Translating Science from the Bench to the Dietary Guidelines

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http://www.myplate.gov
Disclosures

Boards –

NOF
ILSI
Showalter
Pharmavite

Grants –

NIH
Dairy Research Institute
Nestle
Tate and Lyle
3 Levels of Decision about Nutrition/Diet Recommendations

1. Individual

2. Physician – Clinical Guidelines

Dietary Guidelines for Americans: The Core of Nutrition Policy
Dietary Guidelines for Americans

Legislative Mandate:


• Dietary guidelines must be issued every 5 years
• Dietary guidance issued by the Federal government for the general public is to be reviewed by the Secretaries of Agriculture, and Health and Human Services. (Departments alternate the lead role.)

[Image: ChooseMyPlate.gov]

http://www.myplate.gov
What the Guidelines Do

• Provide dietary advice to consumers
• Set policy for food assistance programs (e.g., school lunches, elderly nutrition)
• Establish overarching goals for
  – National health objectives
  – Nutrition monitoring
  – Nutrition research
• Set framework for standards in
  – Food labeling/fortification
  – Food product development
MyPlate starts with 12 patterns that Americans eat on average and makes changes needed to achieve nutrient recommendations without exceeding calories.

http://www.myplate.gov
DIETARY GUIDELINES FOOD PATTERNS BASED ON

• Food modeling to meet DRIs

• Evidence of relationship of food intake dose to health-RCTs priority
Dietary Reference Intakes

The Dietary Reference Intakes (DRI) are a set of reference values used to assess nutrient intake. The diagram illustrates the risk of inadequacy and excess as a function of intake. The key DRI values are:

- EAR (Estimated Average Requirement): The average requirement for a group of healthy individuals.
- RDA (Recommended Dietary Allowance): The daily intake level adequate to meet the known nutrient needs of nearly all healthy individuals in a particular life stage and gender group.
- UL (Tolerable Upper Intake Level): The maximum intake level unlikely to cause adverse health effects.

The graph shows that as intake increases from below the EAR to above the RDA, the risk of inadequacy decreases to 0.5. Conversely, as intake increases from below the UL, the risk of excess increases to 0.5.
Camp Calcium
Metabolic Studies
What are calcium requirements in adolescents?

Funded by NIH (NIAMS)
We LOVE the fountain!
Crossover

Study Design

Washout

Controlled diet

High or Low Ca or Salt

Controlled diet

High or Low Ca or Salt

Crossover

Washout

Metabolic Balance

Metabolic Balance
Maximal Calcium Retention as a Function of Intake

Over 1 year, represents gain of 4% skeleton

Jackman et al., AJCN, 1997
Estimated bone gain from our model increasing Ca intake from 800 → 1300 mg/d:

10% increase in peak bone mass
This could delay onset of osteoporosis by 13 years and decrease risk of fracture in postmenopausal women by 50%

Bonjour et al., Med Sport Sci 2007; 51: 64; WHO 1994
Effect of Increasing Dietary Calcium

- *Ca oral
- *Ca IV
- Intake
- Intestine
- Fecal
- Kidney
- Bone
- Ca Pool
- Absorption
- Bone formation
- Bone resorption
- Urine
- \( V_u \)
Boys have higher bone accretion than girls

Bailey et al., JBMR 14:711, 1999
Camp Calcium tested whether boys require more calcium for their larger skeletons.

Boys matched for Tanner Stage to girls

~3.6

Braun et al., AJCN, 84:4142006
Role of Race?
Differences in Regulators of Calcium Metabolism

Whites have higher Ca intake and Vitamin D status, but lower PTH than other groups.
Diet and race effects on Ca retention in adolescent girls

Ca Intake explained 12.3% and Race explained 13.7%
Ca retention in adolescent girls

Braun et al. AJCN 85:1657-63, 2007
Calcium Retention as a function of postmenarcheal age in black and white females

In NHANES III, Femoral neck BMC and BMD was 10% and 13% higher, respectively, in adult black than white women
Summary

Calcium retention varies by sex and race

- Blacks acquire more bone mass than whites and boys more than girls
- Calcium retention is influenced by calcium and salt intake and BMI
Nearly 4 out of 10 Americans Don’t Consume Enough Calcium

NCI Usual Intake Method, NHANES 2009-2010, Day 1-2, Food sources only,
Percent below estimated average requirement for calcium
Dietary Guidelines for Americans – 2010

- Shortfall food groups and related nutrients for children and adults

- Vegetables: Vit A, C, K, Mg
- Fruits: Fiber
- Whole grains
- Fluid milk and milk products: Ca, K, Vit D, Mg, P
- Oils – Vit E
Milk Provides Essential Nutrients

3 cups low-fat milk provide about:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Calcium</td>
<td>&gt;100%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>99%</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>86%</td>
</tr>
<tr>
<td>Protein</td>
<td>54%</td>
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<tr>
<td>Riboflavin</td>
<td>32%</td>
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<tr>
<td>Potassium</td>
<td>28%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>25%</td>
</tr>
</tbody>
</table>

Vit B, Vit A, Zinc, and more…

Percentages for vit D and calcium based on EAR, percentages for all others based on RDA
Dietary Guidelines 2010 recommend 3 cups milk products per day (871/mg Ca)
- Go low-fat or fat-free
- If you don’t or can’t consume milk, choose lactose-free products or other calcium sources

Median Milk Equivalent Intakes in US
- 1.6 – adult men
- 1.2 – adult women
- 2.3 – adolescent boys, aged 14 - 18 y
- 1.5 – adolescent girls, aged 14 to 18 y
- 2.4 – boys, aged 9 to 13 y
- 1.9 – girls, aged 9 to 13 y
Factors Affecting Bioavailability

Lifestage
Load
Status
Presence enhancers and inhibitors
Calcium Bioavailability from Dairy Products

- Healthy white women aged 24-42 y
- Milk intrinsically labeled with stable Ca isotopes

Calcium Bioavailability from Milk at Different Lifestages

Calcium Absorption ~40%

Calcium Absorption ~25%

Calcium Absorption ~80%
Calcium Absorption (%)

* p<0.0001


Weaver and Heaney  Calcif Tissue Int.  49:244, 1991
Fractional calcium absorption from fortified soy beverage compared to milk in young women

This led to inclusion in school lunch program.

Zhao et al. J Nutr 135:2379-2382, 2005
Public Impact

Data determined the calcium requirements for adolescents for North America – 1997

Used for 2004 Surgeon General’s Report on Bone Health

Used for 2005 Dietary Guidelines
2008 State Fair Exhibit *The Bone Zone*

- Created from Indiana Dairy and Nutrition Grant
- Won People’s Choice Award at Congressional Staff Meeting
- Traveling exhibit to Children’s Museums in IN, TN, KY, SC. Scheduled through 2013.
Another strategy to increase calcium nutrition absorption enhancers

Prebiotic fibers modulate calcium absorption by altering colonic microbiota
Functional Fibers and Mineral Metabolism

- Novel dietary fibers / prebiotics improve mineral absorption through unique interactions with colonic microflora.

- PROMITOR® Soluble Corn Fiber (SCF) increases calcium absorption in adolescent boys and girls.

- Precise mechanism by which SCF influences calcium utilization in adolescents has not been elucidated.
Study Design Testing Soluble Corn Fiber

- Adolescent girls (n=9; age 12-14 y) and boys (n=15; age 13-15 y)
- Double-blind, randomized controlled crossover
- Two 3-week metabolic balance periods
- Controlled diets with 600 mg/d calcium and 20 g/d fiber (not including SCF)
- PROMITOR® SCF in fruit snacks
SCF influenced late phase absorption

- Calcium absorption increased by 12% with SCF consumption compared to Control.
- Calcium absorption for SCF was higher than for Control at 24-48 h (*P=0.02).
- Time effect consistent with lower gut absorption.

![Bar chart showing fractional calcium absorption over 24-hour urine pools for SCF and Control groups.](chart.png)
Calcium Absorption correlated with Fermenters

Correlation with Change in Ca Absorption

- Dialister: $P<0.003$
- Oscillibacter: $P<0.008$
- Bacteroides: $P<0.03$
- Butyricoccus: $P<0.04$
- Alistipes: $P<0.05$
- Parabacteroides
- Coprococcus
- Other Lactobacillaceae
- Lactobacillus
- Other Erysipelotrichaceae: $P<0.04$
Conclusions

• First study to show that increases in these specific bacteria were significantly correlated with the observed increase in calcium absorption.

• SCF may be acting through short chain fatty acid mechanisms to increase calcium absorption.

• Consuming PROMITOR® SCF during the adolescent growth spurt poses a potential opportunity to influence peak bone mass via increasing calcium absorption.
Nutrient Interactions

Calcium and Sodium
Effect of dietary salt in calcium retention

• Metabolic balance study
  - Randomized order
  - High/low salt

• Adolescent black and white subjects matched for size and sexual maturity

Palacios, et al. JCEM 89(4):1858-1863, 2004
Dietary salt varied

- Low Na diet → 1.3 g/d
- High Na diet → 4 g/d
Calcium retention
(Mean ± SEM)

* p<0.05 for diet and race
Calcium and sodium metabolism in adolescent white and black girls appears to predict racial differences in prevalence of hypertension and osteoporosis.
4700 mg is the Adequate Intake (AI) for potassium intakes set by the IOM. For children younger than 14 years old, the AI is less than 4700 mg per day.

Only 3 % of Americans met the AI for potassium 2003-2006

NHANES

Fulgoni et al., J Nutr 141:1847, 2011
Meta-analyses of studies investigating the blood pressure-lowering effects of potassium

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean reduction, mmHg</th>
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<tbody>
<tr>
<td>Cappuccio &amp; MacGregor 1991</td>
<td>3754</td>
</tr>
<tr>
<td>Whelton 1997</td>
<td>2933</td>
</tr>
<tr>
<td>Geleijnse 2003</td>
<td>1720</td>
</tr>
<tr>
<td>Dickinson 2006</td>
<td>1877-4692</td>
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*Houston Curr Hypertens 17:471, 2003*
Nutrient Interactions

Urinary Na/K Ratio

• Benefits:
  – Incorporates both Na and K
  – “Corrects” for incomplete urine collections
  – Was shown to predict BP more strongly and consistently than Na excretion in several studies (including INTERSALT and TOHP I)
  – Was shown to predict CVD better than Na or K excretion alone in the TOHP trials

Does the source matter?
Calcium Absorption Efficiency from Various Salts at Loads of 200-300 mg in Premenopausal Women

- Ca Carbonate: ±7%
- Calcium Citrate: ±10.4%
- Ca Citrate Malate: ±2.0%
- CaH PO₄: ±13.0%
- TCP: ±13.0%
- Calcium Oxalate: ±4.0%
- Calcium Lactate: ±8%
- Calcium Sulfate: ±7%
DIETARY GUIDELINES FOOD PATTERNS BASED ON

- Food modeling to meet DRIs
- Evidence of relationship of food intake dose to health
Hierarchy of Evidence

- RCT
  - Double Blinded
  - RCT
- Cohort Study
- Case Control
- Case Series
- Case Report
- Expert Opinion
- Animal/Bench studies

Stronger Evidence

Weaker Evidence
Vitamin D and Ca Supplements Reduced All Cause Mortality by 7% compared to placebo in >70,000 median age 70y

Rejnmark et al., JCEM v97, 2012
STUDY DESIGN & THE THRESHOLD

the control group must be deficient
THE ETHICAL PROBLEM

• placing the control group on a clearly inadequate intake

ETHICALLY ACCEPTABLE?
Milk products and health

US 2010 Dietary Guidelines recommend 3 cups milk products per day (871/ mg Ca)

- For every missing dairy product equivalent, take a 300 mg Ca supplement.

Wont’ get too much.

http://www.myplate.gov
Many kinds of evidence

How does it work?  Can it be studied in people?  Specific effects?  How good is the translation?

Basic Research  Translational Research  Efficacy Studies  Effectiveness Research
Best recommendations use the totality of evidence with liberal doses of critical thinking and LOGIC!
Future Needs

• Good biomarkers for intake and health outcome measures are critical for understanding the relationship of diet and health.
• RCTs to determine requirements of nutrients/diet based on supplements and populations who are not deficient give incomplete answers.
• Improving healthy diets requires assess to health food – responsibility of everyone.