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Pantothenic Acid

SUMMARY

Pantothenic acid functions as a component of coenzyme A and phosphopantetheine, which are involved in fatty acid metabolism. Pantothenic acid is widely distributed in foods; deficiency has been reported only as a result of feeding semisynthetic diets or an antagonist to the vitamin. The primary criterion used to estimate the Adequate Intake (AI) for pantothenic acid is intake adequate to replace urinary excretion. The AI for adults is 5 mg/day. There are no nationally representative estimates of the intake of pantothenic acid from food or from both food and supplements. There is not sufficient scientific evidence on which to base a Tolerable Upper Intake Level (UL) for pantothenic acid.

BACKGROUND INFORMATION

Function

Pantothenic acid is vital to the synthesis and maintenance of coenzyme A (CoA), a cofactor and acyl group carrier for many enzymatic processes, and acyl carrier protein, a component of the fatty acid synthase complex (Tahiliani and Beinlich, 1991). As such, pantothenic acid is essential to almost all forms of life. Most tissues transport pantothenic acid into cells for the synthesis of CoA.

*Physiology of Absorption, Metabolism, and Excretion**Absorption*

CoA in the diet is hydrolyzed in the intestinal lumen to dephospho-CoA, phosphopantetheine, and pantetheine, with the pantetheine subsequently hydrolyzed to pantothenic acid (Shibata et al., 1983). Pantothenic acid was the only one of these pantothenate-containing compounds absorbed by rats in studies on absorption of the various forms. Absorption is by active transport at low concentrations of the vitamin and by passive transport at higher concentrations in animal models (Fenstermacher and Rose, 1986). Because the active transport system is saturable, absorption will be less efficient at higher concentrations of intake, but the intake levels at which absorptive efficiency decreases in humans are not known. Intestinal microflora have been observed to synthesize pantothenic acid in mice (Stein and Diamond, 1989), but the contribution of bacterial synthesis to body pantothenic acid levels or fecal losses in humans has not been quantified. If microbial synthesis is substantial, balance studies in humans may have underestimated pantothenic acid absorption and requirements.

Metabolism

The synthesis of CoA from pantothenate is regulated primarily by pantothenate kinase, an enzyme that is inhibited by the pathway end products, CoA and acyl CoA. Thus CoA production does not reflect the amount of available pantothenate (Tahiliani and Beinlich, 1991). CoA, in forms such as acetyl CoA and succinyl CoA, plays an important role in the tricarboxylic acid cycle and in the synthesis of fatty acids and membrane phospholipids, amino acids, steroid hormones, vitamins A and D, porphyrin and corrin rings, and neurotransmitters. It is also required for the acetylation and acylation of proteins and the synthesis of α -tubulin (Plesofsky-Vig, 1996).

Excretion

CoA is hydrolyzed to pantothenate in a multiple-step reaction. The pantothenic acid is excreted intact in urine, where it can be measured by using a *Lactobacillus plantarum* assay or a radioimmunoassay. The amount excreted varies proportionally with dietary intake over a discrete yet wide range of intake values.

Clinical Effects of Inadequate Intake

Pantothenic acid deficiency has only been observed in individuals who were fed diets virtually devoid of pantothenic acid (Fry et al., 1976) or who were given a pantothenic acid metabolic antagonist, ω -methyl pantothenic acid (Hodges et al., 1958, 1959). The subjects exhibited various degrees of signs and symptoms, including irritability and restlessness; fatigue; apathy; malaise; sleep disturbances; gastrointestinal complaints such as nausea, vomiting, and abdominal cramps; neurobiological symptoms such as numbness, paresthesias, muscle cramps, and staggering gait; and hypoglycemia and an increased sensitivity to insulin. After 9 weeks of a semisynthetic diet devoid of pantothenic acid, blood and urine concentrations were substantially lower (Fry et al., 1976). Historically, pantothenic acid was implicated in the "burning feet" syndrome that affected prisoners of war in Asia during World War II. The condition improved after pantothenic acid supplementation but not when other B-complex vitamins were given (Glusman, 1947).

SELECTION OF INDICATORS FOR ESTIMATING
THE REQUIREMENT FOR PANTOTHENIC ACID*Urinary Excretion*

Urinary excretion on a typical American diet is approximately 2.6 mg/day of pantothenic acid (Tarr et al., 1981) but it is strongly dependent on intake. In a group of healthy adolescents aged 13 to 19 years, pantothenic acid intake (assessed from 4 days of food intake records) was significantly correlated with the pantothenic acid concentration in urine ($r = 0.6$) (Eissenstat et al., 1986). Total daily urinary excretion was not measured. Excretion of pantothenic acid in the urine approached zero after 11 weeks of a diet devoid of the vitamin (Hodges et al., 1958). In 10 young men, the urinary concentration of pantothenic acid fell gradually from 3.05 to 0.79 mg/day in the six men who were fed a semisynthetic diet devoid of the vitamin for 84 days (Fry et al., 1976). The other four men were supplemented with 10 mg pantothenic acid/day for a 63-day period. The excretion of the vitamin in their urine increased from 3.9 to 5.8 mg/day. In a final 7-day period, all 10 subjects were given 100 mg/day of pantothenic acid, and urinary excretion increased to approximately 60 mg/day. The authors suggested that these results implied that substantial amounts of the vitamin can be stored when

intakes are high. However, it is also possible that intestinal absorption was markedly less.

Blood Levels of Pantothenic Acid

Whole Blood

Normal values for pantothenic acid in whole blood have been reported to be 1.57 to 2.66 $\mu\text{mol/L}$ when care is taken to fully release pantothenate from CoA (Wittwer et al., 1989). Concentrations fell from 8.9 to 6.4 $\mu\text{mol/L}$ (1.95 to 1.41 $\mu\text{g/mL}$) when six adult male prisoners were fed a diet free of pantothenic acid for 28 days (Fry et al., 1976). No further reduction was seen during the subsequent 5 weeks of depletion. In comparison, in four similar individuals supplemented with 10 mg/day of pantothenic acid, concentrations at the end of 9 weeks were not increased compared with baseline, suggesting that a value of approximately 9 $\mu\text{mol/L}$ (2 $\mu\text{g/mL}$) represented normal blood concentrations of the vitamin for these subjects. In a study of 63 healthy adolescents, whole-blood concentrations and intake were significantly correlated ($r = 0.4$), but there was no correlation between whole-blood content and urinary excretion of the vitamin (Eissenstat et al., 1986).

Serum or Plasma

Concentrations in plasma are much lower than in whole blood. They do not correlate with whole-blood levels (Cohenour and Calloway, 1972) because the latter also contain CoA and other coenzymes containing pantothenic acid. Plasma concentrations are less reflective of changes in intake or status (Baker et al., 1969). Whole-blood and erythrocyte pantothenic acid concentrations are strongly correlated (Eissenstat et al. 1986).

Erythrocytes

In rats, erythrocytes were found to contain pantothenic acid, 4'-phosphopantothenic acid, and pantotheine but not CoA (Annous and Song, 1995). The correlation between erythrocyte and whole-blood concentrations of pantothenic acid in a group of 57 apparently well-nourished adolescents was 0.8, and the correlation with dietary intake was 0.4 (Eissenstat et al., 1986). Average erythrocyte concentrations were 1.5 $\mu\text{mol/L}$ (334 ng/mL). Correlations between erythrocyte concentrations and both intake and urinary

excretion were similar to those for whole-blood concentrations. There was no significant correlation with urinary excretion of the vitamin. Although it is theoretically possible that erythrocyte concentrations are a more accurate representation of status than whole-blood concentrations because of the contribution of serum pantothenic acid to the latter, no clear advantage of using erythrocyte values was evident in this population group. A model was developed that predicted erythrocyte pantothenic acid concentrations from intake and urinary concentrations, but it explained only 30 percent of the variance in erythrocyte concentrations, which may have resulted from errors in the estimation of intake, variability in tissue storage and utilization, and differences among subjects in the amount absorbed.

FACTORS AFFECTING THE PANTOTHENIC ACID REQUIREMENT

Bioavailability

Little information is available on the bioavailability of dietary pantothenic acid. Values of 40 to 61 percent (mean 50 percent) have been given for absorbed food-bound pantothenic acid. These values were derived by comparing urinary excretion of the vitamin after feeding a formula diet containing 8.2 mg/day of pantothenic acid (of which 6.0 mg was free crystalline pantothenic acid) with excretion after ingestion of natural foods containing 11.5 mg/day (Tarr et al., 1981). It was assumed that 100 percent of the crystalline vitamin was absorbed.

Nutrient-Nutrient Interactions

There is almost no information on the interaction between pantothenic acid and other nutrients. Koyanagi and colleagues (1969) studied subjects consuming a constant diet that contained 2.37 mg of pantothenic acid, 1.17 mg of thiamin, 0.87 mg of riboflavin, 735 IU of vitamin A, and 50 mg of ascorbic acid from food. A supplement containing either 10 mg of pantothenic acid, 5 mg of thiamin, 5 mg of riboflavin, 2,500 IU of vitamin A, or 100 mg of ascorbic acid was given to one of five subject groups (four to five subjects per group) for one week in addition to the diet. The groups receiving the pantothenic acid, thiamin, or riboflavin supplements had increases in the serum and urinary concentrations of pantothenic acid from prestudy values; the groups receiving ascorbic acid or

vitamin A supplements did not. This study suggests that thiamin, and to a lesser extent riboflavin, resulted in changes in pantothenic acid metabolism and excretion. However, the levels of significance were not determined for the nutrients studied.

Oral Contraceptive Agents

Lewis and King (1980) investigated whether high-dose oral contraceptive agents affected pantothenic acid metabolism in 13 women between the ages of 19 and 24 years enrolled in a 12-day confined study. At the end of the study, blood levels and urinary pantothenic acid excretion were similar in the subjects and controls. The investigators concluded that high-dose oral contraceptive agents do not cause significant changes in the biochemical parameters of pantothenic acid.

FINDINGS BY LIFE STAGE AND GENDER GROUP

Infants Ages 0 through 12 Months

Method Used to Set the Adequate Intake

There are no functional criteria for pantothenic acid status that reflect response to dietary intake in infants. Thus, recommended intakes of pantothenic acid are based on an Adequate Intake (AI) that reflects the observed mean intake of infants fed principally with human milk.

Ages 0 through 6 Months. On the basis of a summary of recent studies in North America and the United Kingdom (Picciano, 1995), the average pantothenic acid concentration of mature human milk ranges from 2.2 to 2.5 mg/L. Values at the upper end of this range included those from women taking multivitamin supplements containing pantothenic acid. The AI is based on a reported average intake of human milk of 0.78 L/day for this age group (see Chapter 2) and an average pantothenic acid concentration of milk of 2.2 mg/L. This gives an AI for pantothenic acid of 1.7 mg/day for infants ages 0 through 6 months.

Ages 7 through 12 Months. If the reference body weight ratio method described in Chapter 2 is used to extrapolate from the AI for pantothenic acid for infants ages 0 through 6 months, the AI for pantothenic acid for older infants would be 2.2 mg/day. This is some-

what higher than the value obtained from the second method (see Chapter 2) by extrapolating down from the AI for adults to estimate a recommended intake, which results in an AI for pantothenic acid of 1.4 mg/day. The AI for pantothenic acid for older infants is set as the mean obtained from these two methods of extrapolation, 1.8 mg/day.

Pantothenic Acid AI Summary, Ages 0 through 12 Months

AI for Infants

0–6 months	1.7 mg/day of pantothenic acid	≈0.2 mg/kg
7–12 months	1.8 mg/day of pantothenic acid	≈0.2 mg/kg

Children Ages 1 through 13 Years

No data were found on which to base an Estimated Average Requirement (EAR) and thus a Recommended Dietary Allowance (RDA) for pantothenic acid for children or adolescents of any age group. Thus, AIs have been set instead.

Method Used to Set the AI

Ages 1 through 3 Years. In the absence of additional information, AIs for these age groups have been extrapolated from adult values by using the method described in Chapter 2, which gives an AI of 2 mg/day.

Ages 4 through 13 Years. In a study of 40 preschool children aged 3 to 5 years, dietary intake of pantothenic acid was measured by 3-day food records (Kerrey et al., 1968). The children were grouped by socioeconomic status. Children in the high socioeconomic group had lower reported dietary intakes of pantothenic acid than did children in the low socioeconomic group (approximately 4 and 5 mg/day, respectively). However, the mean urinary excretion of pantothenic acid was 3.36 mg/day in the high socioeconomic group compared with 1.74 mg/day in the low socioeconomic group.

Pace and colleagues (1961) studied 35 healthy girls aged 7 to 9 years during three study periods. Urinary excretion was measured while feeding controlled diets. Dietary intake ranged from 2.79 ± 0.33 (standard deviation [SD]) mg/day to 5.00 ± 0.82 mg/day. Average daily excretion of urinary pantothenic acid was 1.3 mg (47 percent of intake) when intake was 2.79 ± 0.33 mg/day and 2.7 mg (63 percent of intake) when intake was 4.49 ± 0.76 mg/day. These

data indicate that intakes of 2.8 to 5.00 mg/day exceed urinary excretion.

By extrapolating the AI for children from the adult AI for pantothenic acid using the method described in Chapter 2, values of 3 and 4 mg/day are obtained for children ages 4 through 8 years and 9 through 13 years, respectively. These values are consistent with the results reviewed above.

Pantothenic Acid AI Summary, Ages 1 through 13 Years

AI for Children

1–3 years	2 mg/day of pantothenic acid
4–8 years	3 mg/day of pantothenic acid

AI for Boys

9–13 years	4 mg/day of pantothenic acid
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AI for Girls

9–13 years	4 mg/day of pantothenic acid
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Adolescents Ages 14 through 18 Years

Evidence Considered in Setting the AI

Eissenstat and colleagues (1986) studied 26 healthy males and 37 healthy females aged 14 to 19 and 13 to 17 years, respectively. The subjects kept 4-day dietary records. The average pantothenic acid intake was 6.3 ± 2.1 (SD) mg/day for boys and 4.1 ± 1.2 mg/day for girls. Only six subjects took pantothenic acid supplements, which provided at least 5 mg/day of additional pantothenic acid. Pantothenate in subjects' daily pooled urine samples was measured by radioimmunoassay. The average urinary pantothenate excretion for the unsupplemented subjects was 3.3 ± 1.3 (SD) mg/g of creatinine for the boys and 4.5 ± 1.9 mg/g of creatinine for the girls (approximately 5.0 mg/day for the boys and 4.2 mg/day for the girls, based on average creatinine values for adult individuals of this height) (Schneider et al., 1983).

Whole-blood and erythrocyte pantothenate were also measured. Whole-blood averages were 1.86 ± 0.47 $\mu\text{mol/L}$ (411.9 ± 102.8 ng/mL) for boys and 1.57 ± 0.52 $\mu\text{mol/L}$ (344.5 ± 113.6 ng/mL) for girls. Erythrocyte pantothenate concentrations averaged 1.70 ± 0.47 $\mu\text{mol/L}$ (375.6 ± 104.3 ng/mL) for boys and 1.36 ± 0.42 $\mu\text{mol/L}$ (301.4 ± 93.5 ng/mL) for girls. These data indicate that intakes of

less than 4 mg/day supported normal concentrations of pantothenic acid (1.57 to 2.66 $\mu\text{mol/L}$) (Wittwer et al., 1989) in whole blood.

Similarly, Kathman and Kics (1984) reported that during a 4-day test period, eight boys and four girls aged 11 to 16 years had average pantothenic acid intakes of 5.6 mg/day (range 4.0 to 7.9 mg/day). These values were calculated from diet diaries and check lists. Average urinary pantothenic acid excretion was 3.74 mg/g of creatinine. However, over this 4-day period there was no statistically significant correlation between pantothenic acid intake and excretion.

By extrapolating the AI for adolescents from the adult AI for pantothenic acid using the method described in Chapter 2, a value of 5 mg/day is obtained when urinary excretion was converted to mg/day from mg/g creatinine, which is consistent with the results reviewed above.

Pantothenic Acid AI Summary, Ages 14 to 18 Years

AI for Boys

14–18 years 5 mg/day of pantothenic acid

AI for Girls

14–18 years 5 mg/day of pantothenic acid

Adults Ages 19 through 50 Years

Evidence Considered in Setting the AI

The usual pantothenic acid intake is 4 to 7 mg/day, as reported for small groups of U.S. adults and adolescents (Bull and Buss, 1982; Kathman and Kics, 1984; Srinivasan et al., 1981; Tarr et al., 1981). There is no evidence suggesting that this range of intake is inadequate. Thus, the approximate midpoint—5 mg/day—is set as the AI for adults. The adequacy of this intake is supported by the only study of the relationship between daily intake and excretion in adults (Fox and Linkswiler, 1961). Eight healthy women aged 18 to 24 years were studied to determine the urinary excretion of pantothenic acid on three levels of intake in the normal range. On self-selected diets the women consumed 3.4 to 10.3 mg/day of pantothenic acid as estimated from the tables of Zook et al. (1956) and Sarrett et al. (1946). Diets were then standardized to include 2.8 mg/day of pantothenic acid for 15 days, 7.8 mg/day for 10 days, and 12.8 mg/day for 10 days. The mean urinary excretion of pantothenic acid after consumption of these pantothenic acid intakes

was stated to be 3.2, 4.5, and 5.6 mg, respectively. However, the published plot of these data suggests that excretion averaged closer to 4 and 5 mg/day at the 2.8 and 7.8 mg/day intakes, respectively, lending some uncertainty to the results. From the regression equation given relating intake to urinary excretion, a pantothenic acid intake of approximately 4 mg/day would result in a similar amount of urinary excretion of this vitamin. Because of uncertainties in the accuracy of the published values in foods used to estimate intakes, small number of subjects studied, and lack of information about the effects of intake on the efficiency of absorption and storage of the vitamin, these results can only be used to support the adequacy of the AI and not to set an EAR and RDA.

There is no information on pantothenic acid requirements of middle-age adults aged 31 through 50. The AI for younger adults, 5 mg/day, is therefore recommended for the age range 19 through 50 years. Similarly, there is no basis for determining a separate recommendation based on gender, so the AIs for men and women are the same.

Pantothenic Acid AI Summary, Ages 19 through 50 Years

AI for Men

19–30 years **5 mg/day of pantothenic acid**

31–50 years **5 mg/day of pantothenic acid**

AI for Women

19–30 years **5 mg/day of pantothenic acid**

31–50 years **5 mg/day of pantothenic acid**

Adults Ages 51 Years and Older

Evidence Considered in Setting the AI

In a study of 65 noninstitutionalized men and women aged 65 years or older (mean age 73 years), pantothenic acid intakes from food averaged 2.9 mg/1,000 kcal, or 5.9 ± 0.1 (standard error) mg/day (range 2.5 to 9.5 mg/day) (Srinivasan et al., 1981). Sixty percent of these elderly consumed supplements that increased this usual intake by 17 mg/day. The supplements did not, however, increase blood concentrations of the vitamin. Urinary pantothenic acid excretion of unsupplemented individuals averaged 6 mg/day. These data support the adequacy of the 5.9 mg/day intake from diet alone. There was no change in urinary excretion with age. Because there

is no basis for expecting an increased pantothenic acid requirement in the elderly, the AI is set at 5 mg/day—the same as for younger adults.

Pantothenic Acid AI Summary, Ages 51 Years and Older

AI for Men

51–70 years **5 mg/day of pantothenic acid**
> 70 years **5 mg/day of pantothenic acid**

AI for Women

51–70 years **5 mg/day of pantothenic acid**
> 70 years **5 mg/day of pantothenic acid**

Pregnancy

Evidence Considered in Setting the AI

There is little information on pantothenic acid requirements during pregnancy. In a longitudinal study of 26 pregnant women during their third trimester and at 2 weeks and 3 months postpartum, blood pantothenate concentrations were significantly lower than those of 17 nonpregnant control women, but there was no difference in daily urinary excretion during late pregnancy compared with control subjects (Song et al., 1985). Moreover, when data for unsupplemented women measured in the third trimester and again at 2 weeks postpartum were combined, average intake exceeded excretion across the range of intakes (mean dietary intake 5.3 ± 1.7 [SD] mg/day in pregnancy, 5.9 ± 2.0 [SD] mg/day in lactation, and 2 to 11 mg/day overall). In the absence of information showing that usual intakes in the United States and Canada are inadequate to support a healthy pregnancy outcome, and rounding up from this average intake, an AI of 6 mg/day of pantothenic acid is set for pregnant women.

Pantothenic Acid AI Summary, Pregnancy

AI for Pregnancy

14–18 years **6 mg/day of pantothenic acid**
19–30 years **6 mg/day of pantothenic acid**
31–50 years **6 mg/day of pantothenic acid**

*Lactation**Evidence Considered in Setting the AI*

The pantothenic acid content of milk appears to increase with increased intake of the vitamin. In India usual intakes of pantothenic acid were correlated with the concentration of the vitamin in human milk (Deodhar and Ramakrishnan, 1960). A similar finding was reported for 26 mothers who were nursing infants at 2 and 12 weeks postpartum (Song et al., 1984); milk pantothenate content was significantly correlated with dietary intake ($r = 0.51$) and urinary excretion ($r = 0.57$) of the vitamin and weakly correlated with blood concentrations ($r = 0.19$). The pantothenic acid content of the milk of supplemented mothers was approximately five times higher than that of the unsupplemented mothers. Blood pantothenic acid concentrations were significantly lower in lactating women at 3 months postpartum (Song et al., 1985) and at 6 weeks postpartum (Cohenour and Calloway, 1972) than for control women who had not been pregnant. Although there is no evidence that pantothenic acid intakes are inadequate to support function during lactation, on the basis of the additional secretion of the vitamin in human milk (1.7 mg/day) and the lower maternal blood concentrations reported when intakes are about 5 to 6 mg/day, an AI of 7 mg/day of pantothenic acid is recommended.

*Pantothenic Acid AI Summary, Lactation***AI for Lactation****14–18 years 7 mg/day of pantothenic acid****19–30 years 7 mg/day of pantothenic acid****31–50 years 7 mg/day of pantothenic acid**

INTAKE OF PANTOTHENIC ACID

Food Sources

Pantothenic acid is found both free and conjugated in virtually all plant and animal cells. To estimate the dietary intake of pantothenic acid in foods, it is necessary to convert bound pantothenic acid, for example, in coenzyme A (CoA) and fatty acid synthetase, to the free form. Various analytical methods have been used to gather information on the pantothenic acid content of foods (Orr, 1969; Schroeder, 1971; Walsh et al., 1981; Zook et al., 1956). Older data on food

composition were based on microbiological assays for pantothenic acid. A high-performance liquid chromatography method was published relatively recently and has been used for the analysis of pantothenic acid in infant formulas (Romera et al., 1996). However, data on the pantothenic acid content of food regardless of method are very limited. Chicken, beef, potatoes, oat cereals, tomato products, liver, kidney, yeast, egg yolk, broccoli, and whole grains are reported to be major sources of pantothenic acid (Plesofsky-Vig, 1996; Walsh et al., 1981). Royal bee jelly and ovaries of tuna and cod have very high levels of pantothenic acid (Robinson, 1966), but refined grains, fruit products, and meats and fish with added fats or cereal extenders appear to be lower in pantothenic acid content. Freezing and canning of vegetables, fish, meat, and dairy products has been shown to decrease the pantothenic acid content of those foods (Schroeder, 1971). Processing and refining grains resulted in a 37 to 74 percent loss of pantothenic acid (Walsh et al., 1981).

Dietary Intake

The major surveys of nutrient intake used in this report (the U.S. Department of Agriculture Continuing Survey of Food Intakes by Individuals, the Third National Health and Nutrition Examination Survey, and the Boston Nutritional Status Survey) do not estimate the pantothenic acid intake from diet, largely because of the incompleteness of data on the pantothenic acid content of food. Usual daily intakes of about 4 to 7 mg have been reported quite consistently in small groups of adolescents and adults of various ages (Bull and Buss, 1982; Kathman and Kies, 1984; Srinivasan et al., 1981; Tarr et al., 1981). Data from a survey conducted in one province in Canada indicated median daily intakes of pantothenic acid from foods of approximately 5 mg for men and 4 mg for women (Santé Québec, 1995).

Intake from Supplements

Results from the 1986 National Health Interview Survey indicate that 22 percent of U.S. adults took a supplement containing pantothenic acid (Moss et al., 1989).

TOLERABLE UPPER INTAKE LEVELS

*Hazard Identification**Adverse Effects*

No reports of adverse effects of oral pantothenic acid in humans or animals were found. Therefore, a quantitative risk assessment cannot be performed and a Tolerable Upper Intake Level (UL) cannot be derived for pantothenic acid.

In the absence of known toxic effects by ingestion, a lowest-observed-adverse-effect level (LOAEL) and an associated no-observed-adverse-effect level (NOAEL) cannot be determined. A search of the literature revealed no evidence of toxicity associated with the intake of pantothenic acid. Vaxman et al. (1996) noted no toxic effects of 0.2 to 0.9 g/day of pantothenate combined with ascorbic acid (1 to 3 g/day) in a study of effects on wound healing. However, another study (Haslam et al., 1984) indicated that a combination of 1.2 g of calcium pantothenate, 0.6 g of pyridoxine, 3 g of niacinamide, and 3 g of ascorbic acid taken daily for 6 weeks was associated with elevations in serum transaminase levels in children. One of these doses or the combination may therefore cause hepatotoxicity, but it is not possible from this study alone to ascribe to pantothenic acid the reported adverse effect in liver function.

Special Considerations

A review of the literature failed to identify special subgroups that are distinctly susceptible to adverse effects of excess pantothenic acid intake.

Intake Assessment

Because national surveys do not provide data on the intake of pantothenic acid, a reasonable intake assessment of the 90th and 95th percentiles from U.S. or Canadian national surveys is not possible.

Risk Characterization

No adverse effects have been associated with high intakes of pantothenic acid.

RESEARCH RECOMMENDATIONS FOR
PANTOTHENIC ACID

Relatively little information is available about pantothenic acid as a nutrient; priority research areas for this vitamin include the following:

- Pantothenic acid requirements of different age groups, especially infants, children, and the elderly.
- Bioavailability of pantothenic acid from different foods and mixed diets and of the extent to which synthesis by intestinal bacteria contributes to meeting the requirement.
- Use of newer methods, such as high-pressure liquid chromatography, to analyze pantothenic acid in foods. At present, pantothenic acid intakes are not calculated in national surveys such as the Third National Health and Nutrition Examination Survey because of a lack of information on the pantothenic acid content of foods.

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