Bone Matters: Take charge of your bone health

Vitamin D: What is needed for bone health?

Stephanie A Atkinson, PhD, DSc (Hon), FCAHS
Professor, Department of Pediatrics,
McMaster University
McMaster Children’s Hospital
Information Overload on Vitamin D

D-lemmas of D!
Millions of Americans take vitamin D. Most should just stop. Outside of rare cases, rigorous studies of the supplement don’t find any health benefit. By JuliaBelluz@juliaoftoronto julia.belluz@voxmedia.com
Updated Nov 12, 2018, 11:00am EST

"D is for Discouraging: The celebrity supplement may be losing its luster."
February 2, 2019 issue of Science News headline
Magazine issue: Vol. 195, No. 2, February 2, 2019, p. 16
Vitamin D supplements aren’t living up to their hype

Recent studies say taking extra amounts of vitamin D may not be a boon for everyone!

Laura Beil, Jan 27, 2019

https://www.sciencenews.org/article/vitamin-d-supplements-lose-luster
Functions of vitamin D in humans

Active form of vitamin D: 1,25(OH)$_2$D$_3$

- Muscle strength
- Calcium absorption
- Mineral homeostasis
- Cancer cell proliferation
- Calcium reabsorption
- Vitamin D$_3$ synthesis
- PTH secretion
- Immune system regulation
- Diabetes and metabolic syndrome
- Insulin secretion
Vitamin D
Focus on Bone Health in Adults
1. Why & when do we need it?
2. How much do we need?
3. How do we know we are getting enough?
4. Are Canadians at risk of deficiency?
5. Does the new Canada’s Food Guide ensure enough vitamin D intake?
6. Does high dose vitamin D protect against fractures?
D-lemma #1

Why & when do we need Vitamin D?

Bone accrual in early life

- **Pregnant Woman**
  - Diet quality
  - Calcium intake
  - Protein intake
  - Vitamin D status
  - Key nutrients for bone health
  - Gestational weight gain
  - Body composition changes

- **Fetus**
  - Skeleton formation

- **Infant**
  - Birth weight and length
  - Infant bone mass

- **Child**
  - Child weight and length
  - Child bone mass

- **Adolescent**
  - Body mass index
  - Bone mineral density
  - Bone mineral content

Peak bone mass
Predictor of osteoporotic fracture risk
↑ 1 SD BMD = ↓ 1.5-3x risk
Support Bone Mass Growth & Maintenance

- Critical Period - Bone Gain
- Bone maintenance
- Critical Period - Bone Loss

In utero Programming

Male
Female

Peak Bone Mass
Menopause
Low Bone Mass
Osteoporosis
Suboptimal Lifestyle Factors

Weaver CM et al 2016
D-lemma #2

• How much do we need?
  o Sources & metabolism of vitamin D
  o Dietary Reference Intakes (DRIs)
  o Other recommendations
    • Why do they exist?
Vitamin D: Sources & metabolism

Negative effect
- Clothing
- SPF sunscreen
- Glass
- Pigmented skin

Vitamin D status
- 25(OH)D, bound to DBP
- 1,25(OH)₂D₃ (active hormone; acts on VDRs)
Dietary Reference Intakes (DRI): Vitamin D & Calcium

- Collaboration of Health Canada and the National Academy of Sciences in the USA
- Based on careful analysis of scientific studies analyzed in systematic reviews
- Set for a general healthy populations
  - not therapeutic guidelines for people with osteoporosis or other diseases

<table>
<thead>
<tr>
<th>AGE</th>
<th>RDA IU/day</th>
<th>Upper Level IU/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-8 yr</td>
<td>600</td>
<td>3000</td>
</tr>
<tr>
<td>9 - 70 yr</td>
<td>600</td>
<td>4000</td>
</tr>
<tr>
<td>&gt; 70 yr</td>
<td>800*</td>
<td>4000</td>
</tr>
</tbody>
</table>

* Higher due to greater variability in needs in older persons
What is the Upper Level?

Upper Level = an amount above which long-term intake might cause some adverse health effects

Basis

- Hypercalcemia (high blood calcium) caused by excess vitamin D stimulating bone loss

4-8 yr: 3000 IU (75 µg)/day
9–70+ yr: 4000 IU (100 µg)/day
Dilemma.....

Why do different vitamin D recommendations exist from other agencies???
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19-70 yr</td>
<td>600</td>
<td>1500-2000</td>
<td>800-2000</td>
<td>6000-9000</td>
</tr>
<tr>
<td>&gt; 70 yr</td>
<td>800</td>
<td>1500-2000</td>
<td>800-2000</td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td>600</td>
<td>1500-2000</td>
<td>Same as DRI/HC</td>
<td></td>
</tr>
<tr>
<td>UL, IU/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-18 yr</td>
<td>4000</td>
<td>4000</td>
<td>Same as DRI/HC</td>
<td>20,000*</td>
</tr>
<tr>
<td>&gt;19 yr</td>
<td>4000</td>
<td>10,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rationale for Vitamin D Guidelines*

- DRIs for general healthy populations not therapeutic guidelines – systematic review

- Osteoporosis Canada – target is adults at risk of osteoporosis – systematic review

- US Endocrine Society – not based on systematic review – different targets for vitamin D status and deficiency criteria and populations at risk

  *(Rosen LJ & IOM DRI committee. JCEM 2012)*

* Citations for Guidelines on last slide
D-lemma #3

• How do we know we are getting enough?
  o What to assess?
  o What are normal values?
  o Who to assess?
  o Is it easy to assess → health authority regulations?
Vitamin D Status: Serum 25-hydroxyvitamin D (25(OH)D)

Negative effect:
- Clothing
- SPF sunscreen
- Glass
- Pigmented skin
Definitions for Vitamin D Status by serum 25OHD

Severe Deficiency  EAR  RDA > 50 nM for bone health

Cut-off Values by IOM DRIs (2011)*

0  30  40  50  125

Serum 25OHD, nmol/L

*IOM. DRI for calcium and vitamin D. NAP, Washington. 2011
### “Other” Normal Values

<table>
<thead>
<tr>
<th>Vit D Status</th>
<th>DRI US/CAN 2010</th>
<th>US Endocrine Society 2010</th>
<th>Other (clinical labs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severely Deficient</td>
<td>&lt;30</td>
<td>&lt;25</td>
<td>&lt;30</td>
</tr>
<tr>
<td>Insufficient</td>
<td>30-40</td>
<td>50-75</td>
<td>&gt;30 &lt;75</td>
</tr>
<tr>
<td>Adequate/Sufficiency</td>
<td>&gt;50</td>
<td>&gt;75</td>
<td>&gt;75/80</td>
</tr>
<tr>
<td>Excess</td>
<td>&gt;150 for UL</td>
<td>&gt;250</td>
<td></td>
</tr>
</tbody>
</table>
Vitamin D Testing in Ontario

Ontario Health Technology Advisory Committee (OHTAC)*

- **Vitamin D tests in Ontario**
  - mostly requested by patients → soared in 5 yr
  - 2004 - 30,000
  - 2008 - 400,000
  - 2009 - over 730,000

- **COST**
  - 2008 - $7.1M
  - 2009 - **$66 M**

Vitamin D Testing in Ontario

OHTAC – 2010 Recommendations

• No routine vitamin D testing in general population
  o Vitamin D intake/supplementation recommended by Health Canada through education

• OHIP (and other provinces) pay for testing only for:
  o osteoporosis, rickets, osteopenia, malabsorption syndromes, and renal disease or drugs that affect vitamin D metabolism.

Report at:
Vitamin D indulgence in USA

Testing of vitamin D status in the USA

- 2000-2010: $$ Medicare in US spent on vit D testing rose 83-fold – 5th most popular after cholesterol

Vitamin D supplement sales in USA skyrocket!

$248 million
U.S. consumer spending on vitamin D in 2008

$1 billion
U.S. consumer spending on vitamin D today 2018

Answer: D–lemma  #3

Is status easily measured? → YES

- Not necessary for most people, unless uncertain of intake or risk of deficiency
- May be costly if not clinically indicated
Are Canadians at risk of vitamin D deficiency?
Vitamin D Status of Canadians

Canadian Health Measures Survey

Cross sectional survey: 3 to 79 y
N= ~5600 subjects/cycle in 15-18 sites

Cycle 1: Mar 2007 to Feb 2009
Cycle 2: Sept 2009 to Dec 2011
Cycle 3: Jan 2012 to Dec 2013

http://www.statcan.gc.ca/pub/82-625-x/2014001/article/14125-eng.htm

Cycle 4: Jan 2014 to Dec 2015

http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1170018&p2=33

Analysis of data across Cycles 1-3

SPJ Brooks et al. JAOAC Intern 2017
Vitamin D Status in Canadians: 2012-13

Chart 1
Distribution of vitamin D levels in Canadians aged 3 to 79, by age group, household population, Canada, 2012 to 2013

% Vitamin D Deficient

10%  8%  12%  6%

Source: Canadian Health Measures Survey, 2012 to 2013

http://www.statcan.gc.ca/pub/82-625-x/2014001/article/14125-eng.htm
Factors affecting vitamin D status*

- **Diet**
  - Servings milk/d
  - Servings fatty fish/d
  - Supplement use

- **Sun exposure**
  - UVB rays by season
  - Sunscreen SPF

- **Subject characteristics**
  - Age and sex
  - White/non-White
  - Serum cholesterol
  - Body Mass Index (BMI)

* Significant in multiple regression model. SPJ Brooks et al. JAOAC Intern 2017
Diet: Milk Consumption Improves Vitamin D Status

Chart 2
Average vitamin D blood levels, by milk consumption, by age group

<table>
<thead>
<tr>
<th>Age group</th>
<th>Had milk once or more a day</th>
<th>Had milk less than once a day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>68</td>
<td>59</td>
</tr>
<tr>
<td>3 to 5</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>6 to 11</td>
<td>68</td>
<td>60</td>
</tr>
<tr>
<td>12 to 19</td>
<td>67</td>
<td>57</td>
</tr>
<tr>
<td>20 to 39</td>
<td>63</td>
<td>58</td>
</tr>
<tr>
<td>40 to 59</td>
<td>68</td>
<td>58</td>
</tr>
<tr>
<td>60 to 79</td>
<td>75</td>
<td>64</td>
</tr>
</tbody>
</table>

Note: 1. Data are from Cycle 2 of the Canadian Health Measures Survey, collected from August 2009 to November 2011.
Source: Statistics Canada, Canadian Health Measures Survey.
Diet & Season: D Supplements & Sun

CHMS Cycle 2007-13

In ~21% subjects taking D-supplements:
- s25OHD changes by season similar to non-sup users
- s25OHD higher by 11 nmol/L

Note: D-supplement use rose from 2004 to 2015, especially > 31 yr (StatsCan, 6/17)

SPJ Brooks et al. JAOAC Intern 2017
Vitamin D & Population Diversity
Vitamin D Status by Skin Colour

Chart 2
Distribution of vitamin D levels of Canadians aged 3 to 79, by racial background, household population, Canada, 2012 to 2013

% Vitamin D Deficient or Insufficient

White

6% 21%

Non-white

20% 38%

http://www.statcan.gc.ca/pub/82-625-x/2014001/article/14125-eng.htm
Overweight/obese: 31% children in Canada
Adiposity: Vitamin D status in adults by BMI

- Non-whites have lower s25OHD than whites

- In both groups:
  - s25OHD with BMI
  - 25OHD likely sequestered in fat tissue and not released into blood
Answer: D-lemma #4:

WHO is at risk of sub-optimal D status?

Varies by ethnicity, diet & lifestyle

- Low sun exposure
  - Skin pigment
  - Full-coverage clothing
  - Live/work/play indoors
- Non-milk and non-fish eaters
- Non-supplement users in winter
- Obese
- Breast-fed without D supplements
Summary: Vitamin D Status (2007-13)

Adequate (serum 25OHD > 50 nmol/L)
- a level sufficient for healthy bones for most people
  ~68% of all Canadians; most children 3 to 5 yr

- Adequacy more prevalent in:
  o White vs non-White
  o Vitamin D supplement users
  o Normal weight vs obese
  o Summer vs winter
  o Milk and fish consumers

Deficient (< 30 nmol/L) ~ 6% white Canadians
  ~ 20% non-white Canadians
D-lemma #5

Does the new Canada Food Guide provide enough vitamin D?

Where is Vitamin D in new Canada Food Guide Plate?

New Canada Food Guide

Vitamin D natural & fortified foods

- Salmon: 3 oz = 794 IU
- Fortified cereal: 1 cup = 40 IU
- Fortified milk: 1 cup = 120 IU
- Egg yolk: 40 IU
CFG: Protein foods with Vitamin D

<table>
<thead>
<tr>
<th>Vitamin D IU/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
<tr>
<td>64</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>~300 – 700 IU D</td>
</tr>
</tbody>
</table>

- Lower fat milk - 2 cups or
- Fortified soy drink - 2 cups
- Egg - x1
- Fish (fatty) - 2 oz
- Fortified orange juice/cereal etc
- Cheeses - low fat & salt
- Legumes, nuts, seeds
- Lower fat kefir
- Poultry, lean red meat

**DRI vitamin D IU/d**

<table>
<thead>
<tr>
<th>Age</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-70 yr</td>
<td>600</td>
</tr>
<tr>
<td>&gt; 70 yr</td>
<td>800</td>
</tr>
</tbody>
</table>
Health Canada recognizes that it is challenging for Canadians to consume the recommended amounts of vitamin D through the current food supply.

**GOAL**

- Double vitamin D in cow and goat milk & margarine
- Allow vitamin D fortification of yogurt and fortified plant-based beverages equal to milk
- Later allow other foods to be fortified with vitamin D

Vitamin D–lemmas: Current status

**Issues:** Well documented

**Resolutions:**

- Target risk groups with education & food sources & guidance on safe vitamin D supplementation
  - Pregnant women
  - Breast-fed infants to 2 yr
  - Non-white; low sun exposure
  - Overweight
  - Non-milk/non-fish eaters
  - Those ‘at-risk’ of osteoporosis

- Improved vitamin D availability in food supply - FDR

- Need implementation strategies in community
  - Health Canada

Vitamin D Deficiency Rickets in Children: A national travesty

Canadian Pediatric Surveillance Program

- 2004 - 104 cases of rickets confirmed by x-ray
  - Mean age of 1.4 y; 75% vitamin D deficient
- 2014-15 - 149 cases reported; 48 rickets by x-ray
  - ~ 50% < 9 years age; 70% vitamin D deficient
- Who?
  - 10% Caucasian; 24% Inuit/First Nations; 33% black
  - Most breast-fed; most NO vitamin D supplements

Prevention of **Rickets** in Kids

- **Pregnancy**
  - Ensure dietary sources & vitamin D supplement (600 IU/d)

- **Infants** – Breast-fed±formula 0-2 y
  - Vitamin D drops supplement @ 400 IU/d

- **Toddlers and children**
  - D-fortified beverage – milk, soy, other plant-based
  - Or supplement @ 600 IU/d
D-lemma #6: Does high dose vitamin D protect against fractures?
Osteoporosis Therapies

- **Calcium**
  - Good dietary sources – fortified foods
  - Ca supplements not > 1000 mg/d (500 mg/dose)

- **Vitamin D**
  - 800-2000 IU/d

- **Exercise & falls prevention**

http://www.osteoporosis.ca/multimedia/tools.htm
Vitamin D: Effects on Fractures, Falls and Bone Mineral Density

• Systematic review – synthesis of 81 randomized controlled trials of 50,000 adults

Results

• No effect of vitamin D supplements > 800 IU/day
  • Risk of fractures or falls
  • Change in bone mineral density by DXA
Vitamin D: Effects on Fractures, Falls and Bone Mineral Density

Cautious Interpretation Needed

Study limitations:
- Healthy community-dwelling women >65 years
- Intervention vitamin D > 800 IU/day ± calcium
- Vitamin D alone without calcium may not be beneficial
- Participants started study with different vitamin D status

Results do not apply to people at high risk for fractures:
- Older age living in nursing homes
- Diets low in calcium and vitamin D
- Less sun exposure and mobility
- Osteoporosis

Bolland MJ et al. Lancet Diabetes & Endocrinology 2018
Osteoporosis Canada responded

- Persons with OP who take 800-2000 IU vitamin D/day
  - achieve normal 25OHD & calcium homeostasis

- Need more research to determine the optimal dose for those with osteoporosis and risk of fracture

- Avoid excess vitamin D to avoid harms

Approaches to Ensure Optimal Vitamin D Status (serum 25(OH)D) in Canadians
Vitamin D

The body itself makes vitamin D when it is exposed to the sun.

margarine, fortified milk, fish, and fortified cereals are food sources of vitamin D.

Supplements

- D₃
- D₂
- Fish oil
- Vegan
- Organic
- Gluten-free

- Capsule
- Gel cap
- Drop
- Liquid
- Flavoured
- Chewable
Vitamin D & more for Bone Health
D'end of D-lemmas!

THANK YOU!

Dr. Stephanie Atkinson – satkins@mcmaster.ca
Key References

• Institute of Medicine, DRI for Vitamin D and Calcium. http://www.hc-sc.gc.ca/fn-an/nutrition/vitamin/vita-d-eng.php

• Osteoporosis Vitamin D Guideline - http://www.cmaj.ca/content/182/12/E610.full.pdf+html?sid=f553e359-4720-4159-8b65-21638d1cc9e1


• Statistics Canada, Vitamin D blood levels of Canadians, CHMS 2013 – http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11727-eng.htm

• Brooks, SPJ et al. An analysis of factors associated with 25-hydroxyvitamin D levels in white and non-white Canadians. J AOAC Intern 2017;100:1345