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The University of Nebraska - Lincoln Ph.D. 1985

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by

Nancy M. Lewis

A DISSERTATION

Presented to the Faculty of
the Graduate College in the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Doctor of Philosophy

Major: Interdepartmental Area of Nutrition

Under the Supervision of Professor Hazel M. Fox

Lincoln, Nebraska

August, 1985

TITLE

Current Nutrition Issues: Effect of Bran or Multivitamin-Mineral Supplements on Vitamin B12 Status, Counseling Skills of Nutrition Students and Breastfeeding Duration of WIC Mothers

BY

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APPROVED	DATE
Hazel Fox	August 13, 1985
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GRADUATE COLLEGE **UNIVERSITY OF NEBRASKA**

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Nancy M. Lewis, Ph.D.

University of Nebraska, 1985

Adviser: Hazel M. Fox

Four projects were conducted. In the first project urinary vitamin B_{12} excretion of 41 omnivore and vegetarian subjects was measured using a microbiological assay when subjects consumed controlled vegan, lacto-vegetarian and omnivore diets supplemented with bran. Subjects' mean calculated vitamin B_{12} intake was 2.48 ug/day while consuming self-selected diets and 6.83 ug/day while consuming controlled diets. Mean urinary vitamin B_{12} excretion was 1.13 ug/day during the self-selected diet period and 0.93 ug/day during the controlled diet periods. The lowest urinary vitamin B_{12} excretion occurred when white bran was added to the controlled diets; however, the effect was not significant. In project two, thirteen adult women consuming self-selected diets were given a multivitamin-mineral supplement for 5 days or no supplement for 5 days in a cross-over design. Urinary vitamin B_{12} was measured as in project one. Mean urinary vitamin B_{12} excretions during the pre-supplemented period, the supplemented period and post-supplemented period were 0.028, 0.397 and 1.867 ug/day, respectively. Mean calculated vitamin B_{12} intake from self-selected diets was 1.93 ug/day. In project three, 34 nutrition students were videotaped before and after a counseling skills workshop. Twenty-four students (experimental group)

attended the three-hour workshop and 10 students (control group) did not attend the workshop. Each videotape was evaluated by two registered dietitians. Eight counseling behaviors were used significantly more by experimental group students than by control group students following the workshop. Project four included a telephone survey of 45 WIC mothers to identify factors related to duration of breastfeeding and to evaluate an intervention designed to extend breastfeeding of these mothers. Late introduction of formula, positive attitude toward breastfeeding, previous breastfeeding experience and father in the home increased breastfeeding duration. The correlation of previous breastfeeding experience with positive attitude toward breastfeeding was significant. Experimental group mothers (N=13) who received additional education and postpartum support via two telephone calls, responded more positively than control group mothers (N=15) to two attitude statements and were less likely than control mothers to introduce formula because of lack of breastmilk.

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ACKNOWLEDGEMENTS

I would like express appreciation to Dr. Hazel M. Fox for providing the opportunity for me to study for this degree and for providing advice and encouragement throughout my graduate program. Thank you to Dr. Constance Kies for providing the opportunity to work with human subjects, for providing needed assistance in the analysis and writing of the human studies and for serving as a member of the reading committee.

I appreciate the helpful suggestions of Dr. Robert Filbeck, who served as a member of the reading committee, and the willingness of Dr. Thomas Sullivan and Dean Hazel Anthony to serve as committee members.

Kent Eskridge is appreciated for his assistance with statistical analysis. Many thanks to Mick McGee, Barbara Dripps, Donna Hahn, Lori Rausch and Bunny Penton for providing technical assistance and encouragement and to Dr. Phyllis Staats, Dr. Nancy Betts, Dr. Audrey Hay, Dr. Anna M. Brenner, Mrs. Linda Young and Mrs. Jo Taylor for their assistance and continuing interest in my progress.

The cooperation of the staff of the Family Service Open Door Health Center and of members of the Student Dietetic Association is greatly appreciated.

A heartfelt thanks to Austin and Mainert for sacrificing on my behalf and for their loving companionship and to my parents, William and Mary Franklin for instilling the "love of learning."

EFFECT OF BRAN OR MULTIVITAMIN-MINERAL SUPPLEMENTS ON VITAMIN B_{12} STATUS

INTRODUCTION

The current interest in dietary fiber stems from epidemiological evidence suggesting that diseases common in Western countries - including colon cancer, diverticular disease of the colon and diabetes are seldom found in societies where people consume diets high in fiber (Burkitt et al., 1974). As a result of this suggestion, extensive research has been conducted to identify the role fiber plays in human health. Recent evidence suggests that certain dietary fibers have a protective effect against chemically induced carcinogenesis in animals and in maturity-onset diabetes and hypercholesterolemia in humans (Kay and Truswell, 1977; Haber et al., 1977; Wilson et al., 1977).

On the basis of this and other research, current dietary guidelines recommend that Americans increase their consumption of whole grain cereal products and other foods that provide dietary fiber (Committee on Diet, Nutrition and Cancer, 1982; USDA and USDHHS, 1980). However, little is known about the interactions of dietary fiber with vitamins or the effect of dietary fiber on vitamin status. Since fiber has been shown to interfere with the absorption of certain minerals (James et al., 1978), it could also reduce the availability of vitamins from the diet.

Increasing numbers of Americans are consuming vegetarian diets. Some vegetarians have been shown to be in poor vitamin B_{12} nutritional status (Armstrong et al., 1974; Abdulla et al., 1981). Increased consumption of fiber by vegetarians might aggravate an already marginal vitamin B_{12} status.

In addition to dietary fiber, Americans have increased their use of multivitamin-mineral supplements. The vitamin B_{12} content, availability and safety of these supplements have been questioned recently (Kondo et al., 1982).

Urinary excretion of a water-soluble vitamin may be used as an indication of nutritional status, absorption, utilization or dietary intake. If nutritional status of the water-soluble vitamin is adequate, a decrease in urinary excretion of that vitamin may be interpreted as indicating a decrease in dietary intake, a decrease in intestinal absorption or an increased need and utilization of that vitamin.

Two studies were conducted to determine the effect of bran supplemented vegetarian and omnivore diets and of multiple vitamin-mineral supplements on urinary vitamin B_{12} excretion.

LITERATURE REVIEW

VITAMIN B_{12}

History

The history of vitamin B_{12} (cobalamin) dates back to the 1820's when Combe first described a fatal anemia due to "some disorder of the digestive and assimilative organs." The disease was always fatal and therefore was called "pernicious anemia" meaning "tending toward death." Minot and Murphy (1926) won a Nobel Prize in medicine for discovering that pernicious anemia could be cured by feeding liver.

Soon after the discovery of Minot and Murphy, Castle and Townsend (1929) reported that the substance in liver was not the only factor involved in pernicious anemia. They identified a genetic defect which prevented pernicious anemia patients from completing gastric digestion. Castle and Townsend called the substance in normal gastric juice "intrinsic factor" and they demonstrated that it was required for the absorption of a substance from liver which they called "extrinsic factor." Vitamin B_{12} was isolated in 1948 and identified as the "extrinsic factor" (Rickes et al., 1948). Hodgkin (1965) was awarded a Nobel prize in chemistry in 1964 for identifying the chemical structure of the vitamin.

Chemical Structure

The structure and synthesis of vitamin B_{12} have been reviewed recently by Ellenbogen (1984).

Vitamin B_{12} is a large, water soluble molecule (mol wt 1355) with a complex chemical structure. A distinguishing feature of this vitamin is

the presence of cobalt which accounts for the dark red color of the vitamin. The cobalt is surrounded by four, nitrogen-containing, five-membered rings. This ring structure is called a "corrin" ring because it is the core of the vitamin B_{12} molecule. Different forms of cobalamin exist depending upon the group attached to cobalt. The two cobalamin forms known to have coenzyme activity in humans are methyl cobalamin and 5'-deoxyadenosyl cobalamin. These two forms, plus hydroxocobalamin, are the predominant forms in human plasma and tissue and are thought to be the major forms found in animal products (Linnel et al., 1974). However, to the chemist, vitamin B_{12} is cyanocobalamin which contains a cyanide group attached to cobalt. This is the most stable form of the vitamin. Products such as multivitamin supplements, breakfast cereals, diet foods and supplemented animal feeds provide cyanocobalamin which has been produced commercially from bacterial fermentation. Humans can convert cyanocobalamin to nutritionally active forms of the vitamin (Seetheram and Alpers, 1982).

Cobalamin Analogues

Analogues of vitamin B_{12} can be produced by changing a part of the chemical structure. Microorganisms can utilize the more than 20 analogues that occur naturally; however, animals cannot utilize these analogues. Some cobalamin analogues may act as cobalamin antagonists or antimetabolites. For example, in humans cyanocobalamin analogues have been identified which compete with vitamin B_{12} for binding to intrinsic factor and therefore reduce absorption of the vitamin (Bunge and Schilling, 1957, as cited by Ellenbogen, 1984).

Kondo et al. (1982) investigated the possibility that interactions in multivitamin and multivitamin-mineral pills might convert cobalamin to cobalamin analogues. They found that the interactions of vitamin C, thiamin and/or copper with cyanocobalamin converts 61.3% of the cyanocobalamin to several different cobalamin analogues which have very little or no coenzyme activity and may inhibit coenzyme activity. Less than 1% analogue formation occurred with one of the components or any combination of two of the three components. The formation of analogues decreased from 61.3 to 31.8% when ferrous fumarate was added to solutions containing vitamin C, thiamin and copper sulfate. In the One-A-Day Multivitamin plus Minerals pill (Miles Laboratory), 36.2% of the cyanocobalamin had been converted to cobalamin analogues; however, none of the cyanocobalamin in the multivitamin pill without added minerals was converted to analogues. Some of the analogues inhibited cobalamin dependent enzymes in mice.

Herbert et al. (1982) determined the vitamin B_{12} content of 15 multivitamin-mineral preparations commonly used in the United States. They reported 7.1 ug of vitamin B_{12} per supplement in Miles One-A-Day Plus Minerals. The label on the supplement stated that it provided 6 ug/supplement. Each supplement also contained 1.6 ug of vitamin B_{12} analogues.

Digestion, Absorption and Excretion

A recent review of the absorption and transport of vitamin B_{12} has been published (Seetheram and Alpers, 1982). In foods, cobalamin is linked to polypeptides. The first step in the digestion of protein-bound vitamin B_{12} occurs in the stomach. The low pH of the stomach and

peptic digestion facilitate the release of vitamin B_{12} from protein (Cooper and Castle, 1960). Pancreatic proteases will also release vitamin B_{12} bound to proteins in foods. After release from food proteins, cobalamin is bound to R protein, a glycoprotein secreted by stomach and salivary glands. R protein binds cobalamin at both acidic and neutral pH and at pH 2 and pH 8 it has a higher affinity for cobalamin than does intrinsic factor (Allen et al., 1978).

In the small intestine, pancreatic proteases such as trypsin and chymotrypsin degrade the R protein cobalamin complex so that vitamin B_{12} is free to bind with intrinsic factor. In the presence of calcium and an alkaline pH the intrinsic factor-B_{12} complex then binds to specialized receptors on the ileal cell surface (Hagedorn and Alpers, 1977). Some research indicates that cobalamin enters the enterocyte leaving free intrinsic factor, which may then bind with additional cobalamin (Hines et al., 1968). However, others have demonstrated that the intrinsic factor-cobalamin complex is absorbed by the enterocyte (Kapadia et al., 1981). In this case it is not known what happens to intrinsic factor. Cobalamin leaves the enterocyte attached to a transport protein, transcobalamin II.

Active absorption of vitamin B_{12}, which utilizes intrinsic factor, is the primary method of absorption for physiological doses of cobalamin (approximately 1-5 ug). Herbert et al. (1980) have suggested that this mechanism can account for the absorption of a maximum of 1.5-3 ug of free vitamin B_{12} at one time. Vitamin B_{12} may also be absorbed by simple diffusion. This passive mechanism of absorption does not require intrinsic factor and occurs when the amount of vitamin B_{12} is large.