Operations
Research
Flight
Ground
Service
Education/Outreach
Clinical Nutritional Assessment (MedB8.1)

Preflight
Inflight
Postflight

![Nutrition Food Frequency Questionnaire]

- Dried fruit, fruit roll-ups, prunes
- Kuraga, mashed dried apricots, prunes
- Cobbler, cranapple dessert
- Other fruit, like apples with spice, applesauce, berry medley, fruit cocktail, mandarin oranges, mixed fruit, peach ambrosia, peaches, pears, pineapple, strawberries
- Apple cranberry sauce, apple dessert, cherries with cream sauce, foxberries, peach dessert
- Raw fresh fruits or vegetables, like apples, onions, oranges, tomatoes
- Beans, Soups
- Black beans
- Chicken consommé, cream of mushroom, hot and sour, minestrone, potato, tomato basil, vegetarian vegetable soup
- Pureed pea soup, pureed vegetable soup
- Chicken noodle soup
- Borsch with meat, cucumber soup, Kharcho mutton soup, meat and vegetable soup, noodle soup with meat
- Red beans and rice, split pea soup
Nutrition SMO
Extend MedB 8.1
Inflight Collections
CM evaluation
UPA

SV urine Ca, mg/dL

Hour of day

Urine Calcium Content
  +24%

Urine Volume
  -17%

Urine Calcium Concentration
  +49%
Fish intake may mitigate bone and muscle loss, cardiovascular, and cancer risks.
Vitamin K status does not appear affected by spaceflight (or bed rest).
Dietary Animal Protein:Potassium Ratio

<table>
<thead>
<tr>
<th>Bone Breakdown (NTX)</th>
<th>Dietary Animal Protein:Potassium Ratio (g/mEq)</th>
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<tr>
<td>0</td>
<td>0.50</td>
</tr>
<tr>
<td>250</td>
<td>0.55</td>
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<tr>
<td>500</td>
<td>0.60</td>
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<tr>
<td>750</td>
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<td>1000</td>
<td>0.70</td>
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<td>0.75</td>
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<tr>
<td>1500</td>
<td>1.00</td>
</tr>
<tr>
<td>1750</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Preflight**

- L-180: 4-d High APro:K
- L-45: 4-d Low APro:K

**Inflight**

- FD15: 4-d Low APro:K
- FD30: 4-d Monitored
- FD60: 4-d Low APro:K
- FD120: 4-d High APro:K
- FD180: 4-d High APro:K

**Postflight**

- R+30: 4-d Monitored
- R+180: 4-d Monitored
- R+365: 4-d Monitored

**NOTE:** the low ratio diet is **NOT** low protein, and **NOT** vegetarian.
Diets are designed to maintain: energy, protein, calcium, sodium.
800 IU Vitamin D/day maintains vitamin D status during flight. In Antarctic analog: Vitamin D, stress, and viral reactivation are interrelated.
Vitamin D
2011 Dietary Reference Intakes

[Graph showing the relationship between total Vitamin D intake (IU/day) and achieved 25OHD (nmol/L) for different age groups and obesity status.]
Vitamin D Dosing Study

Increased urinary calcium is more often observed at higher vitamin D doses.
Gaps remain in our understanding the interrelationships of iron, oxidative damage, immune function, and radiation.
Sodium

In 2005-2006, the average US intake of Na was estimated at 3,436 mg Na/d*
In 1990-1999, the average US intake of Na was estimated at: 3,377 mg for 31-50 yo M**
3,539 mg for 31-50 yo F

* http://www.cdc.gov/media/pressrel/2009/r090326.htm
** IOM, Dietary Reference Intakes, 2004
Biochemistry

Enzyme A

Intermediate 1

Enzyme B

Intermediate 3

C

Intermediate 2

C

Intermediate 3
Proteins
- Assembled based on “blueprints”

For many (all?) enzymes, there are small differences in blueprints across the population
- These are known as “polymorphisms”
  - poly = multiple, “morph” = forms
- Example: blood types
Everybody has 2 copies (one from mom and one from dad), resulting in four possibilities of this MTHFR polymorphism:

- **C/C** (~35% of the population)
- **C/T** (or **T/C**) (~50% of the population)
- **T/T** (~15% of the population)
Folic acid → tetrahydrofolate → 5,10-methylenetetrahydrofolate → 5,10-methylenetetrahydrofolate reductase (MTHFR)

- Homocysteine
- Methionine synthase (MS) (Vitamin B12)
  - S-adenosylmethionine (SAM)
  - S-adenosylhomocysteine (SAH)

Methionine synthase needs Vitamin B12, and Vitamin B6 is needed for cystathionine β-synthase (CBS)

- Cystathionine
- MMA 2MCA

SAM is involved in the methylation of DNA, proteins, and lipids.

Thymidine synthesis requires 5 methyltetrahydrofolate.
5,10-methylenetetrahydrofolate reductase (MTHFR)

Methionine synthase (MS)

Cystathionine β-synthase (CBS)

Vitamin B6

Vitamin B12

S-adenosylmethionine (SAM)

S-adenosylhomocysteine (SAH)

DNA, proteins, lipids

Methylated DNA, proteins, lipids

5 methyltetrahydrofolate

2-methyl citric acid (mMol/L)

Cystathionine (mMol/L)

Homocysteine (mMol/L)

MMA 2MCA

5,10-methylenetetrahydrofolate
Homocysteine misincorporation into proteins

5,10-methylenetetrahydrofolate reductase (MTHFR)

Homocysteine (umol/L)

Cystathionine β-synthase (CBS)

Vitamin B6

Methylated DNA, proteins, lipids

Hemoglobin (g/dL)

DNA, proteins, lipids

5,10-methylenetetrahydrofolate (MTHFR)

Methylated DNA, proteins, lipids

2-methyl citric acid (nmol/L)

S-adenosylhomocysteine (SAH)

S-adenosylmethionine (SAM)

5-methyltetrahydrofolate

Cystathionine (nmol/L)

Methionine synthase (MS)

Vitamin B12

DNA, proteins, lipids

2-methylcitric acid (nmol/L)

Methionine (umol/L)

Ferritin (males) µg/L

Homocysteine (umol/L)

Methionine (umol/L)
5,10-methylenetetrahydrofolate reductase (MTHFR)

Homocysteine misincorporation into proteins

Methionine synthase (MS)

Vitamin B12

S-adenosylmethionine (SAM)

S-adenosylhomocysteine (SAH)

Vitamin B6

Cystathionine β-synthase (CBS)

Methylated DNA, proteins, lipids

Homocysteine

MMA 2MCA

cystathionine

5-methyltetrahydrofolate

5,10-methylenetetrahydrofolate

tetrahydrofolate

methionine

Histidine

Serum Folate (nmol/L)

Vit B6 (4-PA, µmol/d)

DNA, proteins, lipids
Homocysteine misincorporation into proteins

5,10-methylenetetrahydrofolate
5-methyltetrahydrofolate
homocysteine (MS)
tetrahydrofolate
methionine
MMA 2MCA
cystathionine

Cystathionine β-synthase (CBS)
Methionine synthase (MS)
S-adenosylhomocysteine (SAH)

DNA, proteins, lipids

Methylation process

DNA, proteins, lipids
MTHFR polymorphisms associated with:
- Increased risk of ischemic and hemorrhagic stroke
- Increased risk of migraine

Increased homocysteine associated with:
- Increased risk of vascular events
- Increased risk of stroke
- Risk factor for retinal venous occlusive disease
- Risk factor for narrower retinal vasculature in men

Case study(ies?) exists relating folic acid deficiency and optic neuropathy

We’ve documented 4 intermediates strongly suggesting the existence of polymorphism(s) in the 1-carbon metabolism pathway.

Additional evidence: folate/B6; ferritin, hemoglobin

Follow-on proposal submitted to HHC/VIIP

Expected results:
- Inform risks
- Inform therapeutic options
- Inform VIIP research
Physiological Systems

Vehicle/Mission

Nutrient Requirements

Countermeasures