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DTN2PNU Principles of Human Nutrition
Lecture 8: Vitamins

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Today

Key questions to be covered:

Introduction to:

• Fat-soluble vitamins
• Water-soluble vitamins
Required readings


• CHAPTERS 10 and 11
Vitamins

• Are organic compounds
• Required as a nutrient by an organism
• Cannot be synthesised in sufficient quantities and must be obtained from the diet
• “Accessory growth factors”
• Come in two groups:
  1. Fat soluble
  2. Water soluble
Bioavailability and Provitamins

• Bioavailability is the rate and extent that a nutrient is absorbed and used.

• Precursors, also known as provitamins, are consumed in an inactive form and become active vitamins in the body.
FAT-SOLUBLE VITAMINS
Fat-soluble Vitamins

- Closely associated with the absorption and transport of lipids
- Optimal absorption requires presence of bile salts
- Transported by chylomicrons
- Stored in body lipids
  - Vitamin A
  - Vitamin D
  - Vitamin E
  - Vitamin K
Vitamin A (retinol)

Provitamins
Carotenoids; beta-carotene

Biochemical/Physiological Function
Synthesis of rhodopsin and other light receptor pigments;
Metabolites involved in growth, cell differentiation, proliferation & growth

Deficiency Syndrome or symptoms
EYES-Poor dark adaptation, night blindness, xerosis, keratomalacia, xeroderma, Bitot’s spots
Vitamin A (retinol)

**Good Sources**
Beef liver, dairy, sweet potato, carrots, spinach, pumpkin

**RDI Adults**
Men 900, Women 700 ug/day (retinol equivalents), more for pregnancy/lactation

**Toxicity**
Acute Hypervitaminosis A- nausea, vomiting, double vision, dizziness
Chronic Hypervitaminosis A (Generally 10x RDI but has been seen in 3-4 xRDI)- anorexia, skin issues, loss of hair, bone and muscle pain, conjunctivitis and ocular pain

**Interactions**
Interacts with Vit E and Vit K (excess VitA interferes with absorption)
Protein
Zinc
Vitamin D

Provitamins

Ergosterol, 7-dehydrocholesterol, Vitamin D\textsubscript{2} (ergocalciferol), Vitamin D\textsubscript{3} (cholecalciferol)

Biochemical/Physiological Function

Regulator of bone mineral metabolism, blood calcium homeostasis, cell differentiation, proliferation & growth

Deficiency Syndrome or symptoms

Children- rickets

Adults- osteomalacia
Vitamin D

Good Sources

Synthesised in skin exposed to UV light. Fortified milk, margarine, butter, juices, cereals, and chocolate mixes; veal, beef, egg yolks, liver, fatty fish (herring, sardines, salmon, and their oils).

RDI not available only AI and UL

Toxicity

Hypercalcemia- through dietary sources

Interactions

• Calcium
• Phosphorus
• Vitamin K
Vitamin E (tocopherols/ tocotrienols)

Biochemical/ Physiological Function
Antioxidant

Deficiency Syndrome or symptoms
Infants- anaemia
Children & Adults- neuropathy and myopathy

Good Sources
Vegetable seed oils

RDI not available just AI and UL

Toxicity
One of the least toxic vitamins, but does increase tendency for bleeding

Interactions
• Selenium
• Vitamin C
• Sulphur-containing amino acids
May impair/inhibit absorption of beta-carotene, Vitamin K
Vitamin K

Biochemical/Physiological Function
Activates blood clotting factors

Deficiency Syndrome or symptoms
Children: hemorrhagic disease of newborns
Adults- defective blood clotting

Good Sources
Synthesised by gut bacteria, green leafy veg, soy beans, beef liver

RDI not available only AI

Interactions
Vit A & E antagonise vit K

?Vit D
WATER-SOLUBLE VITAMINS
Water Soluble Vitamins

- Water-soluble Vitamins
  - Vitamin C
  - B-complex Vitamins
    - Energy Releasing
      - Thamin
      - Riboflavin
      - Niacin
      - Pantothenic acid
      - Biotin
      - Vitamin B6
    - Haematopoietic
      - Folate
      - Vitamin B12
      - Vitamin B6
      - Pantothenic acid
    - Other Roles
      - Vitamin B6
      - Thiamin
      - Folate
      - Vitamin B12
      - Niacin
Thiamin (B1)

Main Coenzymes
Thiamin diphosphate (TDP) or Thiamin pyrophosphate (TPP)

Biochemical/ Physiological Function
Oxidative decarboxylation of alpha-keto acids and 2-keto sugars

Deficiency Syndrome/Symptoms
Beriberi, muscle weakness, anorexia, tachycardia, enlarged heart, oedema

Good Food Sources
Yeast, pork, sunflower seeds, legumes

RDI Adults
Women 1.1 mg/d, Men 1.2 mg/d

At risk of deficiency
Alcoholism, elderly, malabsorptive conditions
Beriberi- 2 Kinds dry/wet

Dry beriberi (and Wernicke-Korsakoff syndrome) results in the loss of strength and of some feeling in the limbs due to nerve degeneration. Symptoms of dry beriberi include:

- Pain
- Tingling
- Loss of feeling (sensation) in hands and feet
- Muscle damage with loss of muscle function or paralysis of the lower legs
- Vomiting
- Strange eye movements
- Mental confusion/speech difficulties
- Difficulty walking
- Coma
- Death
Beriberi- 2 Kinds dry/wet

Wet beriberi is caused by accumulated fluid in the limbs (oedema) and in the abdomen (ascites) because of a heart malfunction, increased heart rate (tachycardia), enlarged heart related to congestive heart failure, lung congestion, nerve degeneration is commonly present as well. Symptoms of wet beriberi include:

- Increased heart rate
- Swelling of the lower legs
- Lung congestion
- Enlarged heart related to congestive heart failure
- Shortness of breath with activity
- Awakening at night short of breath
Riboflavin (B2)

Main Coenzymes

Flavin adenine dinucleotide (FAD), Flavin mononucleotide (FMN)

Biochemical/Physiological Function

Electron transfer reactions

Deficiency Syndrome/Symptoms

Ariboflavinosis- sore throat with redness and swelling of the mouth and throat mucosa, cheilosis and angular stomatitis (cracking of the lips and corners of the mouth), glossitis (magenta tongue with atrophy), seborrheic dermatitis or pseudo-syphilis (moist, scaly skin particularly affecting the scrotum or labia majora and the nasolabial folds), and a decreased red blood cell count with normal cell size and hemoglobin content (normochromic normocytic anemia)

Good Food Sources

Beef liver, steak, mushrooms, ricotta, oysters, skim milk

RDI Adults

1.1mg/d Women, 1.3 mg/d Men

At risk of deficiency- Alcoholism, heart failure, hypermetabolic conditions
Niacin (B3)

Main Coenzymes
Nicotinamide adenine dinucleotide (NAD), and NADP

Biochemical/Physiological Function
Electron transfer reactions

Deficiency Syndrome/Symptoms
Pellagra, diarrhoea, dermatitis, mental confusion/dementia

Good Food Sources
Tuna, beef liver, chicken breast, beef, mushrooms

RDI Adults
Women 14, Men 16 (niacin equivalents)

At risk of deficiency
Alcoholism, malabsorptive conditions, Hartnup disease
Pantothenic Acid

Main Coenzymes
Coenzyme A

Biochemical/ Physiological Function
Acyl transfer reactions

Deficiency Syndrome/Symptoms
Very rare- numbness and tingling of hands and feet, vomiting, fatigue

Good Food Sources
Widespread in foods esp. Egg yolk, liver, kidney, yeast

RDI not available only AI
AI women 4mg/d, men 6mg/d

At risk of deficiency
Alcoholism, malabsorptive conditions
Biotin

Main Coenzymes
N-carboxybiotinyl lysine

Biochemical/ Physiological Function
C0₂ transfer/carboxylation reactions, Biotin is a coenzyme for carboxylase enzymes, involved in the synthesis of fatty acids, isoleucine, and valine, and in gluconeogenesis

Deficiency Syndrome/Symptoms
Very rare- anorexia, nausea, depression, dry scaly dermatitis

Good Food Sources
Synthesised by gut bacteria, also found in yeast, liver

RDI not available, Al only
Al women 25, men 30 µg/day

At risk of deficiency
Excessive raw egg white ingestions (avidin: biotin-binding protein), alcoholism, malabsorptive conditions
Vitamin B₆

Main Coenzymes
Pyridoxal phosphate (PLP)

Biochemical/Physiological Function
Transamination and decarboxylation reactions

Deficiency Syndrome/Symptoms
Dermatitis, swollen tongue, convulsions

Good Food Sources
Steak, navy beans, potato, salmon, banana, wholegrains

RDI
Adults 19-50 yo 1.3mg/d, women >50 yo 1.5mg/d, men >50 yo 1.7mg/d

At risk of deficiency
Elderly, alcoholism, use of certain medications
Folate

Main Coenzymes
Derivatives of tetrahydrofolic acid

Biochemical/ Physiological Function
One-carbon transfer reactions

Deficiency Syndrome/Symptoms
Megaloblastic anaemia, diarrhoea, fatigue, depression, confusion
During pregnancy- neural-tube defects

Good Food Sources
Brewer’s yeast, spinach, asparagus, turnip greens, lima beans, beef liver

RDI adults
400 ug/d
Pregnancy 600 ug/d, Lactation 500 ug/d

At risk of deficiency
Alcoholism, malabsorptive conditions, use of certain medications
VEGEMITE

A rich source of (per 5 g serve):

- Thiamin (25% RDI)
- Riboflavin (25% RDI)
- Niacin (25% RDI)
- Folate (50% RDI or 25% RDI for women of childbearing age)
Vitamin B₃₂

Main Coenzymes
Methyl cobalamin, adenosyl cobalamin

Biochemical/ Physiological Function
Methylation of homocysteine to methionine, conversion of methylmalonyl CoA to succinyl CoA

Deficiency Syndrome/Symptoms
Megaloblastic anaemia, degeneration of peripheral nerves, skin hypersensitivity, glossitis

Good Food Sources
Meat, fish, shellfish, poultry, milk

RDI Adults
2.4 ug/d, Pregnancy 2.6 ug/d, Lactation 2.8 ug/d

At risk of deficiency
Elderly, strict vegetarians, pernicious anaemia, some disorders affecting stomach & ileum
Folate & Vitamin B$_{12}$ Interaction

- Synergistic relationship
- Without Vitamin B$_{12}$ the methyl group from 5-methyl THF can’t be removed and is trapped
- Folate supplements can mask Vitamin B$_{12}$ deficiency
Vitamin C

Biochemical/ Physiological Function
Antioxidant
Cofactor of hydroxylating enzymes involved in synthesis of collagen, carnitine, norepinephrine

Deficiency Syndrome/Symptoms
Scurvy, fatigue, poor wound healing, bleeding gums, spontaneous rupture of capillaries

Good Food Sources
Papaya, orange juice, cantaloupe, broccoli, brussels sprouts, green capsicum, grapefruit juice, strawberries

RDI Adults
45 mg/d, more in pregnancy and lactation

At risk of deficiency
Elderly, alcoholism, smoking

Interactions
Iron, copper
Vitamin Loss

• The organic nature of vitamins means they can be destroyed by exposure to light, oxidation, **cooking**, and storage.

• There are methods used to minimise nutrient losses.
  
  — Refrigerate fruits and vegetables.
  
  — Store cut fruits and vegetables in airtight wrappers or closed containers and refrigerate.
  
  — Clean fruits and vegetables before they are cut.
  
  — Use a microwave, steam, or simmer in small amounts of water.
  
  — Save cooking water for other uses.
  
  — Avoid high temperatures and long cooking times.
Summary

Today we have discussed:

- Water & fat soluble vitamins
- Food Sources

- Aim to know the key roles of each of the vitamins and at least 3 good food sources of each
- We will discuss specific vitamins in more detail in future lectures focusing on: energy metabolism, blood and bone health and antioxidants.
References


Image Sources

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Thank you