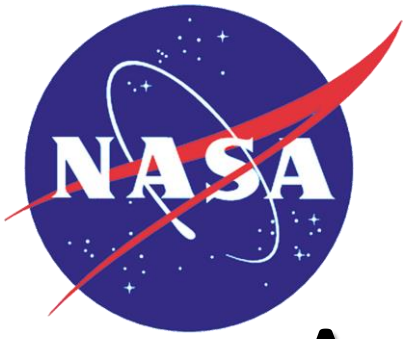


Assessing Cardiovascular Disease Risk in NASA Astronauts Across the Lifespan

Jacqueline Charvat, PhD, Stuart M.C. Lee, PhD,
Eddie Davenport, MD, Carolyn Barlow, PhD , Laura DeFina, MD,
Nina Radford, MD, Michael Stenger, PhD, Mary Van Baalen, PhD

The Cooper Institute®

KBRwyle

Purpose

- NASA needs to understand risk of CVD outcomes among astronauts
  - Inform HRP and Space Medicine
- NASA needs to understand any interactions between the occupational health effects of spaceflight exposure and normal aging
  - Guide occupational surveillance of astronauts in the future

Cardiovascular Alterations of Spaceflight

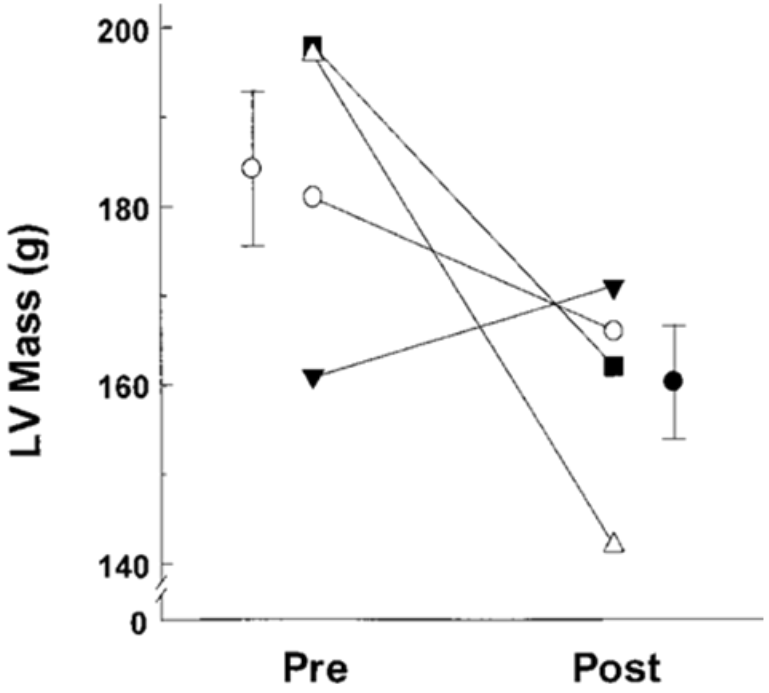


Fig. 3. LV mass measured by MRI before (Pre) and after (Post) the D-2 mission on 4 astronauts. Circles with error bars represent mean 6 SE before and after spaceflight.

Perhon, et al, 2001

Cardiovascular Alterations of Spaceflight

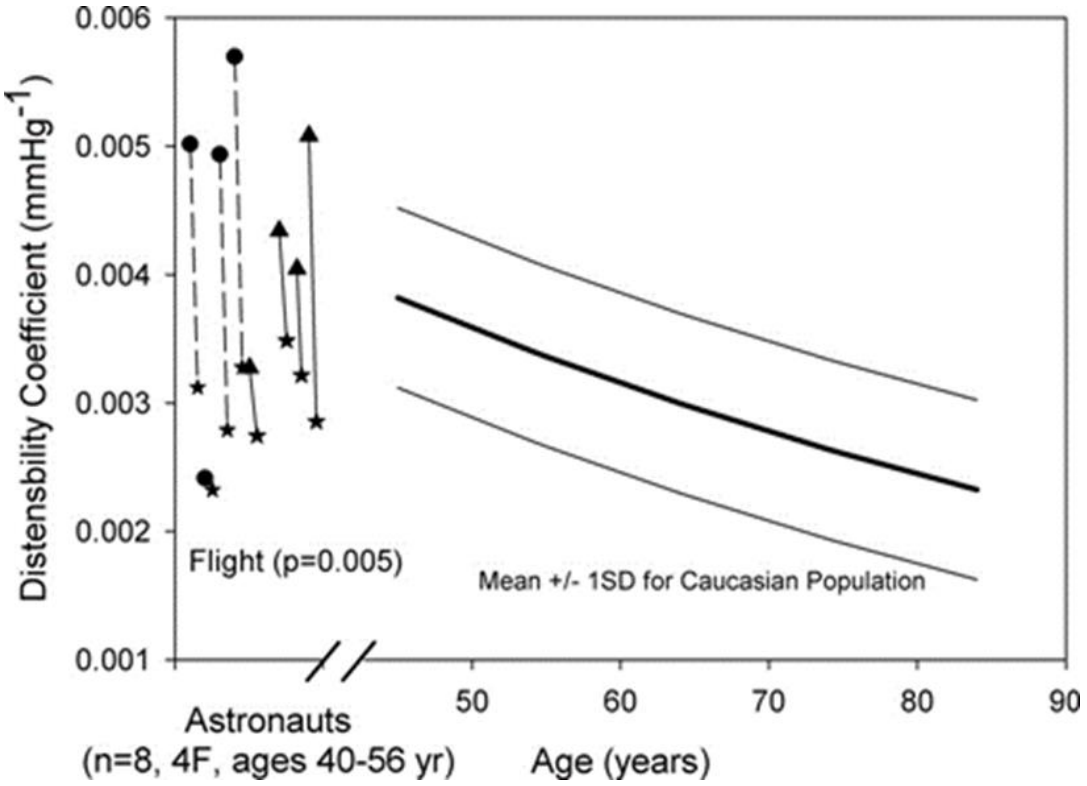
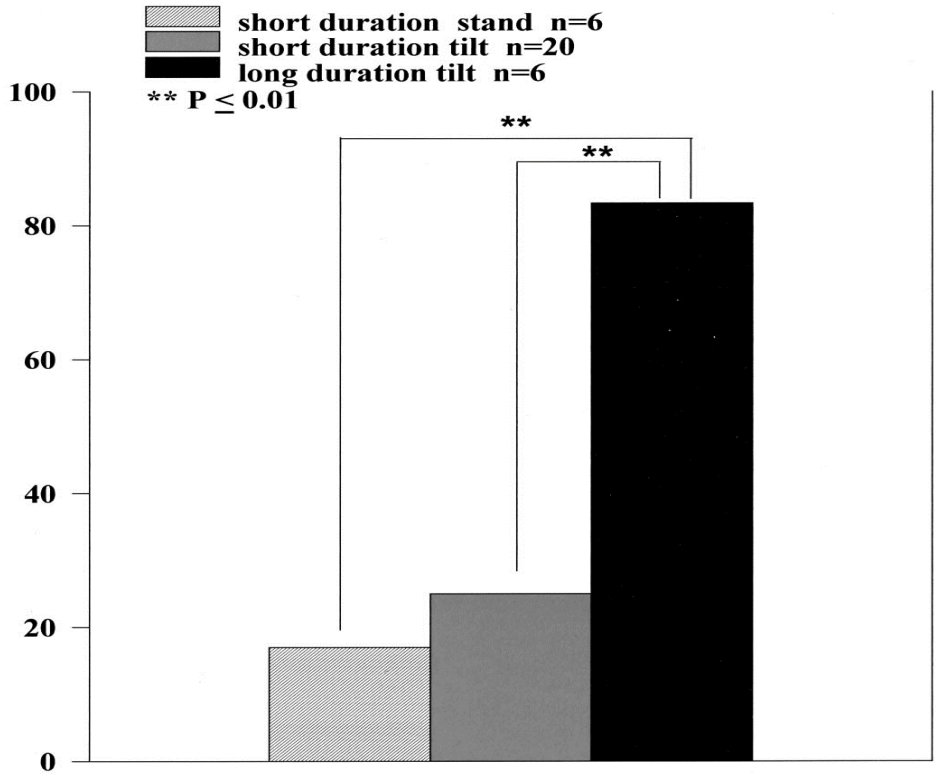


Fig. 1. Carotid distensibility coefficient (cDC using brachial pulse pressure for comparison to population data) is shown for the astronauts (left) and a reference population (right).

Hughson, et al, 2016

Cardiovascular Alterations of Spaceflight



Incidence of presyncope during stand and tilt testing after short- and long-duration flights. Presyncope is defined as the failure to complete 10 minutes of 80° upright tilt without symptoms.

Meck, et al, 2001

Cardiovascular Disease

- Unsure if acute cardiovascular changes translate to overt disease
- Combined chronic effects of spaceflight and aging are not understood
- Spaceflight-related exposures may increase risk for CVD
  - Altered dietary and exercise habits
  - Physical/emotional stress
  - Circadian rhythm shifts
  - Radiation
  - Repeated exposures to microgravity

Limited Epidemiological Data on Astronauts

- Most recent epidemiological studies on CVD risk were published in 2000 (Hamm) and 2005 (Hamilton)
- No current data published on CVD Outcomes in astronauts
- Need to understand the health risks in astronauts as spaceflight exposures evolve
  - Short duration missions → Long duration missions (6 months to 1 year) → Very Long duration missions (3 years)

NASA does not have a current understanding of lifetime CVD risk in the astronaut corps

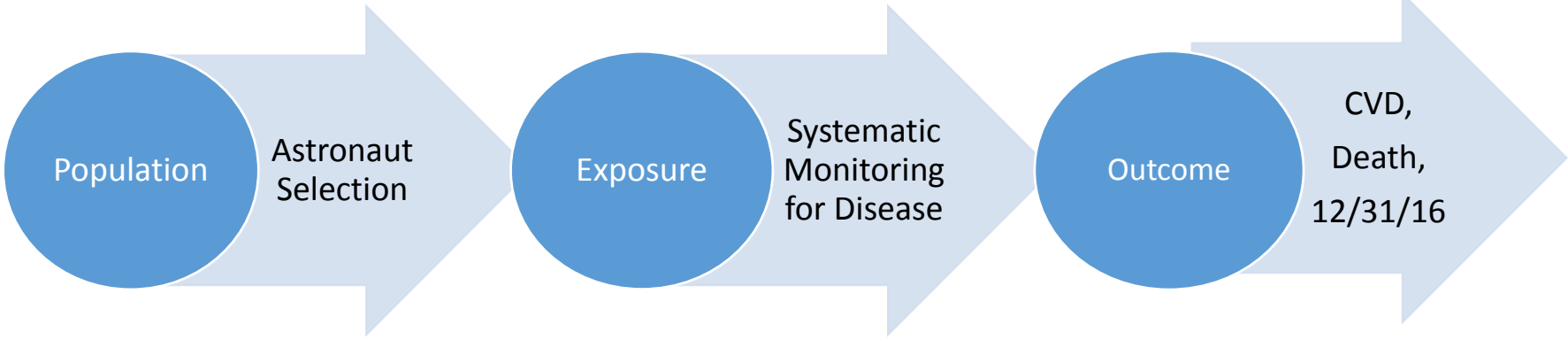
Comparing Astronauts to Other Cohorts

- Comparison to general population hampered by:
  - Selection bias
  - Healthy worker effect
  - Health status across time
  - Cohort effect
    - Changes to lifestyle, health and practice of medicine over 60 years
  - Small numbers of NASA Astronauts
- We have been actively seeking cohorts to compare the astronauts with and all have limitations.

Cohorts Considered for Comparison

- Coronary Artery Risk Development in Young Adults (CARDIA)
- Defense Medical Surveillance System
- Framingham Heart Study
- Dallas Heart Study
- Multi-Ethnic Study of Atherosclerosis (MESA)
- Millennium Cohort
- Prospective Army Coronary Calcium study
- **Air Force Aviators**
- **Cooper Center Longitudinal Study**

Study Design



Historical Cohort Study

- Similar to a prospective cohort in that a sample from a population is monitored for the exposure of interest and then the outcome of interest
- Retrospective Identification of participants in cohort, classifying exposure of interest (spaceflight) and then reviewing records for outcomes of interest
- Common Occupational Epidemiologic Method
  - Used for rapid execution since do not need to wait for follow up time to accrue or study participants to be recruited

Study Questions

- Are there differences in the incidence of CVD Outcomes between each cohort and the NASA Astronaut Corps?
  - MI, Stroke, Revascularization
- Are there differences in the incidence of CVD risks between each cohort and the NASA Astronaut cohort?
  - Hypertension, Hyperlipidemia, Arrhythmias, Diabetes
- Are there differences between each cohort and the NASA Astronaut cohort in how CVD risk factors change across time?
  - Lipid profile
  - CV related behaviors – exercise, smoking

Air Force Aviators

	Study Design
Collaborators	Eddie Davenport, MD, FACC, Lt Col, United States Air Force Chief Cardiologist Aeromedical Consultation Service
Study Subjects	Current or previous aviator from the USAF
Sample Size	3-1 Air Force to Astronaut ratio
Inclusion Criteria	Aviators with normal ECG at 35 years of age At least one additional ECG 15 years later
Exclusion Criteria	Any history of CVD prior to age 35 ECG
Matching Variables	Year of ECG/Astronaut Selection, Sex
Status	Air Force Identified Sample USAF IRB Review

Cooper Center Longitudinal Study

	Study Design
Collaborators	Laura DeFina, MD – President/CEO, The Cooper Institute Nina Radford, MD – Cardiologist, Cooper Clinic Carolyn Barlow, PhD – Senior Epidemiologist, The Cooper Institute
Study Subjects	Current or previous participant in CCLS
Sample Size	3-1 Cooper to Astronaut ratio
Inclusion Criteria	At least one exam following CCLS Baseline
Exclusion Criteria	Any CVD diagnosis at CCLS Baseline
Matching Variables	Age, Year of Study Entry, Sex, Baseline BMI, Education, Employment Status
Status	JSC IRB in Progress

Data

- Exposure of Interest
  - Spaceflight
    - Number of days in space
    - Number of missions
- CVD Outcomes
  - Primary – MI, revascularization and stroke
  - Secondary – HTN, hyperlipidemia, arrhythmias, diabetes
  - Changes to risk factors across time
- Covariates (as available at each exam):
  - Demographic variables
  - Vital signs
  - Laboratory Testing: Lipid, CRP, Fasting glucose, HbA1c, CACs, cIMT
  - Medication use
  - ECG interpretation
  - Behaviors: Exercise, smoking
  - Family history of cardiovascular disease
  - Military and/or piloting history

Proposed Analyses

- Logistic Regression
  - Dichotomous CVD outcomes
  - Odds of having CV outcome different between cohort and astronauts
- Survival Analysis
  - Time to CVD Outcome
  - Differences in time to CVD outcome between cohort and astronauts

Limitations

- Data harmonization within and between different cohorts may be difficult
  - Different data collection methods by cohort
  - Different data collection methods across time
  - Astronaut records initially collected for medical care
- Analyses based on current understanding of cardiovascular disease
  - As with any cohort, changes to how disease is diagnosed and managed across time
  - Accounting for those changes by using comparable birth cohorts that are followed longitudinally
- Differences in the way astronauts are selected versus how either cohort creates bias

Study Team

Lifetime Surveillance of Astronaut Health
- Jacqueline Charvat, PhD
- Mary Van Baalen, PhD

JSC Cardiovascular and Vision Laboratory
- Stuart M.C. Lee, PhD
- Michael B. Stenger, PhD

United States Air Force
- Eddie Davenport, MD

Cooper Clinic
- Carolyn Barlow, PhD
- Laura DeFina, MD
- Nina Radford, MD

Questions?

Back up

Strength of Cohorts Chosen

- Air Force
  - Aviators and astronauts chosen for health status
- Cooper Center Longitudinal Study
  - Breadth of cardiac measures on participants

Air Force Aviators

- Dr. Eddie Davenport, MD, FACC, Lt Col, USAF
  - Chief Cardiologist Aeromedical Consultation Service at Wright Patterson Air Force Base in Dayton, OH
- Study Subjects
  - Current or previous aviator from the US Air Force
- Inclusion Criteria
  - Aviators with normal EKG at 35 years
  - Aviators who then had at least one additional EKG ~ 15 years following
- Exclusion Criteria
  - Aviators with any history of CVD prior to age 35 EKG
- Matching
  - Random sample of aviators who meet criteria will be
  - Matched 3-1 by year and gender
- Current Status
  - Air Force has identified an aviator sample
  - Currently at USAF IRB review

Cooper Center Longitudinal Study

- Laura DeFina, MD – President/CEO, The Cooper Institute
- Nina Radford, MD – Cardiologist, Cooper Clinic
- Carolyn Barlow, PhD – Senior Epidemiologist, The Cooper Institute
- Study Subjects
  - Current or previous participant in CCLS with at least one exam following baseline
- Inclusion Criteria
- Exclusion Criteria
  - Any CVD diagnosis at baseline
- Matching
  - Age, year of selection, gender, Baseline BMI, education and employment
  - Random sample of cohort members who meet criteria will be matched 3-1
- Current Status: JSC IRB in process