Module 4: Nutritional Deficiencies – Iron and Vitamin D

Slide 1: A Preschool Nutrition Primer for Dietitians
Module 4: Nutritional Deficiencies – Iron and Vitamin D

The Nutrition Resource Centre and NutriSTEP® present *Nutritional Deficiencies – Iron and Vitamin D*. This training module is one of five topics to increase the knowledge, skills and competence of Registered Dietitians who work in a variety of care settings. The goal of these evidence-informed Primers is to increase your comfort level to provide quality nutrition services to your clientele and support team-based care of young children.

Slide 2: Learning Objectives for this presentation are to:

- Know about iron and vitamin D metabolism and their related deficiencies
- Learn the risk factors and consequences of iron and vitamin D deficiency in children
- Be aware of the treatments used in both types of deficiencies
- Understand how to prevent iron and vitamin D deficiency in young children

Slide 3: Presentation Outline for Iron deficiency will include the following topics:

- Role of Iron
- Iron Balance and Requirements
- Long Term Consequences
- Clinical Presentation
- Stages
- Incidence and Risk Factors
- Prevention
- Treatment

Slide 4: Presentation Outline for Vitamin D deficiency will include the following topics:

- Vitamin D
    - Functions

    - Sources
    - Physiology
- Vitamin D deficiency
    - Prevalence
    - Risk factors
- Osteomalacia/Rickets
- References

Slide 5: Iron Deficiency Anemia

Is defined as low erthrocytes (also called red blood cells) and low hemoglobin. The diagram below on the left shows someone with normal amounts of red blood cells. The diagram on the right shows someone with iron deficiency anemia with decreased amounts of red blood cells.

Slide 6 & 7: Red blood cells, hemoglobin and heme

The diagram on this slide and the next shows the red blood cell, an enlarged view of a hemoglobin molecule. Each red blood cell contains several hundred hemoglobin molecules. Each hemoglobin molecule contains heme (an iron compound) – this is where oxygen binds to on the hemoglobin molecule.

Slide 8: Role of Iron in Iron Deficiency Anemia

- **Heme** is the **iron** compound in Hemoglobin
- Iron is essential in the formation of Hemoglobin
- Iron deficiency can lead to ↓ Hemoglobin
- Heme in Hemoglobin transports oxygen from the lungs to body tissues via the blood

Slide 9: Role of Iron in Iron Deficiency Anemia continued…

- Transportation and utilization of oxygen for cell energy production (this includes Hemoglobin)
- Maintains iron homeostatis (including Ferritin).
- Decrease in dietary iron leads to decrease in storage iron, leading to a decrease in hemoglobin production followed by impairment of body function

Slide 10: Iron Balance consists of absorption and excretion

- Absorption is determined by
    - body iron stores
    - form and amount of iron in foods, and

    - combination of foods in the diet
- Excretion is determined by
    - loss through intestinal mucosa
    - iron deficiency decreases excretion, and
    - iron overload increases excretion

Slide 11: Iron Absorption

There are two dietary sources of iron: Heme and Non-heme

- Heme iron:
    - Is mainly from meat, well absorbed
    - Is 10% of iron in the average diet (less for infants)
    - In the diet has little influence on its absorption
- Non-heme iron:
    - Is in iron salts
    - Is the majority of an infant's diet
    - Absorption is influenced by diet (enhancers include: meat, citric acid, ascorbic acid)
    - While inhibitors include; phosphates (such as cow's milk and egg yolk), bran, oxalates (spinach) and polyphenols (such as tannate in tea)

Slide 12: Iron Absorption

- It is well absorbed in breastmilk
- Possible factors are:
    - lower calcium and phosphate content
    - increased concentration of lactoferrin (iron binding protein)
    - increased digestibility (influence of intestinal mucosa may facilitate iron absorption)
- If there is a decrease in iron stores, it will lead to an increase in iron absorption
- If one has good iron stores, it will lead to a decrease in absorption

Slide 13: Iron Requirements from the Dietary Reference Intakes recommend

- Ages:
    - 0-6 months is 0.27mg/day
    - 7-12 months is 11.0 mg/day
    - 1-3 years is 7.0 mg/day

- 4-8 years is 10.0mg/day

Slide 14: The Long Term Consequences of Iron Deficiency Anemia

- Iron is prioritized to the red blood cells at the expense of other tissues, including the brain
- The tissue level of iron deficiency results in neurobehavioural consequences
- Poorer performance on developmental tests (motor & psychomotor)
- Poorer performance on tests of cognitive function
- May be irreversible and can not be ruled out

Slide 15: Clinical Presentation of Iron Deficiency Anemia

- Decrease in or absent iron stores (primarily ferritin)
- Decreased serum iron
- Decreased transferrin saturation
- Decreased hemoglobin and hematocrit
- Decreased Mean Cell Volume (also known as microcytic anemia)

Slide 16: Some Other Findings in Iron Deficiency Anemia are

- Decreased energy, and fatigue
- Decreased appetite (anorexia)
- Eating non-food items (pica, pagophagia)
- Poorer cognitive performance and
- Delayed psychomotor development

Slide 17: Stages of Iron Status

The diagram below shows how Iron Deficiency progresses from Iron Depletion, then Iron Deficient Erythropoesis, and finally Iron Deficiency Anemia.

Slide 18: Stages of Iron Status

This chart shows several stages of iron status, from normal, to iron depletion, to iron deficient erthryopoesis, to iron deficiency anemia. Bloodwork indicators that can be affected include ferritin, transferrin saturation, serum iron, mean cell volume, hemoglobin, and/or hematocrit.

Slide 19: Incidence of Iron Deficiency Anemia

- Is greatest incidence in children aged 1-3 years

- **9%** incidence of **iron deficiency** in US children age 1-3 years old (based on the reference NHANES III. 1989-1994)
- **And 1/3 (3%)** of those had **Iron Deficiency Anemia**
- Ages 3-11 are at less risk
- Risk increases again during rapid growth period of puberty; and females are at more risk
- Incidence of iron deficiency anemia was >20% in the early 1970s

Slide 20: Despite the decreased incidence, it is still the most common childhood nutritional problem

Slide 21: Risk Factors include:

- Premature birth
- Low birth weight (<2500g)
- Multiple births
- Low income
- Age 1-3 years
- Adolescence (especially menstruating females)
- Pregnancy

Slide 22: Diet-Related Risk Factors include:

- Use of non-iron fortified infant formulas
- Early introduction of cow's milk (<9-12 months of age)
- Exclusive breast feeding > 6 months (without alternate iron source introduced)
- Delayed introduction to iron-containing solids
- Excessive cow's milk intake or overall fluid intake to the exclusion of solids

Slide 23: Prevention of Iron Deficiency Anemia

- The American Academy of Pediatrics and the Canadian Pediatric Society have recommendations, among them …
    - Exclusive breast feeding to 6 months with introduction of supplemental source of iron at 6 months.
    - For breastfed preterm or low birth weight infants, give iron supplement drops until 12 months corrected age of (2mg/kg/day).

  - In non-breastfed infants, use of iron-fortified infant formula from birth to 12 months with introduction of iron-containing solid foods at 6 months (such as infant cereal and meat).

Slide 24: The American Association of Pediatrics and the Canadian Pediatric Society recommend

- Delay introduction of cow's milk until 9-12 months old.
- Avoid excessive milk intake of >24oz/day in children 1- 5 years old.
- Continue iron-fortified foods beyond the first year.
- May supplement high-risk children with an iron-containing multivitamin in the 2nd year, especially if there is no heme iron in the diet.

Slide 25: An example of an Iron-Rich Diet

- At least 2 servings of high-iron foods each day (e.g. infant cereal, meat)
- Include iron-absorption enhancing foods (e.g. vitamin C, heme with non-heme foods)
- Limit intake of milk (16-24oz/day)
- Limit juice (4oz/day)

Slide 26: Samples of Iron-Rich Foods include:

- Beef, chicken, turkey, lamb, fish, pork
- Cooked beans and lentils
- Eggs, peanut butter, chick peas and tofu
- Dried fruit and dark green vegetables

Slide 27: Treatment of Iron Deficiency Anemia

- Ferrous sulphate 3-6mg/kg x 3 months
- Recheck Hemoglobin or Hematocrit levels at 1 and 3 months.
- Reassess Hemoglobin or Hematocrit 6 months after successful treatment
- An iron-rich diet may be used to help maintain normal iron status (i.e. prevention)

Slide 28: Functions of Vitamin D

- It is a hormone
- It is a vitamin
- It is a gene-regulator (genomic)

- Structurally, vitamin D is derived from a steroid and is a seco-steroid since one of its rings is broken, or open
- Vitamin D and its metabolites exhibit unusual flexibility that allows interactions with binding proteins

Slide 29: Sources of Vitamin D are…

- Photosynthesis by skin whereby
  - Vitamin D3 is hydroxylated by liver to 25-hydroxyvitamin D, then is hydroxylated by the kidneys to 1,25 dihydroxyvitamin D
- Oily fish
- Shitake mushrooms
- Fortified foods: such as milk, margarine, and cereals

Slide 30 and 31:

This diagram shows the cycle of how sources of vitamin D (dietary and sun exposure) are absorbed and hydroxylated by the liver to 25-hydroxyvitamin D, the primary circulating form of vitamin D. Then it is further hydroxylated by the kidneys to 1-25-dihydroxyvitamin D, the physiologically active form of vitamin D to be used in the body as noted in the next slide, #32.

Without vitamin D, only 10-15% of dietary calcium is absorbed. The interaction of 1-25-dihydroxyvitamin D with the vitamin D receptor increases the efficiency of intestinal calcium absorption to 30-40%.

Slide 32: The Physiology of 1-25-dihydroxyvitamin D

- Most tissues and cells in the body have vitamin D receptors.
- In the Jejunum and ileum
  - It Increases the absorption of calcium and magnesium
- In the Bone
  - It is required for proper mineralization
- In the Cardiovascular system, it
  - Inhibits of vascular smooth muscle proliferation
  - Suppresses of vascular calcification
  - Down regulates of pro-inflammatory cytokines, and
  - Down regulates of renin-angiotensin system
- In the Islet cells
  - It improves insulin sensitivity

Slide 33: The Physiology of 1-25-dihydroxyvitamin D (continued)

- In the Muscle
  - It Increases protein synthesis and increased number and size of type 2 muscle fibers
- In the Skin
  - It has Antiproliferative, immunosuppressive and prodifferentiating effects
- In the Immune System
  - It expresses potent antimicrobial peptides and
  - It increases oxidative burst potential of macrophages
- In Selected Cancer Cells
  - It has Antiproliferative and prodifferentiating effects, increases apoptosis, and decreases angiogenesis

Slide 34: Vitamin D Deficiency in Canada

- Suboptimal vitamin D levels are wide spread at an estimated 1 billion worldwide.
- The Canadian population is particularly vulnerable since the sun must be greater than 45 degrees above the horizon to synthesize Vitamin D. Unfortunately, the sun is almost never 45 degrees above the horizon in the Arctic Circle.
- For most of Canada, skin photosynthesis cannot occur between October-March.

Slide 35: Osteomalacia/Rickets

Osteomalacia, also known as Rickets. The diagram shows the normal structure of healthy bones compared with the structure of one with rickets.

Slide 36: Causes and Risk Factors

The most common cause of osteomalcia or rickets is a deficiency of vitamin D. Vitamin D facilitates calcium absorption and other minerals in the gastrointestinal tract necessary for bone building. Due to the lack of vitamin D, calcium and other minerals aren't absorbed efficiently, so they are not available for mineralization in the bone building process. This results in soft bones.

The Risk Factors include:

- Insufficient sunlight exposure. Sunlight makes vitamin D in your skin. Therefore osteomalacia can develop in people who spend little time in the sunlight, wear very strong sunscreen, live in areas where sunlight hours are short, or where the air is smoggy.
- Insufficient vitamin D intake. A diet low in vitamin D is the most common cause seen worldwide. Is less common in the U.S. because many foods, such as milk and cereals, are fortified with vitamin D.
- Certain Surgeries. The removal of part or all of your stomach known as gastrectomy, can lead to this disease because the stomach breaks down foods to release vitamin D and other materials, which are then absorbed by your intestines. Surgery removing or bypassing your small intestine can lead to osteomalacia.
- Chronic pancreatitis. Pancreatitis is the long-standing inflammation of your pancreas, an organ that makes digestive enzymes and hormones. If the pancreas is inflamed, enzymes in charge of breaking down food and releasing nutrients do not flow as freely into your intestines.
- Chronic sprue. In this autoimmune disorder, the lining of the small intestine is damaged by consuming foods having gluten, a protein found in wheat, barley, and rye. Damaged intestinal lining doesn't absorb nutrients, such as vitamin D, as well as a healthy one would.

Slide 37: Symptoms and Diagnosis

In the early stages the patient may not feel the symptoms, but may be seen in X-rays or diagnostic tests.

As the condition worsens symptoms may include:

- bone pain (such as lower spine, pelvis, legs and feet) and muscle weakness
- it may cause weakness and stiffness in the arms and legs, and
- decreased muscle tone and discomfort during movement

When diagnosing, health professionals will inquire about the patient's time spent in the sun and about their diet. In order to rule out other bone diseases the following tests may be conducted:

- **Blood and urine tests.** In the cases caused by vitamin D deficiency or phosphorous loss, abnormal levels of vitamin D and minerals calcium and phosphorous are often detected through blood and urine tests.

- **X-ray**. Slight cracks in the bones, which are visible on x-rays known as looser transformation zones, are characteristic of people with osteomalacia.
- **Bone scan.** Bone scans detect areas of high and low bone metabolism in your body. Radioactive dye is injected in the vein and a picture of the amount of radioactive dye gathers in your bones. Those with osteomalacia have radioactive dye unevenly distributed in some areas of their bones.
- **Bone biopsy.** A bone biopsy is performed by inserting a slender needle through the skin and into the bone to withdraw a small sample, which is then viewed under a microscope. Even though bone biopsies are very accurate in detecting osteomalacia, it is often not needed to make the diagnosis.

Slide 38: Treatment

- If caused from a dietary or sunlight deficiency, replenishing the low serum vitamin D usually cures the condition.
- Doctors also recommend vitamin D supplements depending on the dose needed and other health problems.
- Oral Vitamin D supplements are usually prescribed for several weeks or months. Rarely done, vitamin D can also be given as an injection or through a vein in the arm.
- If serum calcium and phosphorous are low, the patient may also take these mineral supplements.
- Undergo periodic blood tests to assess vitamin D and other mineral levels are within normal limits. X-rays are taken to determine bone improvement.
- Symptoms may lessen within a few weeks of treatment but doctors suggest vitamin D indefinitely for prevention.

Slide 39: Prevention

Spend a few minutes in the sun

- Direct sun exposure to arms and legs for 5-10 minutes daily is sufficient for adequate vitamin D production.
- If living in cold climates and don't get enough sun exposure during the winter, can build enough vitamin D stores in the skin during warmer months.

- Regular use of sunscreen helps prevent skin cancer and premature skin aging but is a concern that the frequent use of strong sunscreen can increase the risk of developing ostemalacia.

Eat foods high in vitamin D such as

- Oily fishes (including salmon, mackerel, and sardines) and egg yolks.
- Fortified foods such as cereal, bread, milk, and yogurt.

Slide 40: Prevention (continued)

Take supplements

- If not enough vitamins and minerals in diet or a medical condition affecting the ability of absorb nutrients; recommend asking the doctor about taking vitamin D and calcium supplements.

Exercise

- Such as walking helps strengthen bones, but if patient has slight fractures due to osteomalacia, they should avoid strenuous activity until their bones heal.

Slide 41: Dietary Reference Intakes Updates for Vitamin D and Calcium

Health Canada and the Food and Nutrition Board of the Institute of Medicine are currently undertaking the study to assess current data and update the DRI values for calcium and vitamin D. Chronic and non-chronic disease indicators will be considered in the revisions as well as incorporating systemic evidence-based reviews of the literature and assessing potential indicators of adequate and excess intakes. Determining intake excess and adequacy will be based on strength of evidence and public health significance. The sources of uncertainty in the evidence will also be considered in this study.

The project of updating the DRI for vitamin D and calcium is a 24-month study. The study is expected to be completed by March 2011. At the present time, the vitamin D and calcium DRI values remain the same.

Slide 42:

This is the end of the presentation. There are practice questions that can be completed on your own time, and are not part of the audio presentation. The questions and correct answers are located in the separate link titled Modules 1-5: Case Study Questions and Answers.

Slides 43-45:

No voice recording.