc nutriture and infant activity and other developmental indicators, it is difficult to judge the public health importance of increased play in this age group. Children receiving nutritional supplementation in the first 3 y of life as part of the INCAP Longitudinal Study did have improved cognitive development, including motor milestones, and these effects persisted into adulthood (Pollit 1993). Thus, the increase in frequency of play in our study should be viewed as encouraging and could be meaningful for developmental or cognitive outcomes in the long term (Neisser 1991, Siegel 1992). More research, conducted in a variety of settings and in which both available dietary zinc and base-line zinc nutriture vary, is needed to answer these questions.

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