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

Preflight
Inflight
Postflight

Nutrition Food Frequency Questionnaire

<table>
<thead>
<tr>
<th>Fruit</th>
<th></th>
<th>Expedition 15</th>
<th>Number of Packets</th>
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</thead>
<tbody>
<tr>
<td>Dried fruit, fruit roll-ups, prunes</td>
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<tr>
<td>Kuraga, mashed dried apricots, prunes</td>
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<tr>
<td>Cobbler, cranapple dessert</td>
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<tr>
<td>Other fruit, like apples with spice, applesauce, berry medley, fruit cocktail, mandarin oranges, mixed fruit, peach ambrosia, peaches, pears, pineapple, strawberries</td>
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<tr>
<td>Apple cranberry sauce, apple dessert, cherries with cream sauce, foxberries, peach dessert</td>
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<tr>
<td>Raw fresh fruits or vegetables, like apples, onion, oranges, tomatoes</td>
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<tr>
<td>Beans, Soups</td>
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<tr>
<td>Black beans</td>
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<tr>
<td>Chicken consommé, cream of mushroom, hot and sour, minestrone, potato, tomato basil, vegetarian vegetable soup</td>
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<tr>
<td>Pureed pea soup, pureed vegetable soup</td>
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<tr>
<td>Chicken noodle soup</td>
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<tr>
<td>Borsch with meat, cucumber soup, Kharcha mutton soup, meat and vegetable soup, noodle soup with meat</td>
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<tr>
<td>Red beans and rice, split pea soup</td>
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</tbody>
</table>
Nutrition SMO
Extend MedB 8.1
Inflight Collections
CM evaluation
SV urine Ca, mg/dL

Hour of day

UPA

Urine Calcium Content
Urine Volume
Urine Calcium Concentration

+24%
-17%
+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).
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

- Children & Adolescents
- Young & Middle Aged Adults
- Older Adults

- Non-obese
- Obese

Total Vitamin D Intake (IU/day) vs. Achieved 25OHD (nmol/L)

Total Vitamin D intake (IU/d) vs. Achieved 25OHD (nmol/L)
Increased urinary calcium is more often observed at higher vitamin D doses.
Gaps remain in our understanding the interrelationalships 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

3500 mg/d = ISS requirement (JSC-28038); and the “old” RDA
2300 mg/d = US Dietary Reference Intake Tolerable Upper Intake Level (UL)**, and NASA exploration requirement (JSC-63555)

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

Intermediate 1

Enzyme A
vitamin

Intermediate 2

Intermediate 3
Enzyme B
vitamin

Intermediate 3

C

X

C
One Carbon Transfer

Folic acid

5,10-methylene tetrahydrofolate

5,10-methylene tetrahydrofolate reductase (MTHFR)

5 methyltetrahydrofolate

Methionine synthase (MS)

Methionine

S-adenosylmethionine (SAM)

S-adenosylhomocysteine (SAH)

Cystathionine b-synthase (CBS)

Cystathionine

Volument B6

MMA

2 MCA

Cystathionine

Methylated DNA, proteins, lipids

DNA, proteins, lipids

Thymidine synthesis

S-adenosylhomocysteine

Methylated DNA, proteins, lipids
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)
5,10-methylenetetrahydrofolate reductase (MTHFR)

Methionine synthase (MS)

Cystathionine β-synthase (CBS)

Vitamin B12

S-adenosylmethionine (SAM)

S-adenosylhomocysteine (SAH)

Methylated DNA, proteins, lipids

Pre Mean L-10 FD15 FD30 FD60 FD120 FD180 RD+0 RD+30

0 50 100 150 200 250 300 350

Homocysteine (umol/L)

Cystathionine (nmol/L)

2-methyl citric acid (nmol/L)

5 methyltetrahydrofolate

2-methyl tetrahydrofolate
Homocysteine misincorporation into proteins

5,10-methylenetetrahydrofolate reductase (MTHFR)

MMA 2MCA

cystathionine

Cystathionine β-synthase (CBS)
    Vitamin B6

S-adenosylhomocysteine (SAH)

DNA, proteins, lipids

S-adenosylmethionine (SAM)

Methylated DNA, proteins, lipids

Homocysteine

methionine

Methionine synthase (MS)
    Vitamin B12

5,10-methylenetetrahydrofolate

5 methyltetrahydrofolate

2-methyl citric acid (nmol/L)

Cystathionine (nmol/L)

Homocysteine (umol/L)

MMA (nmol/L)

Ferritin (males) µg/L

Hemoglobin (g/dL)

DNA, proteins, lipids
Polymorphism/Associated Risks

- 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

Nutrient Requirements

Vehicle/Mission

Countermeasures