Impact of vitamins & nutrients on neurological function

NUTRITION ACROSS THE LIFESPAN

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Outline of lecture

• Scientific Publishing and Peer Review

• Nutrition in:
  • Early Development
  • Older adults

• Break

• Nutrition in older adults
How does publishing in science work? What is peer review?
Publishing in Science and Peer Review

Video: https://www.lib.ncsu.edu/tutorials/peerreview/
Nutritional Sciences and Neuroscience

- Evidence-based
- Continually being updated by new data
- Dynamic fields that are always changing
- It is important to have tools to know what sources for recommendations to trust
Overview Video

https://www.youtube.com/watch?v=3S1wU7xHVGM
Early Neurodevelopment

- The first 1,000 days of life are crucial for brain development — and food plays an important role.

- During this critical period all of our organs and tissues are being formed and educated, setting the foundation for our lifelong health.

- Adequate nutrition during the first 1000 days
Developing brain

• First two years of life are like scaffolding for the brain.

• Literally define how the brain will work for the rest of a person’s life

• Nerves grow and connect and get covered with myelin, creating the systems that decide how a child — and the adult she becomes — thinks and feels
# Omega-3

<table>
<thead>
<tr>
<th>Long-chain PUFAs</th>
<th>Name</th>
<th>Abbr.</th>
<th>Structure</th>
<th>Food Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omega-3</td>
<td>alpha-linolenic acid</td>
<td>ALA</td>
<td>18:3n-3</td>
<td>Walnuts, flaxseed oil, soybean, and canola oil</td>
</tr>
<tr>
<td></td>
<td>eicosapentaenoic acid</td>
<td>EPA</td>
<td>20:5n-3</td>
<td>Fatty fish* and fish oils</td>
</tr>
<tr>
<td></td>
<td>docosahexaenoic acid</td>
<td>DHA</td>
<td>22:6n-3</td>
<td>Fatty fish* and fish oils and algal oils</td>
</tr>
</tbody>
</table>

PUFA = poly unsaturated fatty acids
Omega-3

• Healthy fats, that come from the diet

• Human body has a very limited ability to produce these fats.

• Particularly during pregnancy, DHA, an omega-3 found in oily fish is thought to be essential for the developing baby — for their brain, eyes and nervous systems.

• The European Food Safety Authority recommends 1,750mg of omega-3 for pregnant women

• This increased recommendation can easily be reached by including 1-2 portions of oily fish per week.
Omega-3

• Omega-3 fatty acids are also shown to be beneficial at various stages of the lifecycle.

• Among women, high fish intakes resulted in lower prevalence of postpartum depression as well as higher levels of Omega-3 in breast milk.

• It has been proposed that additional Omega-3 from supplements during pregnancy and lactation may improve an infant’s cognitive and visual development.
Neurulation marks the beginning of the formation of the central nervous system and is the process whereby the neural plate forms into a neural tube.

https://www.youtube.com/watch?v=lGLexQR9xGs
Neural Tube Defects (NTDs)

• CNS begins developing at 5 weeks after implantation and neural tube closes at week 6

• Neural tube defects are birth defects of the brain, spine, or spinal cord.

• They happen in the first month of pregnancy, often before a woman even knows that she is pregnant.

• The two most common neural tube defects are spina bifida and anencephaly.

• In 2010, 71,000 deaths as a result of NTDs (worldwide)
Detecting NTD

- Prenatal screen (Ultrasound and blood test)
- Follow up with amniocentesis (if needed)
- Some NTDS have a genetic component, genetic counselor
Example of NTD: Anencephaly

• Means without brain
• occurs during 23rd and 26th day of pregnancy
• resulting in an absence of a major portion of the brain and skull
• infants born without the main part of the forebrain—the largest part of the cerebrum
• usually blind, deaf and unconscious.
• the lack of a functioning cerebrum will ensure that the infant will never gain consciousness
• Infants are either stillborn or usually die within a few hours or days after birth
Example of NTD: Encephaloceles

- protrusions of the brain through the skull that are sac-like and covered with membrane
- groove down the middle of the upper part of the skull, between the forehead and nose, or the back of the skull.
- obvious and diagnosed immediately
Example of NTD: Encephaloceles

• abnormalities include:
  • a build-up of cerebrospinal fluid in the brain, called hydrocephalus
  • paralysis of the arms and legs
  • an abnormally small head, called microcephaly
  • uncoordinated movement
  • mental retardation
  • developmental delay
  • vision problems
  • seizures
Example of NTD: Hydranencephaly

- Missing cerebral hemispheres
- Replaced with filled sacks of cerebrospinal fluid
Spina Bifida Video

https://www.youtube.com/watch?v=6li_v3t9hpU
Spina Bifida

- In spina bifida, the fetal spinal column doesn't close
- Most Common NTD
- Varies in severity
- Affects everyone individually
Causes of NTDs

Osterhues et al., 2012
Folic Acid Before and During Pregnancy

• Shown to reduce incidence of NTD
• Folic acid supplementation for NTDs is not known
Folic Acid recommendation before or during pregnancy

• Folic acid intake for women is 0.4 to 1.0 mg per day
• Should be taken 2 to 3 months before conception, throughout pregnancy and first 4 to 6 weeks after birth (during breastfeeding)
Fortification in Canada

Since 1998 the Government of Canada has required that folic acid be added to all white flour and enriched pasta and cornmeal products sold in Canada.

Health Canada, 2008
Fortification

Table 1. Levels of folic acid fortification in countries with mandatory fortification programs.

<table>
<thead>
<tr>
<th>Country</th>
<th>Fortification level</th>
<th>Date of implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States [25]</td>
<td>140 μg/100 g</td>
<td>1998</td>
</tr>
<tr>
<td>Canada [33]</td>
<td>150 μg/100 g</td>
<td>1998</td>
</tr>
<tr>
<td>Costa Rica [34]</td>
<td>180 μg/100 g</td>
<td>1998</td>
</tr>
<tr>
<td>Chile [35]</td>
<td>220 μg/100 g</td>
<td>2000</td>
</tr>
<tr>
<td>South Africa [36]</td>
<td>150 μg/100 g</td>
<td>2003</td>
</tr>
</tbody>
</table>

Crider et al., 2011
Grain Fortification Legislation

84 countries require fortification of wheat flour, maize flour, and/or rice

To request data, e-mail info@ffinetwork.org
Fortification in Canada Results

A 7-province study showed a reduction of 46% in the overall rate of NTDs, including live births, stillbirths and cases detected prenatally in pregnancies that were subsequently terminated.

Health Canada, 2008
Fortification in Canada Results

De Wals et al., 2007
Mouse Models of NTDs

- 190 mouse models
- 150 survive mid-gestation (~ embryonic day 11)
- 20% risk of exencephaly or spina bifida

Hariis and Juriluff, 2006
Over supplementation of folic acid

- mandatory fortification has lead to increase in folate levels
- longer term effects of high folate levels not known
- Maternal folate supplementation in rats, results in small fetuses and poor protein utilization in late gestation (Achon et al., 1999)
Nutrition in older adults
Questions?
Break
Health Aging

• Super Agers
  • People who live beyond the age of 100 (centenarians) & offspring have protective factors against negative effects of aging

• For example, the gene, cholesteryl ester transfer gene is protective against cognitive decline and Alzheimer's disease
Health Aging

- Cognitive Reserve

- Same pathology, but Person 1 presents with clinical symptoms
- Biological, genetic and environmental differences
- Susceptibility
Health Aging

• Nun Study
  • National Institutes of Aging (in USA)
  • 678 American Roman Catholic sisters
  • Homogenous group (no drug use, little to no alcohol, similar housing and reproductive histories)
Health Aging

• Nun Study

  • Researchers reviewed autobiographical essays written by nuns
  • Essays lacking linguistic density, higher predictor of developing Alzheimer's disease
  • Traits in early, mid and late life have strong relationship to risk of developing Alzheimer's disease
Health Aging

• Delay the effects of aging
  • High levels of education
  • Physical exercise
  • Staying intellectually engaged (e.g. reading)
  • Maintaining social and friendship networks
  • Maintaining healthy diets (e.g. omega 3 fatty acids, protective antioxidants)
What happens to the brain during aging?

- **Preclinical**
  - Silent phase: brain changes without measurable symptoms
  - Individual may notice changes, but not detectable on tests
  - “A stage where the patient knows, but the doctor doesn’t”

- **MCI**
  - Cognitive changes are of concern to individual and/or family
  - One or more cognitive domains impaired significantly
  - Preserved activities of daily living

- **Dementia**
  - Cognitive impairment severe enough to interfere with everyday abilities

Time (Years)
What happens when the brain ages?

• Cognitive impairment and dementia increase as we age
• Dementia affects:
  • 1/50 people 65-70 years old
  • 1/5 people 80 years old
What is dementia?

- Umbrella term
- Describe range of symptoms
- Impaired cognitive capacity
- Memory loss
Alzheimer’s disease dementia

• accumulation of beta-amyloid plaque
• neurofibrillary tangles
• loss of synapses and neurons
Vascular dementia

- reduced blood flow
- caused by stroke or changes to brain vasculature
Neuropsychological changes

• Changes in orientation

  • Orientation defined as awareness of self in relation to one’s surroundings

  • Normal decline in orientation among healthy aging adults

  • Results in conclusive

  • Because of 92% of normal elderly adults (65-84 years old) presented with near perfect orientation
Neuropsychological changes

• Changes in **memory** including declarative memory, working, spatial, procedural memory

• Memories in medial temporal lobe vulnerable to age related decline, including the hippocampus
Hippocampus and Aging

• Hippocampus: critical information and consolidation of memory
• Regulation of emotion, fear, anxiety and stress
Hippocampus and Aging

• Reduction in size; structural changes
• Biochemical changes
• Changes in memory associated with hippocampus
Neuropsychological changes

• Changes in language
  • Changes in performance on verbal tasks as well as location, extent and signal intensity of fMRI
  • Example, compromised performance on tasks related to word retrieval
Nutrition in Older Adults

• Aging impacts nutrition
Nutrition in Older Adults

• **Body composition**
  • Decline in lean body mass
  • Increase in fat mass
Nutrition in Older Adults

- **Bone Density**
  - Peak density achieved around early adulthood
  - Plateaus between 3rd and 4th decades of life
  - Then declines
Nutrition in Older Adults

Endocrine function
- considerable changes
- due to alteration in hormone secretion, receptor number and alterations in sensitivity
- decrease in pancreatic beta cell function, decrease in insulin secretion
- increase risk for diabetes
- decrease in testosterone in men
- decrease in oestrogen and progesterone in women
Nutrition in Older Adults

Gastrointestinal tract
- taste and olfactory perception decline with age
- sensory desire to eat decline with age
- malabsorption of certain nutrients
- 20-50% of older adults believed to suffer from an inflammation of stomach lining
- impaired secretion of stomach acids
- intrinsic factor required for vitamin B12, impaired IF = vitamin B12 deficiencies
Nutrition in Older Adults

**Immune Function**
- dysregulation in both innate and adaptive immune function
- resulting in increased risk and severity of infection
Nutrition in Older Adults

**Energy requirements**
- Energy average requirement (EAR) is the average requirement to maintain healthy body
- EAR is calculated from metabolic rate and physical activity level
- EAR lower in elderly adults than young adults
- Increase in EAR because of comorbidities and infections
Nutrition in Older Adults

Protein requirements

- Complex
  - Too much protein bad and too little, not OK
## Assessment of nutritional status in older adults

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dietary intake</strong></td>
<td>Food dairies; frequency</td>
</tr>
<tr>
<td><strong>Anthropometric measurements</strong></td>
<td>Height, weight, BMI, skin fold thickness</td>
</tr>
</tbody>
</table>
| **Body Composition** | Dual energy X-ray absorptiometry (DEXA): determine muscle mass  
Bioelectrical impedance (BIA): assess dehydration of body |
| **Biochemical indicators** | Plasma vitamin B12; serum ferritin (iron)                                   |
| **Nutrition screening tools** | Assessment tools                                                            |
Malnutrition in older adults

• Increase in prevalence in older adults
• Common in elderly that are hospitalized and institutionalized

• Malnutrition associated with prolonged hospital stay, impaired wound healing and increase in mortality
Malnutrition in older adults

• Dementia or stroke patients
  • Dysphagia \(\rightarrow\) difficulty eating or swallowing
  • Increase risk in malnutrition
Malnutrition in older adults

• **Consequences**
  • Loss of muscle mass and strength
    • Reduced mobility
    • Affects respiratory (increase lung infection) and cardiac muscle function (heart failure)
  • Reduced immune function, increase risk of infection
  • Poor wound healing
  • Loss of mucosal integrity leading to malabsorption
  • Increase risk of pressure sores
  • Psychological impact, causing apathy and depression, exacerbates situation
Malnutrition in older adults

- Study of 1203 free living and special housed residents
- 60-90 year olds in Sweden
- Risk of malnutrition independent predictor of mortality
Malnutrition in older adults

https://www.youtube.com/watch?v=iPNZKyXqN1U
Nutritional Support

1. Oral nutrition support (ONS): food, supplements, sip foods
2. Enteral Feeding: delivery of nutrients to gut
3. Parenteral nutrition: intravenous nutrition

ONS reduced costs at hospital because reduced complications reduced mortality and hospital stay

ONS offered to free living and community dwelling older adults reduced infections, improved quality of life, fewer falls and reduced hospital admissions
Conclusions

- The developing brain requires adequate nutrition
- Negative consequences
Conclusions

- Healthy older adults more likely than young adults to achieve recommended intake of vitamins and minerals

- Absorption and metabolism of some nutrients may be impaired in older people

- Aging associated with changes in body composition and deterioration

- Fall in energy requirement and associated energy intake
Questions?
Next week: B-vitamins in development & aging