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PHOSPHORUS AND MAGNESIUM BALANCE OF ADOLESCENT FEMALES
FED TWO LEVELS OF ZINC

J. L. GREGER, J. HUFFMAN, R. P. ABERNATHY, O. A. BENNETT and S. E. RESNECK

ABSTRACT
Utilization of phosphorus and magnesium by 11 girls (12.5–14.2 yr of age) was measured during a 30-day period in which two different levels of zinc (11.5 and 14.7 mg daily) were fed. The former level is similar to that consumed usually by adolescent females; the latter level is similar to the Recommended Dietary Allowance for zinc. Apparent retention of phosphorus was reduced significantly (p < 0.02) when subjects were fed the higher level of zinc. Both urinary and fecal phosphorus levels were greater, but not significantly greater, when subjects consumed the higher level of zinc. The variations in dietary zinc levels had no effect on magnesium utilization.

INTRODUCTION
SEVERAL INVESTIGATORS have reported finding Americans who were in poor nutritional status in regard to zinc (Greger, 1977; Hambidge et al., 1972, 1976; Henkin et al., 1974; Porires et al., 1967; Sandstead, 1973). Before programs to increase dietary zinc levels are implemented, the effect of varying dietary zinc levels on the use of other nutrients needs to be studied thoroughly. In animal studies and in vitro preparations, zinc has been demonstrated to be antagonistic to the absorption of other minerals (Magee and Matrone, 1960; Murthy et al., 1974; Van Campen and Scaife, 1967). During severe dietary zinc deficiency, animals have been found to lose excessive amounts of nitrogen in the urine (Hsu and Anthony, 1975). Chu and Cox (1972) observed decreased amounts of phosphorus containing compounds in the tissues of animals fed high levels of zinc. However, the effect of moderate alterations in dietary zinc levels on the utilization of other nutrients by human subjects has received limited attention (Greger et al., 1978a, b; Hess et al., 1977; Keltz et al., 1978; Meiners et al., 1977; Tamura et al., 1978).

The purpose of this study was to determine if moderate alterations in dietary zinc levels resulted in changes in the utilization of phosphorus and magnesium by adolescent females.

METHODS

Subjects
Eleven girls, between 12.5 and 14.2 yr of age, agreed to participate in a 30-day metabolic study. Parental approval was obtained. All subjects were given a routine physical examination by a physician with urine analysis prior to their participation in the study. All procedures used in this investigation were approved by Purdue University’s committee on the use of human subjects.

The subjects’ mean height was 158 ± 7 (SD) cm; their mean weight was 52.5 ± 13.6 kg. Six of the subjects had already experienced menarche.

The experimental design
The subjects were split randomly into two groups. During period 1, the first 14 days of the study, group A was fed 11.3 ± 0.8 mg zinc daily (Diet Z11.5) and group B was fed 14.5 ± 0.8 mg zinc daily (Diet Z14.7). During period 2, the last 16 days of the study, group A was fed 14.8 ± 1.1 mg zinc daily (Diet Z14.7) and group B was fed 11.6 ± 1.1 mg zinc daily (Diet Z11.5). The higher levels of dietary zinc were achieved by adding a zinc sulfate solution (donated by Mericon Industries, Inc., Peoria, IL) to the lemonade served at lunch to subjects.

Experimental diet
A 6-day cycle menu containing foodstuffs typical of adolescent food patterns was served throughout the study. The diet was calculated by computer using U.S. Department of Agriculture food composition tables (Wat and Merrill, 1963) and nutrition information supplied by companies to contain 100% of the Recommended Dietary Allowances (RDA) (Food and Nutrition Board, 1974) for 11–14 yr old girls of energy, protein, vitamins A, B, and C, thiamin, riboflavin, niacin, and iron. More details on the diets were given in a previous paper (Greger et al., 1978d).

When similar menus were fed previously, the level of magnesium was found to be low (Greger et al., 1978b). Hence, the girls were given 25 mg of magnesium in the form of magnesium gluconate at each meal. The diet was determined by analysis to contain 1049 ± 50 mg calcium, 906 ± 92 mg phosphorus, 271 ± 22 mg magnesium daily in period 1 and to contain 1058 ± 112 mg calcium, 946 ± 130 mg phosphorus, and 281 ± 26 mg magnesium daily in period 2.

Analyses
Phospholipid markers of brilliant blue were given to subjects on days 5 and 14 during period 1 and on days 19 and 28 during period 2. Fecal composites for the two periods were prepared accordingly. Acidified urine samples were pooled for each period also. Food was composited on a daily basis.

Food and fecal samples were ashed as described by Osis et al. (1972). The magnesium content of the ashed samples and of urine samples diluted with 0.5% strontium chloride were determined by atomic absorption spectrophotometry. The recovery of magnesium added to three food samples that were processed in this manner ranged from 96–99%. Phosphorus content of ashed fecal and food samples and diluted urine samples were determined spectrophotometrically by a modification of the Fiske and Subbarow procedure (Lindberg and Ernst, 1956). The recovery of phosphorus added to three food samples that were processed in this manner ranged from 93–96%.

Fecal and food composites were analyzed for dry matter content. Duplicate aliquots of the composites were dried in a vacuum oven at 70°C for at least 6 hr and dry matter content of samples was calculated.

All statistical analyses were done by computer utilizing the Statistical Package for the Social Science program (Nie et al., 1975). Paired “t” were used to evaluate differences between treatments (Steel and Torrie, 1960).

RESULTS & DISCUSSION

THE RETENTION of phosphorus by ten of the eleven subjects was less (p < 0.02) when the subjects fed Diet Z14.7 rather than Z11.5 (Table 1). In a previous study with adolescents, we observed no significant effect of dietary zinc levels on phosphorus retention (Greger et al., 1978b).

However, in the previous study, the subjects did not serve as their own controls which caused some loss of sensitivity. The mechanism by which zinc affected phosphorus utilization is unclear. Subjects lost slightly, but not signifi-
Table 1—Phosphorus excretion and retention of adolescent females fed two levels of zinc.

<table>
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- Urinary losses
- Fecal losses
- Apparent retention = dietary intake – fecal losses – urinary losses
- Standard deviation

Table 2—Magnesium excretion and retention of adolescent females fed two levels of zinc.

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- Urinary losses
- Fecal losses
- Apparent retention = dietary intake – fecal losses – urinary losses
- Standard deviation

Significantly, more phosphorus in both their urine and feces when fed Diet Z14.7 rather than Diet Z11.5.

Fecal phosphorus losses in this study tended to be somewhat higher than fecal phosphorus levels reported in other studies in which subjects were fed between 800–1000 mg phosphorus daily (Greger et al., 1978b; Leverton et al., 1962; Spencer et al., 1978). There are several possible explanations. The diet contained slightly more calcium than phosphorus. Spencer et al. (1978) observed somewhat increased fecal phosphorus losses as dietary calcium levels were increased. The diet contained the level of nitrogen in the RDA (Food and Nutrition Board, 1974). This is a lower level of protein than adolescent females generally consume (Greger et al., 1978c). Absorption of several minerals is reduced when dietary protein levels are lowered (Schwartz et al., 1973; Walker and Linkswiler, 1972; Van Campen and House, 1974).

The magnesium intake of the subjects in this study was about 90% of the Recommended Dietary allowance for magnesium (1974) and was about 50 mg daily greater than estimated usual intake of adolescent females (Marhefska, 1978). However, two of the girls were in negative magnesium balance when fed Diet Z11.5 and five of the girls were in negative magnesium balance when fed Diet Z14.7 (Table 2). The differences in magnesium excretion and retention due to dietary zinc levels were not statistically significant. Previously, alterations in dietary zinc levels were also not demonstrated to affect magnesium balance significantly (Greger et al., 1978b).

The dry matter content of fecal samples when subjects were fed Diet Z11.5 was 20 ± 4% daily and when subjects were fed Diet Z14.7 was 21 ± 4% daily. While the dietary treatments did not affect the dry matter content of the feces, the dry matter content of fecal samples was correlated to their magnesium content (r = 0.619, p < 0.005), but not their phosphorus content.

The practical significance of alterations in dietary zinc levels on phosphorus utilization by Americans is unclear. The two levels of zinc fed in this study were representative of the level suggested in the RDA (Diet Z14.7) and of the level consumed by adolescent females (Diet Z11.5) (Greger et al., 1978c). The dietary phosphorus level in this study was about 0.9g daily. Marston and Friend (1966) on the basis of retail weight of food sold in the U.S.A. suggested that Americans consumed 1.5g phosphorus daily. Perhaps if the subjects had a consumed a higher level of phosphorus, the majority (7 out of 11) of the subjects would not have been in a negative balance in regard to phosphorus when fed Diet Z14.7. Even so, this interaction deserves further study.

REFERENCES


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