Space Medicine: Terrestrial Applications for Human Health, Performance, and Longevity

Introduction to Human Space Flight
Smith L. Johnston, MD, MS, FASMA


Disclosure Information and Financial Relationships
- Associate Clinical Faculties, Dept. of Preventive, Occupational, and Environmental Medicine, University of Texas Medical Branch in Galveston and The Dept. of Community Health and aerospace Medicine, Wright State Un. School of Medicine in Dayton, Ohio.
- Medical Officer/Flight Surgeon, Johnson Space Center in Houston, Texas.
- FMR Medical Director, NASA JSC Occupational and Flight Medicine Clinic.
- Lead, NASA Wellness and Human Performance Program
- Lead, NASA ISS Fatigue Management Team
- Lead, Astronaut Medical Standards
- Member of the Medical Advisory Board of Virgin Galactic, Inc.
- Member of the Scientific Advisory Committee of Lighting Sciences, Inc.
- Member, Board of Directors, Houston Medical Center Hospice and Palliative Care, Inc.
- 1991 to 2002 ED Staff VAHC and Dept. of Internal Medicine, Kelsey-Seybold, Inc., Houston, Texas.

Medical Care in
High Performance Environments

Really High Performance Environments!

24/7 Environments

Extreme Environments
Operational Space Medicine

What NASA Flight Surgeons Do

Mission: Crew health and safety

Space Life Sciences
Exploring Space · Enhancing Life
Developing ACLS algorithms for on-orbit use and training

Astronauts experience a spectrum of adaptations in flight and postflight:
- Neurovestibular
- Cardiovascular
- Bone
- Muscle
- Immunology
- Nutrition
- Behavior

Human Response to Spaceflight

Human Responses to Weightlessness

Changes in Body Functions in 0g

Bone loss
Muscle atrophy
Decreased immune function
Cardiovascular deconditioning
Balance disorders

Change in Hydrostatic Pressures in 0g
Vision Impairment/Intracranial Pressure (VIIP) – 1 Year ISS

**Background:** Astronauts on long-duration ISS missions have experienced ophthalmic anatomical changes, visual performance decrements of varying degrees and increased intracranial pressure (as measured post flight on 5 crew members).

**Fluid Shift, Loss of Hydrostatic Drainage & Cerebral Venous Congestion**

**Cephalad Fluid Shift**

1G 0G 1G Supine

On ground Initial state in space
Pre to Post Flight Papilledema
(First case 2005. N=6)

Pre Flight
Fundoscopic images of the right and left optic disc.

Post Flight
Fundoscopic images of the right and left optic disc showing Grade 3 edema right and Grade 1 edema left.

Globe Flattening and Axial Length

Increased Pressure Retro-orbital space

Finding Present in HI Present in IH Present in VIIP

Flattening of Posterior Globes

√ 64%/78%
√ 54%/100%
43%/--
80%/--
63%/--

Alperin et al. AJNR 2013

Increased Pressure
Retro-orbital space

Possible Contributors to Increased ICP

Fluid Shift
Hyperemia
Masked Exercise
Gender (Males)
Other Factors: Metabolic, Genetic, Anthropometry
Venous Occlusion

ISS Inflight CO2 Levels:

- CO2 mission average=3.56mmHg (0.33%) (10x normal sea level atmospheric: 0.0314%)
- Average Peak CO2=11.2mmHg (0.7%) (20x)

ISS Commander Jeff Williams working on EMU and

Space Medicine:
Terrestrial Applications for Human Health, Performance, and Longevity

Introduction to Human Space Flight

Smith L. Johnston, Ill, MD, MS
Flight Surgeon and FMR Medical Director of Clinical Operations
Lead Physician, Wellness and Human Performance Program
Lead, ISS Fatigue Management Team
NASA Johnson Space Center
• Discuss the role of genetics, environment, nutrition, fitness, and psychological well being in Astronaut Health and Wellness.

• Explain how Space Medicine pre-flight screening, in-flight countermeasures, and post-flight longitudinal occupational surveillance programs contribute to Astronaut and Cosmonaut Health.

• Apply these Preventive and Occupational Space Medicine principles, programs, and technologies to terrestrial Health, Human Performance, and Longevity.

Nature Versus Nurture: The Role of Genes Versus Environment in Aging and Exceptional Longevity

Gerontologists often cite studies of life spans amongst identical twins reared apart to describe the genetic and environmental components of aging.

70-80% environment and 30-20% genes.

The study of Seventh Day Adventists at Loma Linda University who as a group have perhaps the longest average life expectancy in the United States, 88 years for men and 89 years for women.

• Vegetarian
• Don't smoke
• Regularly exercise
• Spend a lot of time with their families and with their religion

Many Americans do the opposite (e.g. excessive meat consumption, lack of exercise, smoking, etc) and thus it is not surprising that on average

• Americans die 8-10 years sooner.

The average American has the genes to reach their mid-late 80s, they just need to take very good care of themselves with proper lifestyle choices. The oldest subjects in the twin studies lived to their early to mid-eighties.

• The average life expectancy for most of us, age 86 years for men and 89 years for women.

THE BASICS

Genetics is the study of single genes and their effects.

'Gene' is defined as a region in the genome that produces a protein.

"Genomics," a term coined only 15 years ago, is the study not just of single genes, but of the functions and interactions of all the genes in the genome.

- 20,000 genes with 6 billion base pairs on 23 Chromosomes

The science of genomics rests on direct experimental access to the entire genome (genotype) and applies to common conditions (phenotype), such as breast cancer and colorectal cancer, human immunodeficiency virus (HIV) infection, tuberculosis, Parkinson's disease, and Alzheimer's disease.

These common disorders are also all due to the interactions of multiple genes and environmental factors. They are thus known as multifactorial disorders. Genetic variations in these disorders may have a protective or a pathologic role in the expression of diseases.
Polymerase Chain Reaction (PCR): Fast, inexpensive technique for making an unlimited number of copies of any piece of DNA. Sometimes called “molecular photocopying,” PCR has had an immense impact on biology and medicine, especially genetic research.

Revolution in the technical approach

Genomics + Computation + Array technology

New generation of diagnostic tests

Project Jim: A Personal Genome

- Spring of 2007, in partnership with 454 (Sequence), BCM presented Dr. James Watson with the first complete Personal Genome Sequence
  - Approx. 2 months
  - Approx. $1M

- Disease Genes from HGMD
  - Showing ~60 from 310

Entire Genome:
- 6,000,000,000 base paired sequenced chip with ~1,000 clinical associations

Cost of 1 million in 2007:
- $300,000 in 2008
- $100,000 in 2009
- ~ $5,000 in 2015

Baylor Chip:
- A 600,000 base paired sequenced chip with ~1,000 clinical associations
  - 2009 - 2 days - cost ~ $1,500
  - 2013 - 1 day - $350
Personalized Genomic Medicine

“Disease prevention and drug treatment based on knowledge of individual genetic susceptibilities … and strengths ...”

Genome + Environment = Wellness = Longevity

- Our Fuel/Environment – What we Eat and Breathe
- Aerobic Fitness and Strength
- Psychological Well-being
Genome + Environment
= Wellness & Performance
= Longevity

• Our Fuel/Environment – What we Eat and Breathe

• Aerobic Fitness and Strength

• Psychological Well-being = Sleep
Evidence on the impact of sustained exposure to air pollution on life expectancy from China’s Huai River policy

Yaya Chen*, Abram Ex涅森†, Michael Greenstone*‡, and Hongbin Li*†

*Depression Economic Department, Guanghua Management School, Peking University, Beijing, China; †Department of Economics, Harvard University, Cambridge, MA; ‡National Bureau of Economic Research, Cambridge, MA; and †Chinese Academy of Sciences and Department of Economics, Shandong University, Taiyuan, China.

This paper's findings suggest that an arbitrary Chinese policy that greatly decreases total suspended particulate (TSP) air pollution is causing the 50 million residents of Northern China to live more than 11 billion life years more than the current average. The paper's empirical approach is based on China’s Huai River policy, which eliminated the river basin to prevent air pollution from southern China’s Henan, Hebei, and Shandong regions. The study’s main finding is that the policy increased average life expectancy in the region by 5.4 years (95% CI: 3.8, 6.2) and the total number of life years increased by about 1.2 billion (95% CI: 0.94, 1.56).

The State of US Health, 1990-2010

Burden of Diseases, Injuries, and Risk Factors

Living Longer in the U.S., but Not Healthier

By Kelly Y. Young

Life expectancy in the U.S. has increased 19.3 years (from 73.3 to 92.6) over the past 100 years, but prematurity, diabetes, and obesity are some of the most common causes of death in the U.S., according to a report from the National Center for Health Statistics (NCHS). The report, which used data from the Behavioral Risk Factor Surveillance System (BRFSS), found that the top 10 leading causes of death in the U.S. are heart disease, cancer, chronic lower respiratory disease, chronic lung disease, chronic obstructive pulmonary disease, diabetes, injury and poisoning, suicide, and unintentional injury. The report also found that the leading causes of death are mostly preventable, with the exception of cancer and heart disease.
Water Quality
- Water Sampler and Recorder (WS&R)
- Total Organic Carbon Analyzer (TOCA)

Microbiology
- Airborne and Surface Sampler
- Water Microbiology Kit (WMK)
- Surface Sampler Kit (SSK)

Acoustics
- Audio Dosimeter
- Sound Level Meter (SLM)
- Acoustic Countermeasures Kit

Toxicology
- Compound Specific Analyzer - Combustion Products (CSA-CP)
- Formaldehyde Monitor Kit (FMK)
- Solid Sorbent Air Sampler (SSAS)
- Carbon Dioxide Monitor Kit (CDMK)
- Volatile Organic Analyzer (VOA)
- Grab Sample Container (GSC)
Astronaut Mortality (Oct 1, 2012)
Population Statistics (does not include last astronaut class):

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Frequency</th>
<th>Death Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>339</td>
<td>46</td>
</tr>
<tr>
<td>Male</td>
<td>269</td>
<td>42</td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>Astronaut</td>
<td>316</td>
<td>45</td>
</tr>
<tr>
<td>Payload Specialist</td>
<td>23</td>
<td>1</td>
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Causes of death:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Total Frequency</th>
<th>Death Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Circulatory</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>CNS</td>
<td>1</td>
<td>18(19)</td>
</tr>
<tr>
<td>Work Related Accidents</td>
<td>6(5)</td>
<td></td>
</tr>
<tr>
<td>Other Accidents</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

*18 of 10 accidental deaths atypical of U.S. Population work related accidental deaths

Kaplan-Meir Survival Comparisons
Astronauts are well represented by a Normal-Weight (NW), Never-Smoker (NS) population. Median lifespan estimated to be increased relative to U.S. Population
Astronauts are well represented by a Normal-Weight (NW), Never-Smoker (NS) population. Median lifespan estimated to be increased relative to U.S. Population.
Genome + Environment = Wellness = Longevity

- Our Fuel/Environment – What we Eat and Breathe
- Aerobic Fitness and Strength
- Psychological Well-being
- Sleep
Processed and Unprocessed Red Meat Consumption and Risk of Heart Failure: A Prospective Study of Men

Department of Human Nutrition, Warsaw University of Life Sciences – SGGW, Warsaw, Poland
Division of Nutritional Epidemiology, Institute of Environmental Medicine, Karolinska Institute, Stockholm, Sweden

Background—Epidemiologic studies of red meat consumption in relation to risk of heart failure (HF) are scarce. We examined the associations of unprocessed and processed red meat consumption with HF incidence and mortality in men.

Methods and Results—The population-based prospective Cohort of Swedish Men (COSM) included 37,035 men, aged 45-79 y, with no history of HF, ischemic heart disease, or cancer at baseline. Meat consumption was assessed with a self-administered questionnaire in 1997. During a mean follow-up of 11.6 y, 2,891 incidences and 265 deaths from HF were ascertained. Consumption of processed meat was statistically significantly positively associated with risk of HF in both age- and multivariable-adjusted models. Men who consumed 25 g/d processed meat compared to those who consumed <25 g/d had a 1.28 (95% CI: 1.10–1.48, P-trend=0.01) higher risk of HF incidence and 2.43 (95% CI: 1.52–3.88, P-trend<0.001) higher risk of HF mortality. The consumption of unprocessed meat was not associated with increased risk of incidence of HF or mortality from it.

Conclusions—Findings from this prospective study of men with low to moderate red meat consumption indicate that processed red meat consumption, but not unprocessed red meat, is associated with an increased risk of HF.

New Cardiovascular Risk Factor: Again, Gut Bugs, L-Carnitine, and TMAO

Trimethylamine-N-oxide production in the gut is associated with adverse cardiovascular events. In May 2013, we reported the discovery of a proatherogenic molecule, trimethylamine-N-oxide (TMAO). People with the highest blood levels of TMAO, compared with those with the lowest levels, had 2.5-fold higher risk for cardiovascular disease. TMAO is produced when certain gut bacteria metabolize carnitine. In a new study, researchers found that gut bacteria also produce TMAO when metabolizing L-carnitine, a compound that is abundant in red meat. Meat eaters produced more TMAO after meals containing a measured amount of L-carnitine than vegans did. Meat eaters also harbored more of the types of bacteria that metabolize L-carnitine into TMAO. Studies in mice confirmed that diets rich in L-carnitine increased the number of gut bacteria that metabolize L-carnitine into TMAO and were associated with atherosclerosis in the mice. Plasma L-carnitine levels in human subjects who underwent cardiac evaluation predicted adverse cardiovascular events during the months following evaluation, after adjustment for risk factors. And, as in the lecithin study, when gut bacteria in mice were eradicated by antibiotics, diets rich in L-carnitine did not lead to higher TMAO production or to atherosclerosis.

Comment: Taken together, these two L-carnitine studies plus the lecithin study reveal a new cardiovascular risk factor — trimethylamine-N-oxide — that is profoundly affected by gut bacteria. Thus, these studies provide another example of the importance of the gut microbiome on our health.

— Anthony L. Komaroff, MD

Published in Current Opinion on General Medicine June 6, 2013

World Health Organization 2015

The World Health Organization said Monday that eating processed meat such as sausages and ham causes cancer, while unprocessed red meat may also be carcinogenic. The WHO’s cancer research unit now classifies processed meat as “carcinogenic to humans” based on evidence from hundreds of studies, and linked it specifically to colorectal, or colorectal, cancer.

The report outlined that simply eating 50 grams of processed meat each day — the equivalent of two slices of ham — could increase the risk of such cancer by 18%. However, the authors say the risks are relatively small to begin with.

The organization defines processed meat as any type of meat that is salted, cured or smoked to enhance its flavor or preserve it. Processed meat generally contains pork or beef, but may also contain poultry.

The WHO now classifies processed meat in the same category as smoking and asbestos, because of the certainty of a link with cancer, but stressed that did not mean they were equally dangerous.
LDL size, plasma viscosity, luminal pressure, coagulation factors, Immunological insults, inflammatory stressors/chemicals, and others (NO)

Diet
- Fruits and Vegetables = polyphenols, flavonones, omega-3, 7, 9, resveratrol (red wine)...

Exercise
- Lowers LDL, increases HDL, decreases belly fat, increases antioxidants, and blood flow

Floss
- Gingivitis, gum disease = inflammation

CBT
- Sleep and Stress reduction

Rxs
- Statins
Intravascular Ultrasound Coronary Imaging

Rotating Transducer

Normal Coronary Anatomy

Comparison: Normal vs. Diseased Site

Normal Coronary Site

Disease Coronary Site

Theory: Glagov Remodeling Phenomenon

Early Atherosclerosis

More Advanced Disease

Diffuse Disease Not Fully Appreciated by Angiography
High Prevalence of Coronary Atherosclerosis in Asymptomatic Teenagers and Young Adults
Evidence From Intravascular Ultrasound

E. Mintz Tawor, MD; Stacie R. Kapadia, MD; Jeryl Tung, MD; Khaleed M. Zada, MD; Robert E. Higgins, MD; Patrick M. McCarthy, MD; Janusz B. Young, MD; Steven E. Nissen, MD

Background—Most of our knowledge about atherosclerosis at young ages is derived from autopsy studies, which have inherent limitations. Current data on atherosclerosis in young individuals are limited. Intravascular ultrasound provides a unique opportunity for in vivo characterization of early atherosclerosis in a clinically relevant context.

Methods and Results—Intracoronary ultrasound was performed in 265 heart transplant recipients 30-91 ± 32 days after transplantation to investigate coronary arteries in young asymptomatic subjects. The donor population consisted of 140 men and 125 women (mean age, 33 ± 13 years). Intracoronary ultrasound segments were divided into proximal and distal segments. End-diastolic intima-media thickness (EDTIM) was measured in each coronary artery segment. A total of 2049 scans were performed in 1477 segments in 374 coronary arteries (1.7 per person) were analyzed. An atherosclerotic lesion was present in 146 patients, or 31.0%. The prevalence of atherosclerosis varied from 7% in individuals <20 years old to 23% in those 30-39 years old. Median TIDM was 1.05 (IQR 0.88-1.60 mm) vs 1.70 (IQR 1.35-1.55 mm), respectively. For all age groups, the proximal intima-media thickness was greater in men than women, although the prevalence of atherosclerosis was similar (27% in men and 31% in women).

Conclusions—This study demonstrates that coronary atherosclerosis begins at a young age and that lesions are present in 1 of 4 teenagers. These findings support the need for aggressive efforts at coronary disease prevention in young adults.

(Circulation. 2003;107:2765-2770.)

Images courtesy of HeartScan San Francisco
Intravascular Ultrasound Insights into the Regression and Progression of Atherosclerosis

Steven E. Nissen, M.D., Chairman, Department of Cardiovascular Medicine, Cleveland Clinic, Cleveland, Ohio
June 22, 2010

Get your numbers right with Diet, Exercise, and Statins
LDL < 77
HDL Increase of 15%
Study Overview

- In this trial, intravascular ultrasonography was used to compare the effects of atorvastatin versus rosuvastatin on regression of coronary atherosclerosis.

- Both statins led to regression in two thirds of patients, with no significant difference between their effects.
Mean IHT = \frac{\sum_{i=1}^{n} \delta_i}{n}

Left 0.91 mm
Right 0.77 mm
**Calculation of Cardiovascular Disease Risk Among ISS Astronaut Candidates:**

Sept. 6th 2012 – AMB concurred with the NSBRI Cardiac Summit Expert Panel Recommendations:

Use MESA to calculate 10-year risk, based on CACS and FRS

**Apply the following risk reduction factors:**

**Statin Risk Reduction**
- 30% reduction for statin usage meeting 100mg/d LDL target
- 35% reduction for statin usage meeting 70mg/d LDL target

**Fitness Risk Reduction**
- 40% reduction for VO₂max >10 METS <11.5 METS
- 45% reduction for VO₂max >11.5 METS <13 METS
- 50% reduction for VO₂max >13 METS

**HS-CRP Risk Modification**
- 5% risk reduction for hsCRP <0.5
- 5% risk increase for hsCRP >3.0<br>

This was validated by a later in the year Lancet 2012 article that showed Highly Fit individuals on Statins had 70% Reduction in Mortality - Hallal PC and Lee RA. Prescription of physical activity. An undervalued intervention. Lancet 2012; DOI:10.1016/S0140-6736(12)61894-2. Available at: [https://www.thelancet.com](https://www.thelancet.com).

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**USAF Aeromedical Consultation Service (ACS) Database Analysis of Coronary Artery Disease (CAD)**

- 1487 male aviators
  - mean age 43 years, follow-up 14 years
- 929 Normal NML (no lesions)
- 249 mild CAD (minCAD < 50% aggregate stenosis),
- 124 moderate CAD (modCAD 50-120% with no two 50% lesions and no lesion >70%)
- 185 severe CAD (SCAD > 120% aggregate stenosis)
- Average annual event rates at two, five, ten and 15 years for:
  - cardiac death, first nonfatal MI or first coronary revascularization

---

**MESA (Multi Ethnic Study of Atherosclerosis) + Framingham + Calcium = 30% ten year risk**

Framingham (Age, gender, HDL (80), TCH (149), Systolic BP (118), Smoking history [1.], + Calcium of 483

LDL (81), HDL (80), CRP (0.2), and Fitness met rate (13.5) numbers

**Statin Risk Reduction**
- 30% reduction for statin usage meeting 100mg/d LDL target
- 35% reduction for statin usage meeting 70mg/d LDL target

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- 40% reduction for VO₂max >10 METS <11.5 METS
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**MESA Calcium Score 10 year risk**
- 30% x 30 = 27.0
- 30% > 30/10 year = 0.30/year < 0.5/year

Recent data has shown that because MESA data included a population from the age of 45 to 85 years, when a similar population ages 45 to 65 years, the MESA 10-year risk dropped to 12% per 10 years.

MESA Calcium Score 10 year risk 12% x 30 = 0.8
- 12-15 years = 0.07/year
- 15-20 years = 0.33/year
- 20-25 years = 0.33/year
- 25-30 years = 0.33/year
- 30-35 years = 0.33/year
- 35-40 years = 0.33/year
- 40-45 years = 0.33/year
- 45-50 years = 0.33/year
- 50-55 years = 0.33/year
- 55-60 years = 0.33/year
- 60-65 years = 0.33/year
- 65-70 years = 0.33/year
- 70-75 years = 0.33/year
- 75-80 years = 0.33/year
- 80-85 years = 0.33/year

---
Cardiac death, first MI or first revascularization

Average Annual Event Rates

<table>
<thead>
<tr>
<th></th>
<th>2 years</th>
<th>5 years</th>
<th>10 years</th>
<th>15 years</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Min CAD</td>
<td>0.6%</td>
<td>0.4%</td>
<td>0.9%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Mod CAD</td>
<td>1.2%</td>
<td>2.4%</td>
<td>2.3%</td>
<td>2.4%</td>
</tr>
<tr>
<td>SCAD</td>
<td>6.3%</td>
<td>3.3%</td>
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<td>3.2%</td>
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LDL (85), HDL (80), CRP (0.2), and Fitness met rate (13.5) numbers

Statin Risk Reduction
80% reduction for statin usage meeting 100mg/L LDL target
35% reduction for statin usage meeting 70mg/L LDL target

Risk Reduction
40% reduction for VO2max > 10.5 METS
45% reduction for VO2max > 11.5 METS
50% reduction for VO2max > 13.5 METS

HS-CRP Risk Modification
3% risk reduction for hsCRP < 0.5
5% risk INCREASE for hsCRP > 3.0 x 20

Kerstman PRA on USAF ModCAD Data of 1.2% per year by a 70% to 90% reduction on revascularization only (there has not been an MI or sudden death episodes in the USAF data to date)

Using the conservative 70% reduction = 0.36%/year < 0.5/year

**Medical Risk Matrix: MDC-1 Annual Cardiac Event Risk: 0.36%**

Eric Kerstman MD, MPH
Presentation to the AMB
05 February 2014

**Evidence of a New/Novel Risk Calculator to Estimate the Short-Term Risk of an Acute Coronary Event in Astronauts: The Adaptive Cardiac Risk Calculator and Risk Modification Tool (ASTRONAUT)**

B. Kerstman, E. Levine, J. P. Rovner

The Department of Internal Medicine and Division of Cardiology, the University of Texas Southwestern Medical Center, Dallas, TX, for Aerospace and Environmental Medicine

**ABSTRACT:** Recent changes in the scope and objectives of NASA missions require new approaches to address the risk of catastrophic medical events among astronauts, particularly as astronauts (35 events) during current 12-month missions. Using available risk factors in the Framingham Heart Study (FHS), new models were developed to incorporate age, sex, and race. These models were validated for the general population. The models were then validated using the Framingham Heart Study, the Baltimore Longitudinal Study on Aging, and the Multiethnic Study of Atherosclerosis. The models were then used to generate a risk calculator that incorporates age, sex, and race. The calculator also incorporates a variety of other factors to generate a risk score. The risk calculator can be used to estimate the risk of a cardiac event over a 10-year period for an individual. The calculator also incorporates a variety of other factors to generate a risk score. The risk calculator can be used to estimate the risk of a cardiac event over a 10-year period for an individual. The calculator also incorporates a variety of other factors to generate a risk score. The risk calculator can be used to estimate the risk of a cardiac event over a 10-year period for an individual. The calculator also incorporates a variety of other factors to generate a risk score. The risk calculator can be used to estimate the risk of a cardiac event over a 10-year period for an individual.
Cardiac death, first MI or first revascularization

Average Annual Event Rates

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Risk-based Decision Analysis

- Low risk
  - Likely: ≥2% <5%
  - Possible: ≥1% <2%
  - Unlikely: <1%
  - Highly unlikely: <0.5%

- Moderate risk
  - Full utilization of all available medical resources

- High risk
  - Beyond capability of ISS medical resources
  - Planned decrewing (medical evacuation)
  - Emergency evacuation

A Strategy to Arrest and Reverse Coronary Artery Disease: A 12-Year Longitudinal Study of a Single Physician’s Practice

Caldwell B. Esselstyn, Jr., MD

Participants 1985 - 1988

23 men, 1 woman with severe triple vessel coronary artery disease – age range 44 - 68
Goal

- Maintain total serum cholesterol < 150 mg/dl
- Maintain LDL serum cholesterol < 80 mg/dl

Foods to be Included

- Grains
- Legumes, lentils
- Vegetables
- Fruit

Reversal of Coronary Disease

November 27, 1996
July 22, 1999

Link to Nutrition and healthy eating webpage

Vegetarian diet: How to get the best nutrition

A well-planned vegetarian diet is a healthy way to meet your nutritional needs. Find out what you need to know about a plant-based diet.

By Mayo Clinic Staff

A well-planned vegetarian diet can meet the needs of people of all ages, including children, teenagers, and pregnant or breast-feeding women. The key is to be aware of your nutritional needs so that you plan a diet that meets them.

Types of vegetarian diets

NASA astronaut Steve Swanson harvests a crop of red romaine lettuce plants that were grown from seed in space.

Photo NASA
Veggie Overview

- Small Vegetable Production System ~ 0.15 m² growing area
- Flew to ISS on SpaceX-3 and was installed in Columbus module in May, 2014
- Initial experiments validated capabilities using ‘Outrageous’ red romaine lettuce

Dietary Recommendations

- >90% of WHO requirement
- 2-3 servings of fish/wk (aim for n-6:n-3 ratio of <3.4)
- ≥ 6 servings fruits and vegetables per day
- ≥ 5 servings of lycopene-rich foods/wk
- ≥ 2 flavonoid-rich foods per day
- Maintain protein intake at 1.2-1.7 g/kg BW
- Maintain potassium intake at 3500 mg/d
- Maintain calcium intake at 1000-1200 mg/d
- Keep sodium intake as close to 2300 mg/d or lower
- Keep iron intake as close to 10 mg/d or lower
- Vit D3 800 Units/day

Increasing Literature Data on Link between Food/Microbiome and Psychosocial Health

<table>
<thead>
<tr>
<th>Food/Microbiome and Psychosocial Link</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omega-3 fatty acids and mood, personality, behavior</td>
<td>Conklin et al. (2007)</td>
</tr>
<tr>
<td>Poor diet, nutrition deficiency, antisocial behavior</td>
<td>Tarver (2014)</td>
</tr>
<tr>
<td>Brain-gut axis and psychobiotics</td>
<td>Dinan and Cryan (2013)</td>
</tr>
<tr>
<td>Probiotics and neuroactive compound production</td>
<td>Wall et al. (2014)</td>
</tr>
<tr>
<td>Probiotic and reduced psychological distress</td>
<td>Messaoudi et al. (2011)</td>
</tr>
<tr>
<td>Probiotic and reduced anxiety</td>
<td>Rao et al. (2009)</td>
</tr>
</tbody>
</table>

Space Food System Evolution and Challenges for Deep Space Exploration Missions

Grace Douglas, Ph.D.
NASA Human Research Program
Advanced Food Technology
July 28, 2015

Astronaut Kjell Lindgren Corals the Supply of Fresh Fruit

Sunday Styles

The Longevity Feast
Wellness
Preventive Medicine
And Human Performance

1. What we Breath and Eat
   - Our Fuel/Environment
2. Exercise and Strength
   - Staying Physically Fit
3. Psychological Well-being

All-Cause Death Rates by CRF Categories—3120 Women and 10 224 Men—ACLS

Blair SN. JAMA 1989

Florida man dies after asking if bulletproof vest still worked

09/12/2016

TAMPA, Fla. — Police say his cousin, 45-year-old Alexander Garbaldi, pulled out a gun and responded, "Let's see."

Officers found Mendez outside the house with a gunshot wound in his chest. Mendez died a hospital.

"According to the report, Garbaldi initially told officers he found his wounded cousin after hearing a gunshot. However, police say a witness described Garbaldi shooting Mendez.

Police say the vest was found inside the house with a gunshot. Garbaldi was held Sunday without bail on a manslaughter charge. Hillsborough County Jail records didn't show whether he had an attorney.

Blair SN. JAMA 1989
CRF and Breast Cancer Mortality
- 14,551 women, ages 20-83 years
- Completed exam 1970-2001
- Followed for breast cancer mortality to 12/31/2003
- 68 breast cancer deaths in average follow-up of 16 years
- Odds ratio adjusted for age, BMI, smoking, alcohol intake, abnormal ECT, health status, family history, & hormone use

Sui X et al. MSSE 2009; 41:742

Cardiorespiratory Fitness and All-Cause Mortality, Women and Men ≥60 Years of Age
- 4060 women and men ≤60 years
- 989 died during ~14 years of follow-up
- ~25% were women
- Death rates adjusted for age, sex, and exam year

Sui M et al. JAGS 2007.

Joint Associations of CRF and % Body Fat with All-cause Mortality, ACLS Adults 60+
- Deaths adjusted for age, sex and exam year

Sui M et al. JAMA 2007; 298:2507-16

http://www.youtube.com/watch?v=aUaInS6HIGo

Dr. Evans is an Associate Professor of Family Medicine and Public Health at the University of Toronto, staff physician at St. Michael’s Hospital, and Director of the Health Design Lab at the Li Ka Shing Knowledge Institute of St. Michael’s Hospital.
3 Major Muscle Groups
- Knee (L&R)
- Shoulder (L&R)
- Back

Isokinetics
Occupational — Injury Reduction Model
Pioneered the development of a composite Single Index Score for an overall strength rating.
SIS
Utilizing Standardized Protocols and a Proprietary Algorithm

Occupational — Isokinetic Testing

Results
Reductions in incidence and severity of workplace injuries
Reductions:
- Incidence of injury (50%)
- Average Cost per injury (50%)
- Compound for up to 65% to 75% cost reductions

Wellness
Dr. Steven Blair

Association between muscular strength and mortality in men: prospective cohort study
James P Peiris, Anupam S. Jha, Florian Lubelski, James R. Macdonald, Jr, Adam W
Jacobsen, Michael Brachman, and Steven R Blair
SIS Strength Mortality Data

<table>
<thead>
<tr>
<th>Level</th>
<th>SIS</th>
<th>Deaths</th>
<th>Count</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>&lt; 2.93</td>
<td>14</td>
<td>161</td>
<td>8.70%</td>
</tr>
<tr>
<td>Medium</td>
<td>2.93-3.14</td>
<td>57</td>
<td>676</td>
<td>8.43%</td>
</tr>
<tr>
<td>Med. Heavy</td>
<td>3.15-3.37</td>
<td>90</td>
<td>1440</td>
<td>6.25%</td>
</tr>
<tr>
<td>Heavy</td>
<td>&gt;3.38</td>
<td>109</td>
<td>3316</td>
<td>3.29%</td>
</tr>
<tr>
<td>Very Heavy</td>
<td>&gt; 4.04</td>
<td>3</td>
<td>122</td>
<td>2.46%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>270</td>
<td>5593</td>
<td></td>
</tr>
</tbody>
</table>

SIS Strength Mortality Data (P < 0.001)

Percent Survival (Years) by SIS Score

Example: Smith Johnston - Males greater than 55 years of age

Part V: Projected Post-Rehab SIS

Example: SIS moved from 3.27 to 3.47 18% association in 10 year survival
Does Muscle Strength During Adolescence Predict Longevity?

Male teens with low muscle strength had excess risk for premature death. In adults, low muscle strength is associated with higher rates of all-cause and cardiovascular death, but whether the same is true for adolescents is unknown. In this prospective cohort study, Swedish investigators analyzed national data from mandatory conscription examinations in >2.1 million male adolescents (age range, 16–19) to determine the association between muscle strength and premature death (i.e., before age 55).

During a median follow-up of 24 years, >26,000 participants died. Adolescents in the lowest decile of muscle strength had the highest mortality. In analysis adjusted for multiple variables, high muscle strength (as measured with knee extension and handgrip) was associated with 20% to 30% lower risk for premature death from cardiovascular disease and suicide. Muscle strength was not associated with premature death from cancer.

Comment: This large observational study suggests that low muscle strength during adolescence is a risk factor for premature death. However, whether strengthening programs aimed at adolescents with low muscle strength can lower premature mortality is unclear. Nonetheless, the authors’ recommendation that such teens be encouraged to exercise is reasonable.

Published in Journal of the American Medical Association. December 6, 2012

Citation(s): Omede FB et al: Muscular strength in male adolescents and premature death: Cohort study of one million participants. BMJ 2012 Nov 20; 345:e7279. http://dx.doi.org/10.1136/bmj.e7279
Wellness  
Preventive Medicine  
And Human Performance

1. What we Breath and Eat  
   - Our Fuel/Environment
2. Exercise and Strength  
   - Staying Physically fit
3. Psychological Well-being  
   - Sleep

NASA Flight Surgeon Training:  
Sleep, Insomnia, and Fatigue Countermeasures  
in High Performance Environments

---

Smith L. Johnston, MD  
NASA Johnson Space Center, Houston, TX

<table>
<thead>
<tr>
<th>MEDICAL CONDITIONS</th>
<th>PSYCHIATRIC CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthritis</td>
<td>Anxiety</td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>Depression</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>Personality disorders</td>
</tr>
<tr>
<td>Heart failure</td>
<td></td>
</tr>
<tr>
<td>Hyperthyroidism</td>
<td></td>
</tr>
<tr>
<td>Neurological disorders</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>PRIMARY SLEEP DISORDERS</th>
<th>PSYCHOSOCIAL FACTORS</th>
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<tr>
<td>Periodic limb movements in sleep</td>
<td>Bereavement</td>
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<tr>
<td>Sleep disordered breathing</td>
<td>Relocation</td>
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<table>
<thead>
<tr>
<th>CIRCADIAN RHYTHM DISORDERS</th>
<th>INSOMNIA</th>
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<tbody>
<tr>
<td>Advanced / delayed sleep phase</td>
<td></td>
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<tr>
<td>Irregular sleep/wake schedule</td>
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</table>

<table>
<thead>
<tr>
<th>POOR SLEEP HYGIENE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
</tr>
<tr>
<td>Caffeine</td>
</tr>
<tr>
<td>Nicotine</td>
</tr>
</tbody>
</table>

Sleep environment  
Sleep schedule  

<table>
<thead>
<tr>
<th>MEDICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta blockers</td>
</tr>
<tr>
<td>Bronchodilators</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
</tr>
<tr>
<td>CNS stimulants</td>
</tr>
<tr>
<td>Corticosteroids</td>
</tr>
<tr>
<td>Decongestants</td>
</tr>
<tr>
<td>Stimulating antidepressants</td>
</tr>
<tr>
<td>Thyroid hormones</td>
</tr>
</tbody>
</table>


Fatigue: Three (3) Aspects

1. Acute Fatigue: Continuous hours of being awake
2. Chronic Fatigue: Cumulative sleep loss, e.g. sleep debt over past two weeks
3. Circadian time of day (jet lag)

Aeromedical Causal Factors
Reported in Mishaps & HAZREPS

CAPT N. Davenport; NAVSAFECEN data from CAPT John Lee & Mr. John Scott; FY’s 1990-2004

Risk Factor for Physician Errors

- Residents and interns working recurrent 24-hour shifts
- Must 34% more serious mistakes and 5 times the serious diagnostic errors of those working shorter hours (Landrigan et al., 2004)
- Experience a 2-fold increase in on-the-job attentional failures at night (Lockley, et al., 2004)
- Experience a 61% more needlestick and other injuries in the latter hours of work (Ayas, et al., 2006)
- Experience a 1.5 to 2 standard deviance deterioration in clinical and nonclinical performance (Philbert, 2005)
- Make 3 times more fatigue-related preventable adverse events responsible for patient deaths (Barger, et al., 2006)
Fatigue: Three (3) Aspects

1. Acute Fatigue: Continuous hours of being awake

2. Chronic Fatigue: Cumulative sleep loss, e.g. sleep debt over past two weeks

3. Circadian time of day (jet lag)
Long Hours of Wakefulness Degrades Performance

ALCOHOL  WAKEFULNESS

Worse Performance


Jet Lag Disorder Treatment
Computer Based Modeling

FAST is available for commercial purchase at fatiguescience.com

Team Aerospace Begins Here!

Case Study: WJAFG 2014 case, 2 May 2014

Circular Relationship Between Insomnia and Medical Disorders

Insomnia

Stress -
Somatic Manifestations

Night shift work is Associated with:

- Motor vehicle crashes
- Disturbed hormone regulation
- Glucose tolerance
- Weight gain; diabetes risk
- BP; Cardiovascular disease
- Labile emotions
- More distractible; attention span
- Impaired cognition, learning, memory
- Burnout, depression
- Inflammation, infection risk
- Vaccination response
- Cancer risk

Behavioral changes: Diet, smoking, alcohol

Standard Sleep-shifting Schedules for ISS training

(1) Houston to Moscow
(2) Moscow to Houston
(3) Houston to Cologne
(4) Cologne to Houston
(5) Houston to Japan
(6) Japan to Houston
Sleep:
- Humans average 7-9 hours of sleep each night.
- Total sleep duration decreases throughout life.
- Sleep divided into two distinct types:
  - Rapid eye movement (REM): Dreaming occurs, Wakeful-like EEG, Reduced voluntary muscle activity.
  - Non Rapid Eye Movement (NREM): Considered restorative sleep, Arousability, BP, and heart rate decreased.
Unlike terrestrial mammals, marine mammals (cetaceans) swim while asleep and do not have slow wave sleep (SWS) simultaneously in both hemispheres; the eye contralateral to the hemisphere with SWS stays closed, while the other eye stays open.


**Figure 1.** Eight-hour EEG recording in healthy person without insomnia. REM, rapid eye movement.

**Figure 2.** Eight-hour EEG recording in person with insomnia. REM, rapid eye movement.
NATURAL ROUTINES

Crucial hormones related to muscle gain and recovery are all dependent on circadian rhythms

- Growth Hormone
- Cortisol
- Testosterone

ATHLETIC PERFORMANCE FOLLOW A CIRCADIAN RHYTHM

- There is a direct correlation between peak core body temperature and athletic performance (Klein et al., 2007)
  - Core body temperature is the premier indicator of circadian phase.
  - 400m mean time was 169.5s
  - Peak to trough was 5.6s
- Generally, improved performance occurs in the late afternoon 16:00-20:00, with amplitudes of 2-11% over the mean (Forbes-Robertson et. al; 2013)
  - Neuromuscular performance
  - Maximal oxygen uptake
  - Back, Arm and Leg strength
  - Grip strength
  - Cognition
- New Studies show that core body temperature alone doesn’t dictate performance (Pullinger et al.)

Baseball teams beaten by jet lag

Eastward travel by the visitors is a disadvantage for them

<table>
<thead>
<tr>
<th>Visitor’s direction of travel</th>
<th>No. of games</th>
<th>won</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No travel</td>
<td>712</td>
<td>395</td>
<td>54.1</td>
</tr>
<tr>
<td>East–west</td>
<td>144</td>
<td>109</td>
<td>76.2</td>
</tr>
<tr>
<td>West–east</td>
<td>170</td>
<td>110</td>
<td>62.9</td>
</tr>
<tr>
<td>Totals</td>
<td>1,023</td>
<td>614</td>
<td>63.9</td>
</tr>
</tbody>
</table>

When visiting team flies from West Coast to East Coast, East home team wins 63%
When visiting team flies from East Coast to West Coast, West home team wins 56.5%

Sleep after learning is critical for memory consolidation

We integrate new learning with prior knowledge, rehearse routes, and revisit places.

Requires unconscious state we call sleep
Brain May Flush out Toxins During Sleep; Sleep Clears Brain of Molecules Associated With Neurodegeneration: Study

Insomnia

Medical Conditions
- Arthritis
- Chronic lung disease
- Chronic renal failure
- Heart failure
- Hyperthyroidism
- Neurological disorders

Primary Sleep Disorders
- Periodic limb movements in sleep
- Sleep disordered breathing

Circadian Rhythm Disorders
- Advanced / delayed sleep phase
- Irregular sleep/wake schedule

Medications
- Beta blockers
- Bronchodilators
- Calcium channel blockers
- CNS stimulants
- Corticosteroids
- Decongestants
- Stimulating antidepressants
- Thyroid hormones

Psychiatric Conditions
- Anxiety
- Depression
- Personality disorders

Psychosocial Factors
- Bereavement
- Relocation

Sleep: Upon selection, assignment and needed - FS or FMT
Comprehensive Assessment and Training - Every three years or as needed - FS or FMT
Ground Assessment of Medications
Sleep Disorders Screening - Chronobiologic - Hypnotic - Alertness Medications
Pre - Travel or Shift Work Consultation

Clinical Practice Guidelines
Managing Circadian Desynchrony

NASA Guidelines for Management of Circadian Desynchrony in IS Operations

Laminar Organization of the Retina
Melanopsin-containing intrinsically photosensitive retinal ganglion cells (ipRGCs)
~0.3% of all GCs

Primate retina
Dacey et al., Nature 2005

Hattar et al., Science 2002
Daylight Spectral composition of skylight is heavily blue-weighted...

- Peak melanopsin sensitivity is 480 nm
- Peak melatonin suppression is 460 nm

Background/Evidence

Recommended Enhanced SSLAs will have superior power efficiency and longevity compared to the GLA, and provide improved light for vision, better color rendering, improved crew sleep and performance, and enhance plant growth compared to the current SSLA design.

- Typical 4000 K Fluorescent: 0-6000 lux
- Enhanced SSLA: 0-3200 lux (0-2400, this SPD)
- 0-30 watts

Possible Draft Spec Solution: 0-2800 lux

Note: All SPDs are for demonstrative purposes only. They do not represent actual SPDs as neither of the potential SSLAs currently exist.

Light is Medicine!

Sleep 2014
Scientists at Harvard Medical School in association with NASA designed and implemented a bright light treatment program for crew members of STS-35, the first space shuttle mission requiring both dual shifts and a night launch.

- **Phoenix Mars Lander Study Blue LED Countermeasure**
  - NASA HRP/BHP-funded study. Blue light boxes were utilized by the scientists and engineers supporting the Phoenix Mars Lander to facilitate entrainment to the Mars sol (24.65 hours/day) work schedule.

- **Russian Chamber Study Countermeasure - Sunex Light Box**
  - Green (red control) light boxes were employed in the 105-day Russian Chamber Study at the Institute of Biomedical Problems in Moscow to increase alertness during the night shift in both crew members and mission controllers (Funded by NASA HRP/NSBRI).

**STS-108 CIRCADIAN ADJUSTMENT LIGHTING SCHEDULE**

| EST | 0 | 0 | 2 | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 6 | 0 | 7 | 0 | 8 | 0 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| CST | 0 | 0 | 2 | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 6 | 0 | 7 | 0 | 8 | 0 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |

**SUNLIGHT - KSC**

**UNLIGHT - JSC**

**Schematic of timing for light treatment of jet lag**

- Light-Dark (LD) cycle
- Normal entrainment
- Westward flight – sleep later
  - Requires delay to adapt
  - Light before 6 am INTERNAL time
- Eastward flight – sleep earlier
  - Requires advance to adapt
  - Light after 6 am INTERNAL time

Adapted from Arendt & Skene, Sleep Med Rev, 2005

---

**Circadian Desynchrony in Military Operations:**

**Countermeasures to Sustain Operational Readiness**

Michel Paul, Defence Scientist

DRDC - Toronto
We have confirmed that the best melatonin formulation for phase advance is an 8-hr linear sustained release profile and a single dose provides a 92-minute phase advance when given at 1600 hrs in normally entrained individuals (i.e. DLMO at 2100 hrs).

**Circadian advance with melatonin.**

**The role of light as a circadian rhythm disorder and fatigue countermeasure in Space**

Steven W. Lockley, PhD

Division of Sleep Medicine, Brigham and Women’s Hospital, Boston, MA

Division of Sleep Medicine, Harvard Medical School, Boston, MA

83rd Annual Scientific Meeting Aerospace Medical Association

14 May 2012

**ATHLETIC PERFORMANCE FOLLOW A CIRCADIAN RHYTHM**

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  - Neuromuscular performance
  - Maximal oxygen uptake
  - Back, Arm, and Leg strength
  - Grip strength
  - Cognition

- New Studies show that core body temperature alone doesn’t dictate performance (Pullinger et al.)

**National Training Centers, S.C.**

**University of South Carolina study on swimmers: without any sleep deprivation, peak trials showed a significant circadian peak**

**NOTE**

- For the two nights before you leave, you go to bed early (8 p.m. and wake up at 0600 hrs). The earlier you go to bed, the greater the phase adjustment will be. Ex. If you have light night, it's a good idea to wake up early on the morning of the flight. Do not lay the flights in the mornings.

- When you arrive in the hotel, take a hot bath, and get to bed early (before 2200 hrs). Eat a light meal and go to bed early. Do not use bright light or wear sunglasses. Do not take corticosteroids.

- When you wake up in the morning of the flight, avoid light and wear sunglasses until the light. Do not wash your face.

- Early on the flight DC melatonin and by day and by night for a much light in the evening. If you are not sleeping, the light level is not that not bad and it is a good one, but it increases the amount of it. If you are sleeping, wear sunglasses. Do not use bright light or wear sunglasses. Avoid light and wear sunglasses.

- When you wake up in the morning of the flight, avoid light and wear sunglasses until the light. Do not wash your face.

- For the next 2-3 hours after the flight, the light is bright for 6 hours. If you are not sleeping, the light level is a good one, but it increases the amount of it. If you are sleeping, wear sunglasses. Do not use bright light or wear sunglasses.
Implementation
Current GLA Operations on ISS

Crewmembers pulse on/off the light units within a module, from a central SRCA. Most modules have 1-3 SRCA.

Each individual light unit has a dimmer
Each unit has an on/off switch
Background/Evidence

Recommended Enhanced SSLAs will have superior power efficiency and longevity compared to the GLA, and provide improved light for vision, better color rendering, improved crew sleep and performance, and enhance plant growth compared to the current SSLA design.

~15-30 watts

Typical 4000 K Fluorescent
100 lux-540 lux

Enhanced SSLA
0-3200 lux (0-2400, this SPD)
0-30 watts

Possible Draft Spec Solution
0-2800 lux

Note: All SPDs are for demonstrative purposes only. They do not represent actual SPDs as neither of the potential SSLAs currently exist.

RFP versus Revised Light Requirements (RLR)

RLR provides a range of spectral power distributions in one unit and allows for multiple applications of light in the same place (Figure B).

- Emphasize specific wavelengths (470nm, 475nm, 510nm) for morning, day or night to promote alertness.
- Emphasize specific wavelengths (470nm, 475nm, 510nm) for off-duty, pre-bedtime period to promote sleep.
- Enhancing wavelength permits reductions of light illumination and power consumption while still achieving an effective lighting countermeasure.

Figure A

Figure B

Building 9 Evaluation – Node 2 SSLA Illumination
With the goal of improving the alertness of flight controllers, we will determine what type of fatigue countermeasure will be the most feasible, acceptable and effective in this environment.

Our experienced investigative team has developed fatigue countermeasures programs in other occupational groups such as NASA astronauts, police officers, medical residents, firefighters and air marshals.

The NASA Human Research Program’s Behavioral Health and Human Performance Element has recently funded us to put together an educational program for Flight Controllers (FC) that includes screening controllers for sleep disorders and testing a fatigue countermeasure to improve alertness and performance. This research addresses a human system health and medical risk associated with performance errors due to sleep loss, work overload, fatigue.
Tired of being tired when you travel across time zones? Here's some advice for fighting jet lag, straight from a team at NASA.

Phoenix Lander Mission: How to entrain to a Martian day (24.66 h)

Subjects completed daily diaries on PDAs, documenting work, sleep and naps.

Barger et al., Sleep, in press

Dr. Joan Saary, MD, MSc, PhD, FRCP, CIR, FACC
Assistant Professor of Medicine
University of Toronto
OEMAC Conference, Toronto, Sept 28, 2015

What’s New With Blue?
Shiftwork and the Colour of Restake

Dr. Joan Saary, MD, MSc, PhD, FRCP, CIR, FACC
Assistant Professor of Medicine
University of Toronto
OEMAC Conference, Toronto, Sept 28, 2015

Spectral composition of skylight is heavily blue-weighted...

Chang et al. 10.1073/pnas.1418490112

Table 1: Spectral sensitivity and peak spectral at wavelength of blue bands and chronically, symmetry, and mean

Peaks at 452 nm are in the blue light range, compared with broad-spectrum light (white light), with a peak at 612 nm.
Are you an average teen?

- The average teenager spends how many hours engaged in recreational media use?

7.5 hours

Are You Typical?

- What percentage of people used some type of electronics at least a few nights per week within 1 h before bedtime?

90%

LED Technology Provides Early Warning

Starting in January 2016, we will begin providing nail salons around the city with free prototypes of the Genesis Light, a 24-hour lamp that monitors air quality and impacts health. The light sends manicurists, customers and city health officials an alert based on the presence of volatile organic compounds (VOCs), including formaldehyde. While the technology engineered within the Genesis Light is complex, the functionality is simple: A green light for clean air, a red light for toxic air. It also communicates with mobile devices via an app and has the capacity to archive its findings on a digital platform online that will eventually be available to the public.
Investigate performing sleep shifting at Baikonur in a similar manner that the Space Shuttle crew members are sleep shifted prior to launch so that Soyuz launched crew members can begin sleep shifting prior to arrival at the ISS.

3.3.2.2.12 Crew Sleep Shifting Needs for Open Days Between a Vehicle Undock/Unberthing from the ISS and the Next ISS Vehicle Docking/Berthing

All arriving crewmembers should be sleep shifted prior to launch to synchronize with their appropriate in-flight (docked) timelines.
Target N = 34 (Astronauts and Cosmonauts, Flight Directors, and CAPCOMs)

Findings from the study will help inform participants and thus ISS Crewmembers of:

- Individual sleep medication protocols
- Simplify protocols for future individualized testing
- Inform other high performance communities
Develop Operational Ground Testing Protocol to Individualize Astronaut Sleep Medication Efficacy and Residual Effects

Figure 8: PVT performance lapses for all conditions and test bouts. Horizontal lines with asterisks above them highlight statistically significant differences between the means below the end of each line. At Awake 1a the 10 mg dose of zolpidem increased both PVT lapses relative to placebo, 10 mg zaleplon, and 5 mg zolpidem. It also increased PVT lapses relative to placebo and 10 mg zaleplon at Awake 1b.
Figure 21: Standardized differences (effect sizes) on performance and neurobehavioral outcomes for placebo effects compared to the effects of 10 mg Zolpidem. Asterisks refer to original tests shown in Figures 4-20.

10 mg Zolpidem

Figure 22: Standardized differences (effect sizes) on performance and neurobehavioral outcomes for placebo effects compared to the effects of 5 mg Zolpidem. Asterisks refer to original tests shown in Figures 4-20.

5 mg Zolpidem

Figure 23: Standardized differences (effect sizes) on performance and neurobehavioral outcomes for placebo effects compared to the effects of 10 mg zaleplon. Asterisks refer to original tests shown in Figures 4-20.

10 mg Zaleplon

Individual Flight Surgeon Recommendations and Utilization from the Ground Testing Protocol Data of Hypnotics on NASA Astronauts, Flight Directors, Surgeons, and Controllers on Emergent Awakening when compared to placebo or sleep inertia.

Zolpidem (in males)
- 10 mg in males (14) (352/353) had decrements in performance/side effects with need to decrease the dose or change to zaleplon.
- 50% (6/12) had decrements in performance and recommended to decrease the dosage to 5 mg or less.
- 0% (0/14) no decrements in any parameters.

5 mg in males (10) and females (10) (1/20) (9/20) had decrements in performance/side effects with need to decrease the dose or change to zaleplon.
- 40% (4/10) had decrements in performance and recommended to decrease the dosage to less than 5 mg.
- 0% (0/20) no decrements in any parameters.

The starting ground testing dose in males and females should be 5 mg and titrate up or down—using the lowest effective dosage (e.g. 3.5 mg, 3 mg, 2.5 mg, or 1 mg) as possible.

Zaleplon (in males)
- 10 mg in males (24) and females (10) (1/34) (4/34) had decrements in performance/side effects with need to decrease the dose or change to zaleplon.
- 30% (9/30) had decrements in performance and recommended to decrease the dosage to less than 5 mg.
- 0% (0/20) no decrements in any parameters.

5 mg a good starting dose for males and females.

Individual Flight Surgeon Recommendations and Utilization from the Ground Testing Protocol Data of Hypnotics on NASA Astronauts, Flight Directors, Surgeons, and Controllers on Emergent Awakening when compared to placebo or sleep inertia.

Utilization
- Two recently flown ISS crewmembers and one assigned to be flown
  - one crewmember on their present medication dosage
  - one crewmember lowered their dosage
  - one crewmember changed to another medication

Future Recommendations for Exploration Mars Missions
- Develop a standardized ground testing and in-flight protocol for emergent awakening and countermeasures development (e.g. Blue light, new medications, Sleep training, etc.)

Continued support for a Fatigue Management Services Team approach for Individualized Coutermeasures Development.

28 Night Outpatient Study

*Agent vs placebo, P<0.05.
Recommended dose for most moderately adults. 22
3. Park, DR.
Applied Research on the Operational Use of Hypnotics and Stimulants
Aerospace Medicine Grand Rounds
UTMB/NASA-JSC
January 25, 2005

John A. Caldwell, Ph.D. and J. Lynn Caldwell, Ph.D.
Aviation Sustained Operations Research
Fatigue Countermeasures Branch, Air Force Research Laboratory
Brooks City-Base, TX  78235
John.Caldwell@brooks.af.mil and Lynn.Caldwell@brooks.af.mil

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Key
SLEEP

FLYING
TRY TO SLEEP OR NAP PRIORITIZE
BRIGHT LIGHT EXPOSURE
WEAR SUNGLASSES – AVOID LIGHT
DO NOT WEAR SUNGLASSES – SEE LIGHT
M TAKE MELATONIN

Wednesday 15-Apr-09
Thursday 16-Apr-09
Friday 17-Apr-09
Saturday 18-Apr-09
Sunday 19-Apr-09
Monday 20-Apr-09
Tuesday 21-Apr-09
Wednesday 22-Apr-09
Thursday 23-Apr-09
Friday 24-Apr-09
Saturday 25-Apr-09
Sunday 26-Apr-09
Monday 27-Apr-09
Tuesday 28-Apr-09
Wednesday 29-Apr-09
Thursday 30-Apr-09

Dr Mike Duncan
Travel Departure Date: April 18, 2009
Travel Destination: Moscow

Clinical Care Support Technologies to Mitigate Astronaut Fatigue in Space

Figure 4. Brainwaves, eye movements, and airflow were recorded by means of a sleep net and additional sensors. This photograph shows payload commander Rick Linnehan being instrumented by payload specialist Jay Buckey during the STS-9 mission.
Clinical Care Support Technologies to Mitigate Astronaut Fatigue in Space

Daniel Mollicone, PhD, Pulsar Informatics
Provides accurate sleep staging information in a device that is easy-to-operate, unobtrusive and patient-friendly.

It detects movement of your body during sleep. It identifies your sleep state through the movement and expansion of your chest as you breathe in and out, as well as overall body movements such as positional changes, arm movements and shifts. It includes software algorithms that recognize the usual combination of respiration and body movements signals, so that overall sleep state can be reliably assessed.
NASA shows the three-story Human Exploration Research Analog habitat at the Johnson Space Center in Houston.
Astronomers believe a powerful burst of gamma rays may have destroyed the ozone layer, allowing the sun’s ultraviolet radiation to burn fragile life forms, some 440 million years ago. Two-thirds of all species might have been killed during the second-largest extinction in Earth’s history. The most devastating mass extinction occurred 250 million years ago.

**The five greatest extinctions**

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<tr>
<th></th>
<th>440 million years ago</th>
<th>360 million years ago</th>
<th>250 million years ago</th>
<th>220 million years ago</th>
<th>65 million years ago</th>
<th>Today</th>
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<tr>
<td>Early life</td>
<td>First seed</td>
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Source: The Columbia Encyclopedia
NATIONAL GEOGRAPHIC
GLOBAL WARNING
BULLETINS FROM A WARMER WORLD

Temperature rising

Ice melting

An ancient cycle ending?

11/1/2016
Genome + Environment = Wellness = Longevity

• Our Fuel/Environment – What we Eat and Breathe
• Aerobic Fitness and Strength
• Psychological Well-being
• Sleep

These 4 Factors Also Impact Your Immune Function

Of course, the aging process is not the only reason for sub-optimal immune function. You should also be aware of these four additional factors that could potentially affect healthy immune-system function.

Factor #1: Chronic, long-term stress can upset the balance of immune inflammatory responses. That’s why it’s important to maintain healthy relationships and avoid social isolation, decrease stress levels, and seek appropriate help for any life-impacting emotional issues. If you are feeling overwhelmed and run-down, chances are your immune system is feeling it too.

Factor #2: Poor quality sleep also affects immune health and inflammatory balance. Good sleep enhances the formation of immunological memory, which in turn enhances adaptive immune responses. Most experts recommend seven to nine hours per night of high-quality sleep for adults.

Factor #3: Too little exercise and unhealthy weight gain can also affect your immune system. The immune system cells need to co-exist in a certain balance for good health to be maintained. Many factors, including diet and excess body fat, can tip this balance, creating immune cells that can harm, rather than protect, our bodies. Excess body fat, particularly abdominal fat, triggers the production of so-called “pro-inflammatory” immune cells, which circulate in the blood and promote inflammation in our bodies. Maintaining an optimal weight with diet and exercise can help support healthy immune function.

Factor #4: Dietary factors play a critical role in immune health. It’s important to eat plenty of phytonutrient- and antioxidant-rich foods, including dark leafy greens, tomatoes, peppers, broccoli, berries, and other colorful fruits.

Nature Versus Nurture: The Role of Genes Versus Environment in Aging and Exceptional Longevity

Gerontologists often cite studies of life spans amongst identical twins reared apart to describe the genetic and environmental components of aging.

70-80% environment and 30-20% genes.

The study of Seventh Day Adventists at Loma Linda University who as a group have perhaps the longest average life expectancy in the United States, 88 years for men and 89 years for women.

• Vegetarian
• Don’t smoke
• Regularly exercise
• Spend a lot of time with their families and with their religion

Many Americans do the opposite (e.g., excessive meat consumption, lack of exercise, smoking, etc.) and thus it is not surprising that on average

• Americans live 70-75 years

The average American has the genes to reach their mid-late 80s, they just need to take very good care of themselves with proper lifestyle choices. The oldest subjects in the twin studies lived to their early to mid-eighties.

• The average life expectancy for most of us, age 65 years for men and 89 years for women.
Human Male Karyotype, Chromosome Structure and Mapping, and Location of APOE

Figure 2. 23 pairs of chromosomes: one member of each pair is inherited from the mother and one from the father. Chromosomes become visible when the cell is not dividing, stained using Giemsa, and ordered by size. The DNA double helix is unwound and proteins called histones form small packages called nucleosomes, which are in turn wound around histones to form loops that make up the chromosomes. Chromosome 19 is the site of the APOE gene, which is composed of sequences with regulatory functions (introns) and sequences with coding functions (exons). Regions of the gene that are spliced out during transcription to messenger RNA are called introns. The completed regions, exons, contain the sequences that code for the final protein product.

Does Exercise Lengthen Our Lives by Lengthening Our Code? Live?

Exercise was beneficial for preventing mutations in both humans and mice.

Regions were measured in blood pressure, cholesterol levels, and inflammatory cytokines. Exercise increased levels of APOE expression, which regulates cellular aging.

The length of telomeres — the ends of DNA — is related to cellular aging. The longer the telomeres, the healthier the cell. The length of telomeres is controlled by a complex of enzymes and proteins. The nucleosomes allow for a group of enzymes to recognize the ends and regulate gene expression.

Chromosomes show various functional elements: centromere, nucleosome, histone, and centromeric material. The telomeres consist of long DNA sequences that are highly repetitive.

Centenarian offspring have a lower rate of disease and longevity than the general population. The telomeres are on average 25% longer in centenarians than in non-agenarians. The length of telomeres is inversely related to age.

--- Jeffrey L. Kramer, M.D.

New England Centenarian Study

Welcome to the largest and most comprehensive study of centenarians and their families in the world!

To discover the secrets to a long healthy and happy life...

Our two major studies are the New England Centenarian Study and the Free Family Study.

The New England Centenarian Study is funded by:

The New England Centenarian Study is dedicated to:

The science of aging and longevity.

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Predictors of Reaching 100: Not all centenarians are alike. They vary widely in years of education (no years to post-graduate), socioeconomic status (very poor to very rich), religion, ethnicity and patterns of diet (strictly vegetarian to any meat rich in saturated fats). The centenarians studied have a number of characteristics in common:

- Few centenarians are obese. In the case of men, they are nearly always lean.
- Substantial smoking history is rare.
- Centenarians are better able to handle stress than the majority of people.
- Many centenarian women have a history of bearing children after the age of 35 years and even 40 years. From our studies, a woman who naturally has a child after the age of 40 has a 4 times greater chance of living to 100 compared to women who do not.
- Based upon standardized personality testing, the offspring of centenarians, compared to population norms, score low in neuroticism and high in extraversion.

Telomeres cap the ends of linear eukaryotic chromosomes. Researchers propose that knowing whether our telomeres are of normal length (or not) for a given chronological age can provide a valuable indication of our health status before diseases appear. Such information may help people make better decisions regarding for example, diet, exercise and stress. Image from "My, What Long Telomeres You Have", Scientific American April 2011.
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Centenarians had markedly delay disability towards the end of their very long lives, at an average age of ~93 years.

15% have no clinically demonstrable disease at age 100 years “escapers”.

43% have no clinically demonstrable until the age of 80 years “delayers”.

42% have clinically demonstrable disease before at age 80 years “survivors”,

Observed amongst supercentenarians (age 110+ years), that health span equals lifespan. Therefore instead of the aging myth “the older you get the sicker you get”, it is much more the case of “the older you get, the healthier you’ve been”.

Census: Texas has 2,917 centenarians

They also were disproportionately white (more than 80 percent) and lived mostly in urban areas (65 percent). Female centenarians were more likely to live in a nursing home or supervised setting than men, 65 percent of whom lived with family members.

What causes people to live so long? The widely cited and ongoing New England Centenarian Study of the Boston University School of Medicine says there is no single explanation. Utterly long life is mostly the result of luck, good behavioral decisions and some good genes. And of the population of centenarians, there is no standard profile. “They vary widely in years of education (no years to post-graduate), socioeconomic status (very poor to very rich), religion, ethnicity and patterns of diet (strictly vegetarian to extremely rich in saturated fats).”

The leading characteristics were predictable. Few centenarians are obese, and in the case of men, they are nearly always lean. There is little in the way of smoking history; they seem to be able to handle stress better than a majority of people.

Our Job - Keep You Flying
Take Care
THANKS!

Smith L. Johnston, M.D., M.S.
1402 Redway Lane
Houston, Texas
Cell: 713-294-1595
smith.l.johnston@nasa.gov