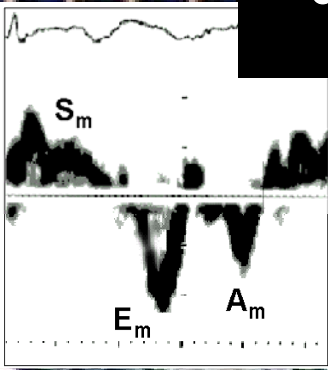
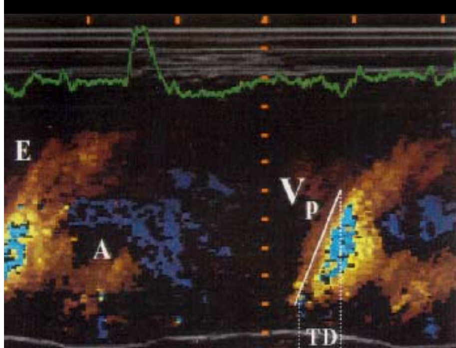
The ICV Study
"Integrated CardioVascular"

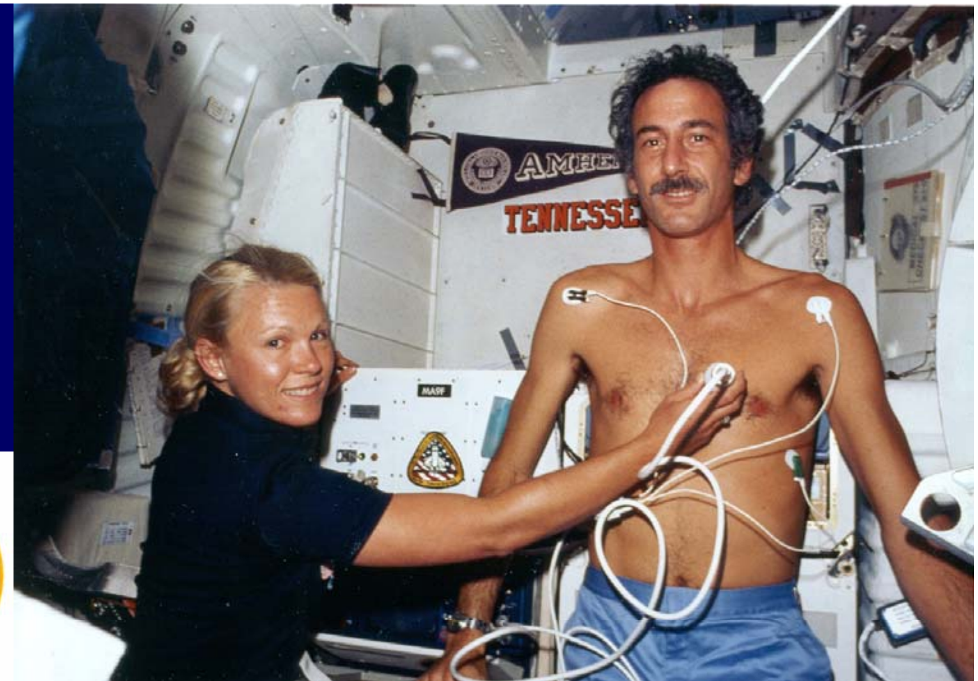
Study: E 377

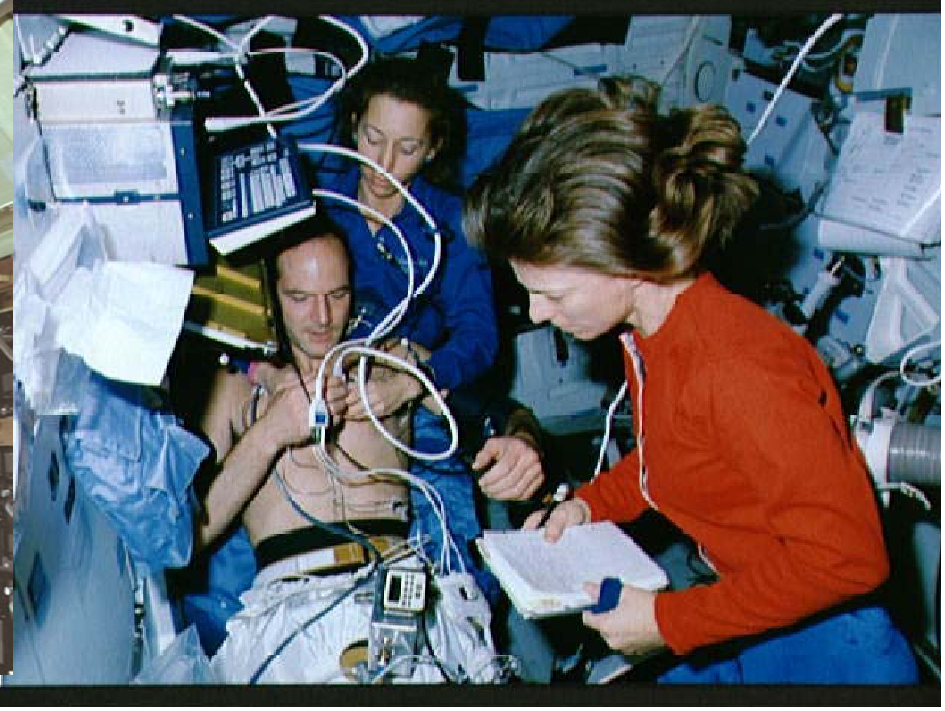
: Benjamin D. Levine, M.D. and Michael





<u>A</u>bnormalities in
<u>R</u>hythm and
<u>D</u>iastolic function due to
<u>I</u>nactivity,
<u>A</u>trophy and
<u>C</u>onfinement


TENNESSEE



Experimental Overview:

Pre-Flight

- Ambulatory ECG, blood pressure, and activity monitoring (24-48 hr);
- Rest and exercise echo
- Magnetic Resonance Imaging (Cardiac MRI) in US and Russia
- Tilt for moon, mars & earth gravity

In-Flight

- Ambulatory ECG, blood pressure, and activity monitoring (24 hr);
- Rest and exercise echo <u>after 2 & 4 weeks, then every 30-60 days</u>

Post-Flight

- Ambulatory ECG, blood pressure, and activity monitoring (24 hr);
- Rest and exercise echo
- MRI (Russia and US)
- Tilt for moon, mars & earth gravity on R+0

<u>Global Objective</u>: To carefully quantify the effects of long duration spaceflight on the structure and function of the heart

And to determine its clinical consequences for:

a). Orthostatic Tolerance (ability to stand up) under moon, mars, and earth gravity;

b). Risk for Cardiac Arrhythmias (if any…);

c). To determine if current countermeasures already are sufficient to prevent any *clinically meaningful* problems.

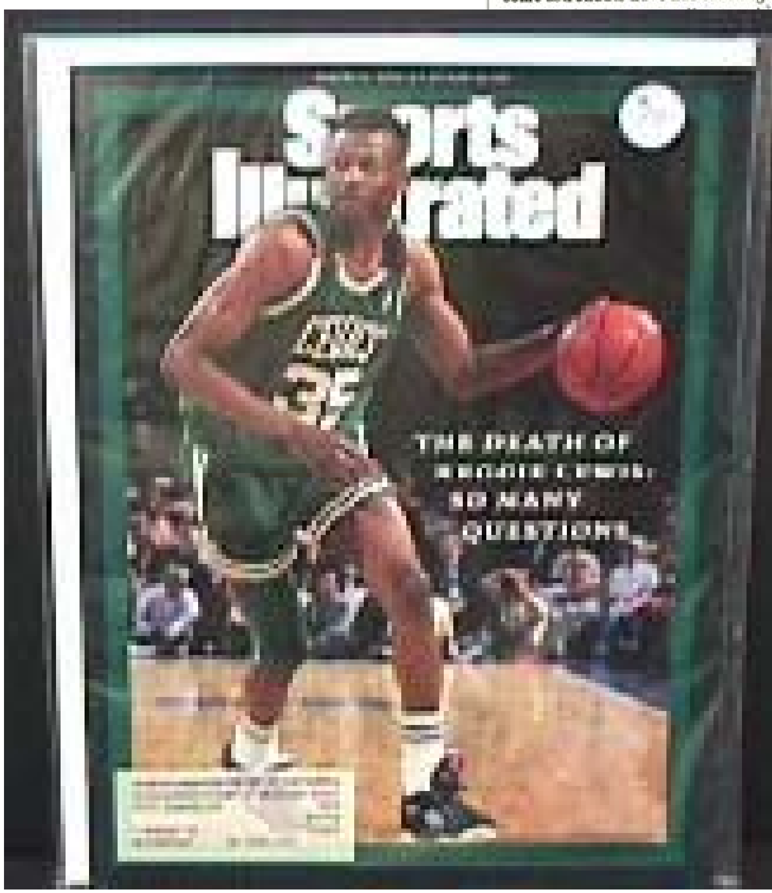
Background

Battling blackouts

Astronauts' fainting worries space doctors

By Robert Cooke
Cox News Service

Sometimes even the "right stuff" isn't enough. Space medicine experts say some astronauts have had fainting spells



Astronauts battle fainting spells

Continued from Page 8D.
include Walter Schirra, Frank Borman and James Lovell.

Although most victims experienced only the initial symptoms of fainting — brief wooziness and an inability to stand up — about a third have actually lost consciousness, the doctors say.

"The astronauts don't consider it much of a problem," said Dr. Philip Johnson Jr., a chief scientist in the space medicine division at NASA's Johnson Space Center in Houston. "But we in the medical end do. And we're trying to do something about it.

"You don't want the commander fainting as you're landing on the runway. It's something you worry about."

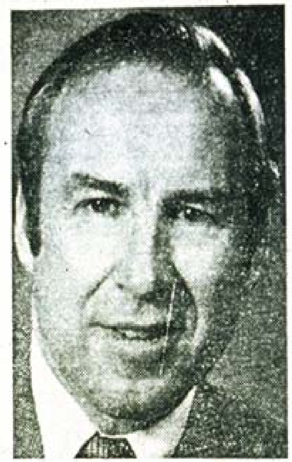
Charles Redmond III, a spokesman for the NASA manned spaceflight program, said, "Obviously, it would be a major concern should that happen to a pilot or a commander during a critical moment in landing."

"One of the things we do is for the pilots and the commanders to wear special zero-G suits," Redmond said. The tight-fighting suits tend to impede the sudden flow of blood into the legs, maintaining blood pressure.

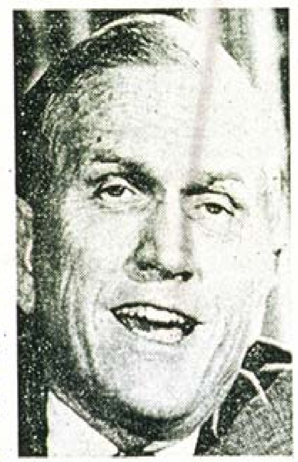
Dr. Harold Sandler, chief of the cardiovascular research office at NASA's Ames Research Center in California, said blackouts first occurred in the Mercury program and "got very severe in the Gemini program" as missions in space became longer.

He said the worst episode was the 14-day Gemini 7 flight, when Borman and Lovell experienced fainting spells after returning to Earth. Sandler said it took longer for both men to regain normal blood pressure than it did for other astronauts.

Although blackout episodes have continued through the Apollo, Skylab and space shuttle programs,



James Lovell



Frank Borman

the doctors say progress is being made now toward solving the problem.

Based on experiments done from 1981 to 1983, shuttle astronauts are now asked to drink large amounts of fluids shortly before returning to the ground, replacing fluids lost during the period of cardiovascular deconditioning in space.

It has long been known that astronauts in space experience a redistribution of their blood supply. There is an uncomfortable increase of pressure in their heads, and their faces become puffy, especially around the eyes.

"They get the puffiness the minute they go up, and lose it the minute they come down," said Dr. Richard Wurtman, a neuroendocrinologist at the Massachusetts Institute of Technology and former head of NASA's Life Sciences Committee.

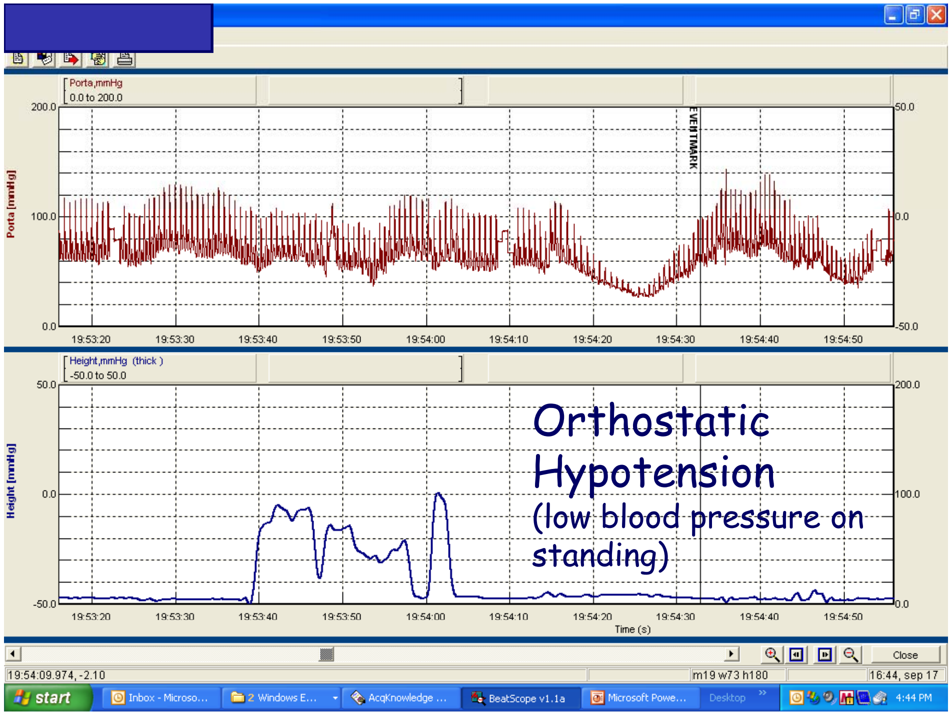
Because there is no gravity to pull blood down into the legs, blood tends to pool in the head and torso. As a result, the body excretes excess fluid, decreasing the total volume of blood by as much as one quart. On returning to normal gravity, the astronaut's blood is suddenly forced down into his legs again. The result is often low blood pressure, and sometimes blackouts.

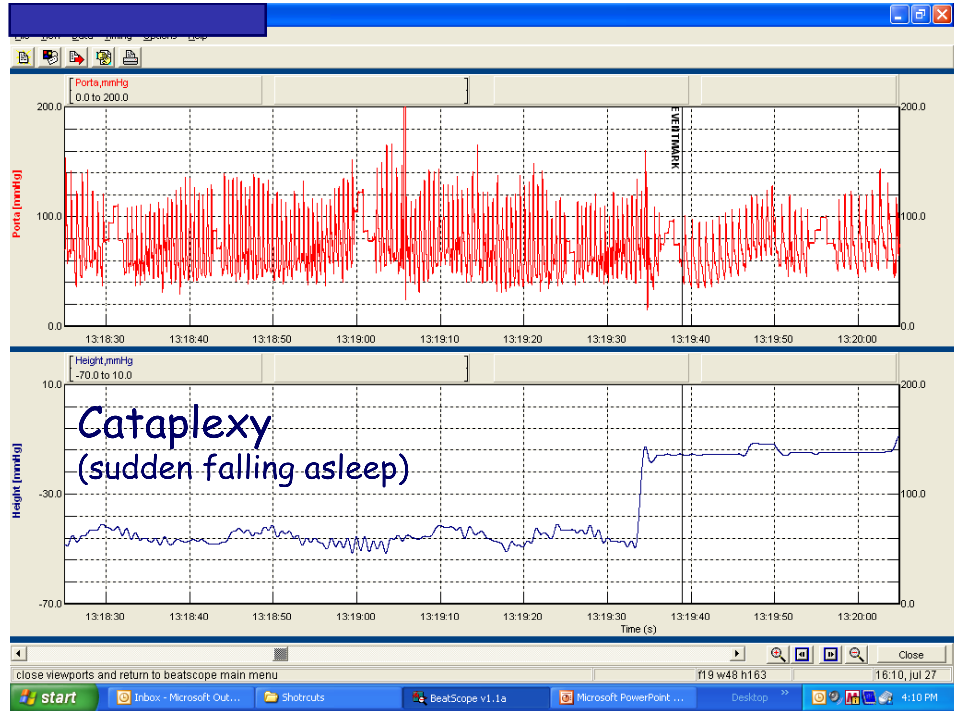
Astronaut Jeffrey Hoffman said that "a lot of people literally pass out" when they re-encounter gravity. Hoffman, a mission specialist who made his first spaceflight last April, discussed the problem publicly at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

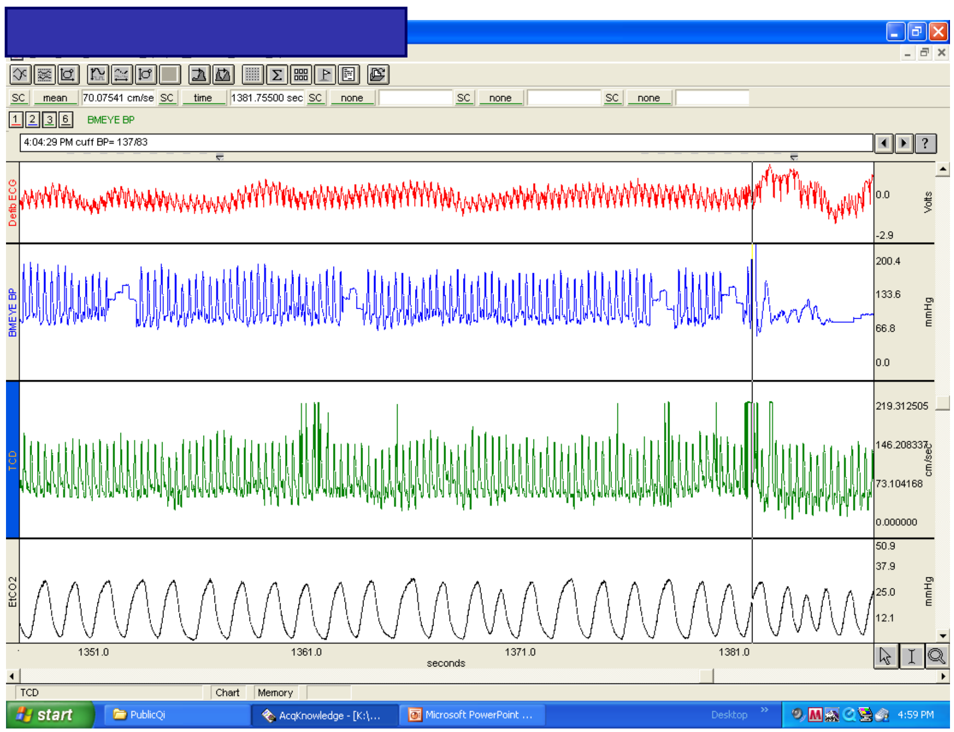
Sandler said the first astronaut to experience loss of consciousness was one of the original seven Mercury astronauts, Schirra, who orbited Earth six times in a one-man Mercury capsule in October 1962.

Although the blackout problem hasn't been discussed widely in the 24 years since the manned spaceflight program began, it has not been hidden. Sandler said it has been reported in technical journals and discussed at international scientific meetings, including some with the Soviets.

Distributed by The New York Times News Service

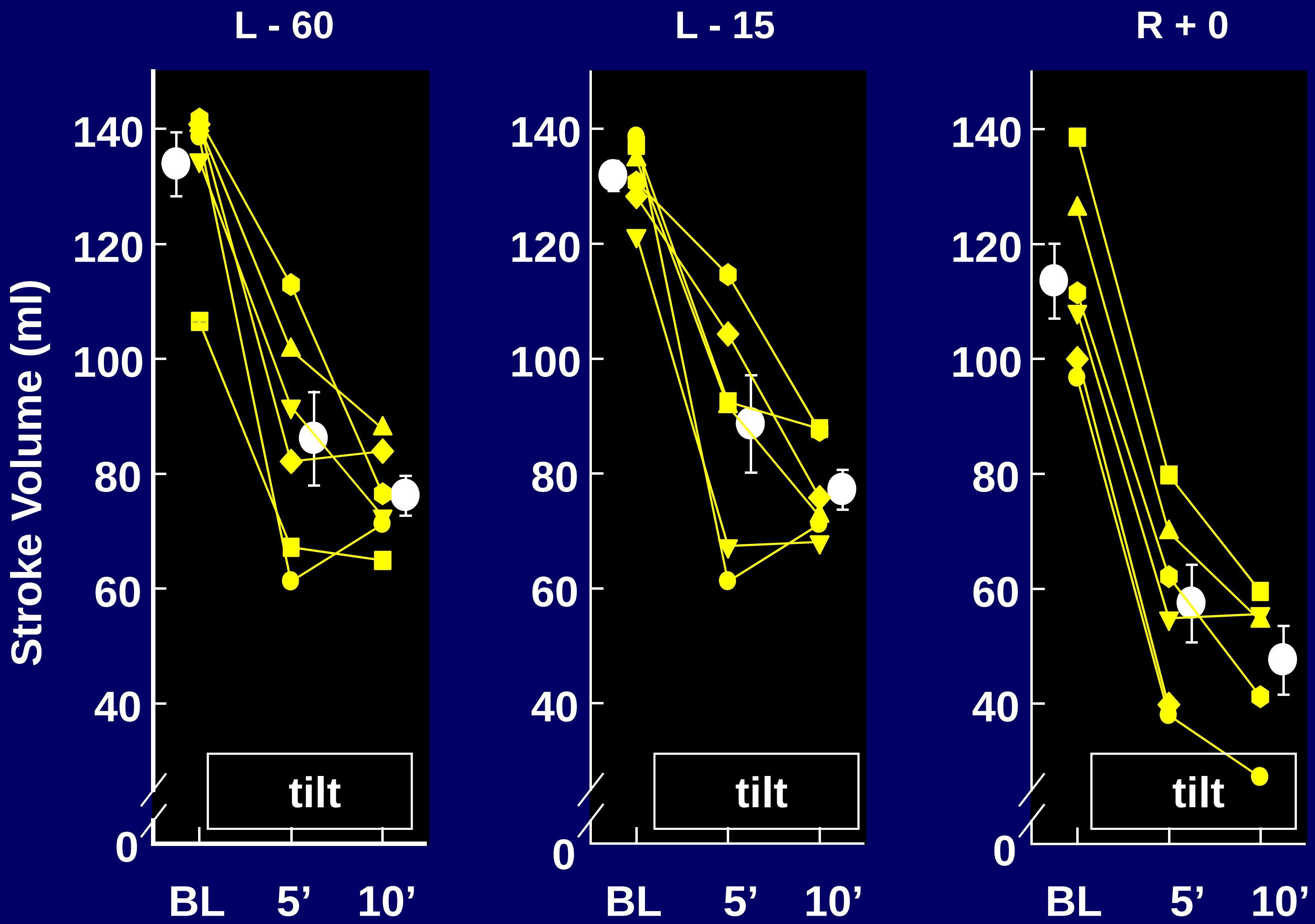






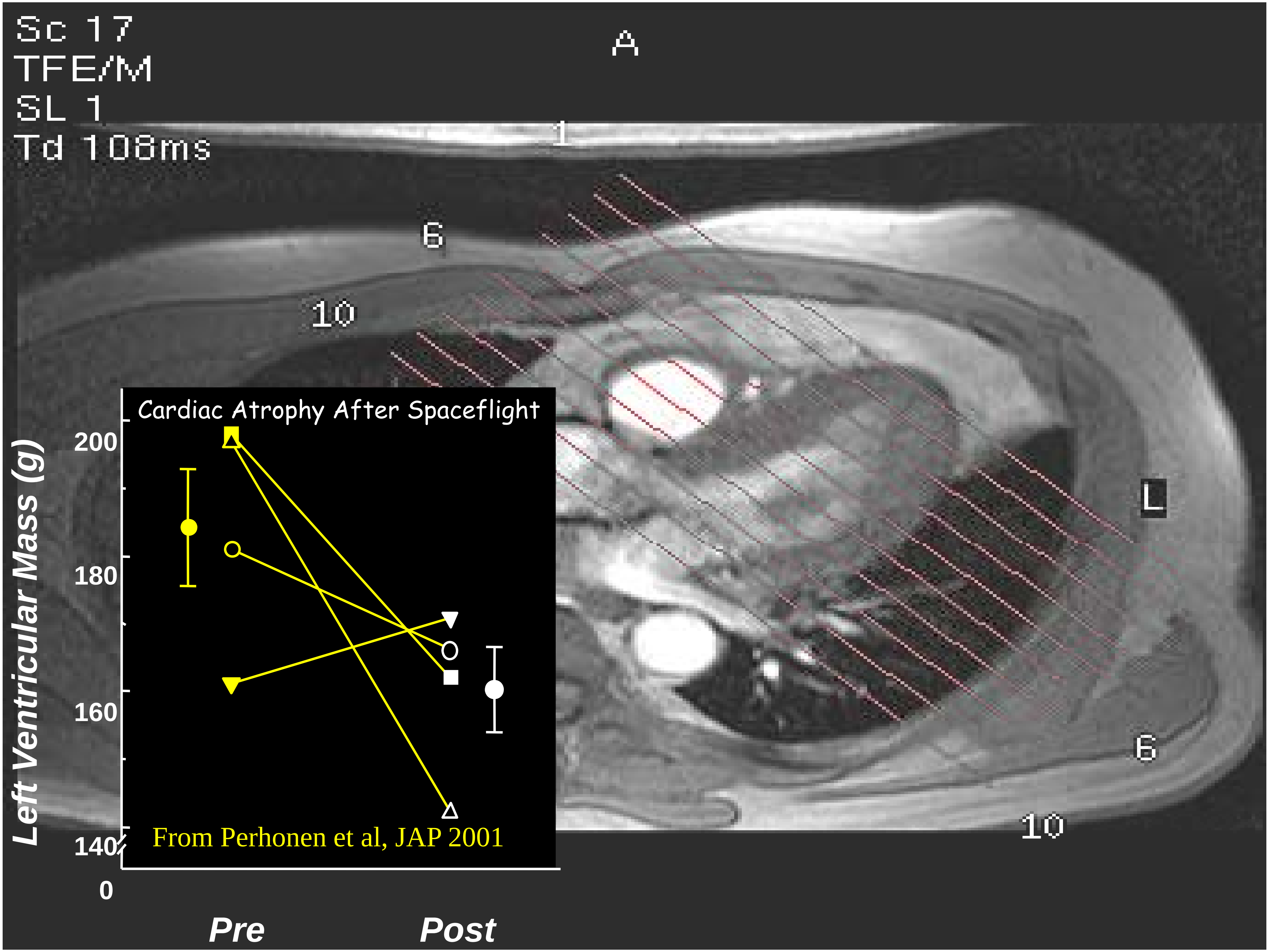
Hysterical Syncope
(fainting due to emotional causes)

Key Characteristic of Cardiovascular Adaptation to Space: A Low Stroke Volume in the Upright Position

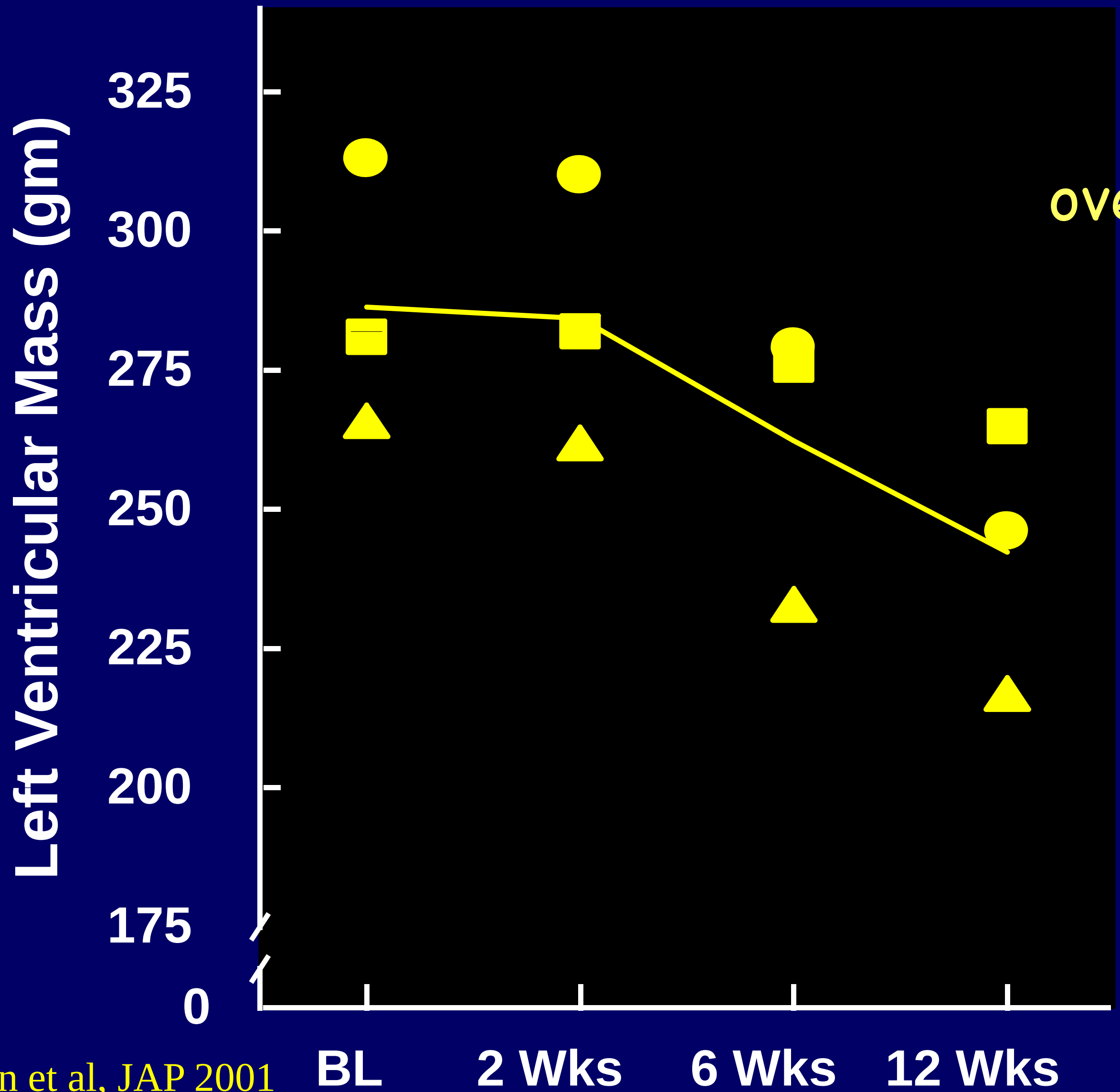


Levine et al, J Physiol 2002

BL=Baseline


Sc 17
TFE/M
SL 1
Td 108ms
A
L
Cardiac Atrophy After Spaceflight
Left Ventricular Mass (g)
200
180
160
140
0
Pre
Post
From Perhonen et al, JAP 2001

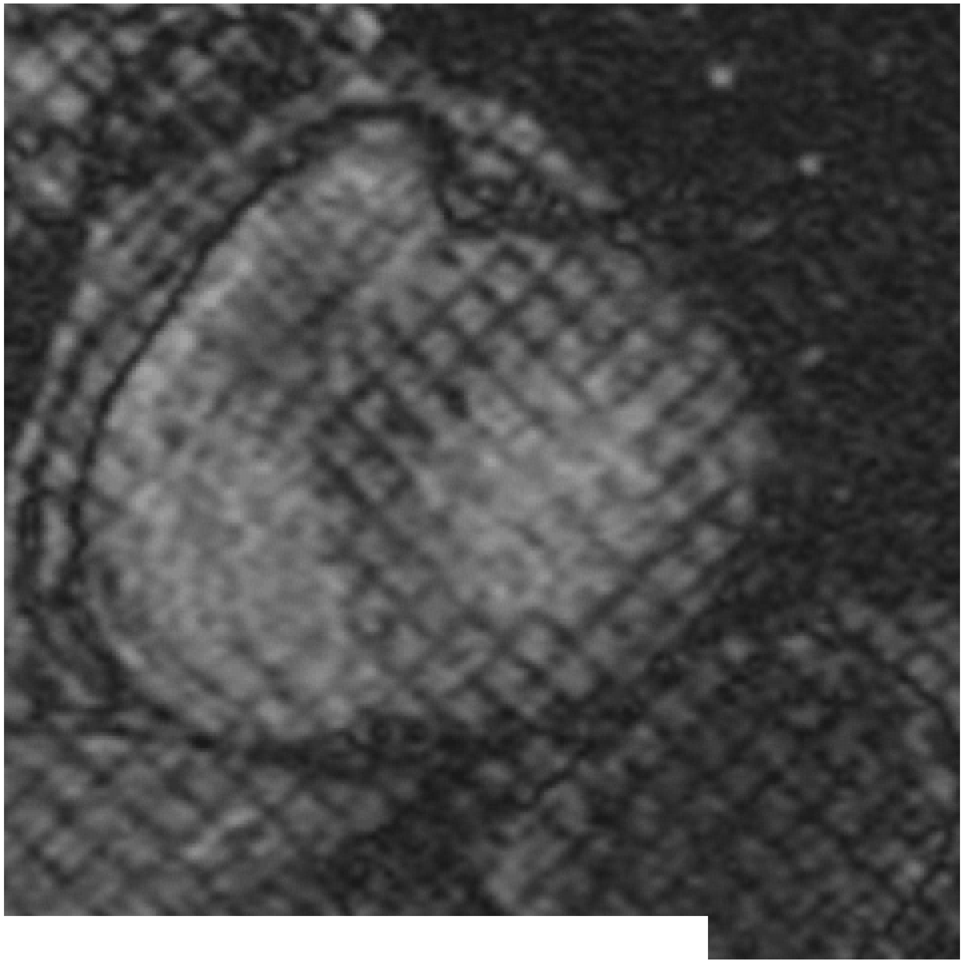
Left Ventricular Mass Continues to Decrease Over 12 Weeks of Bedrest

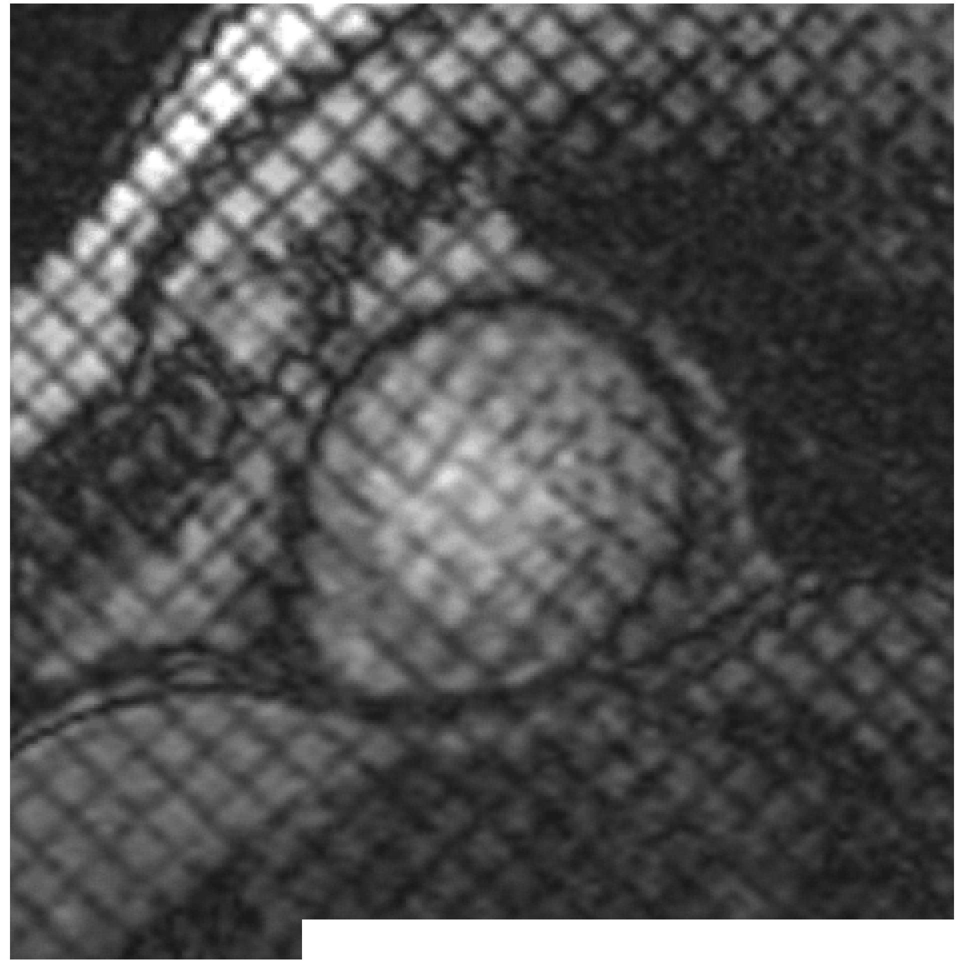


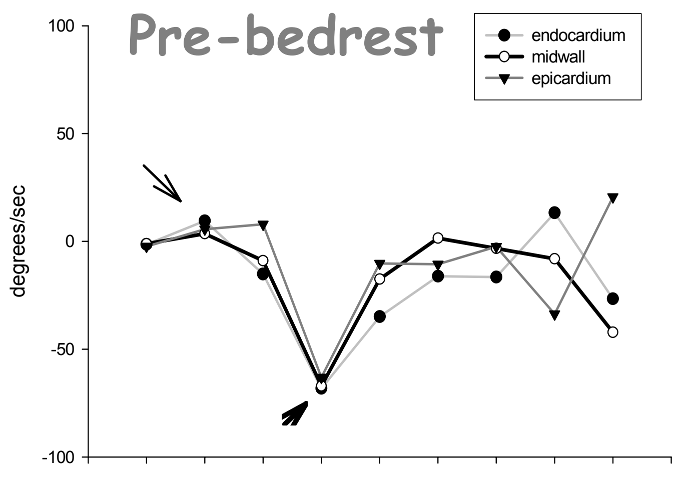
~ 1%/week
over many studies

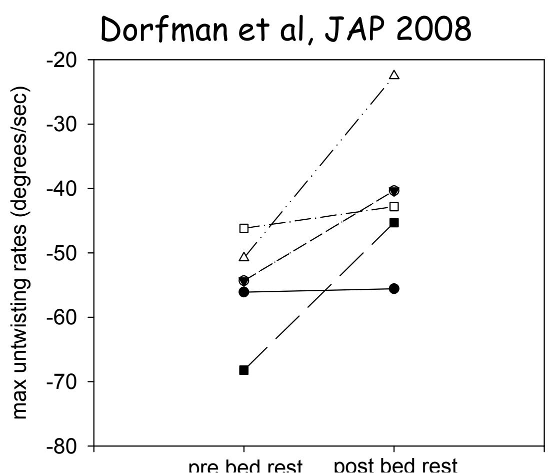
From Perhonen et al, JAP 2001

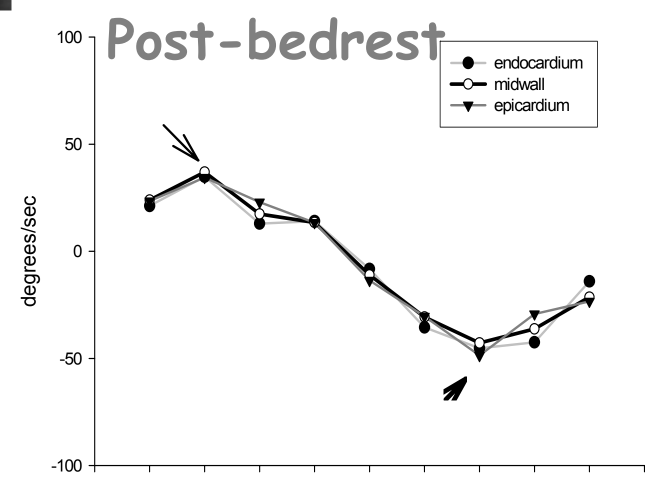
BL=Baseline

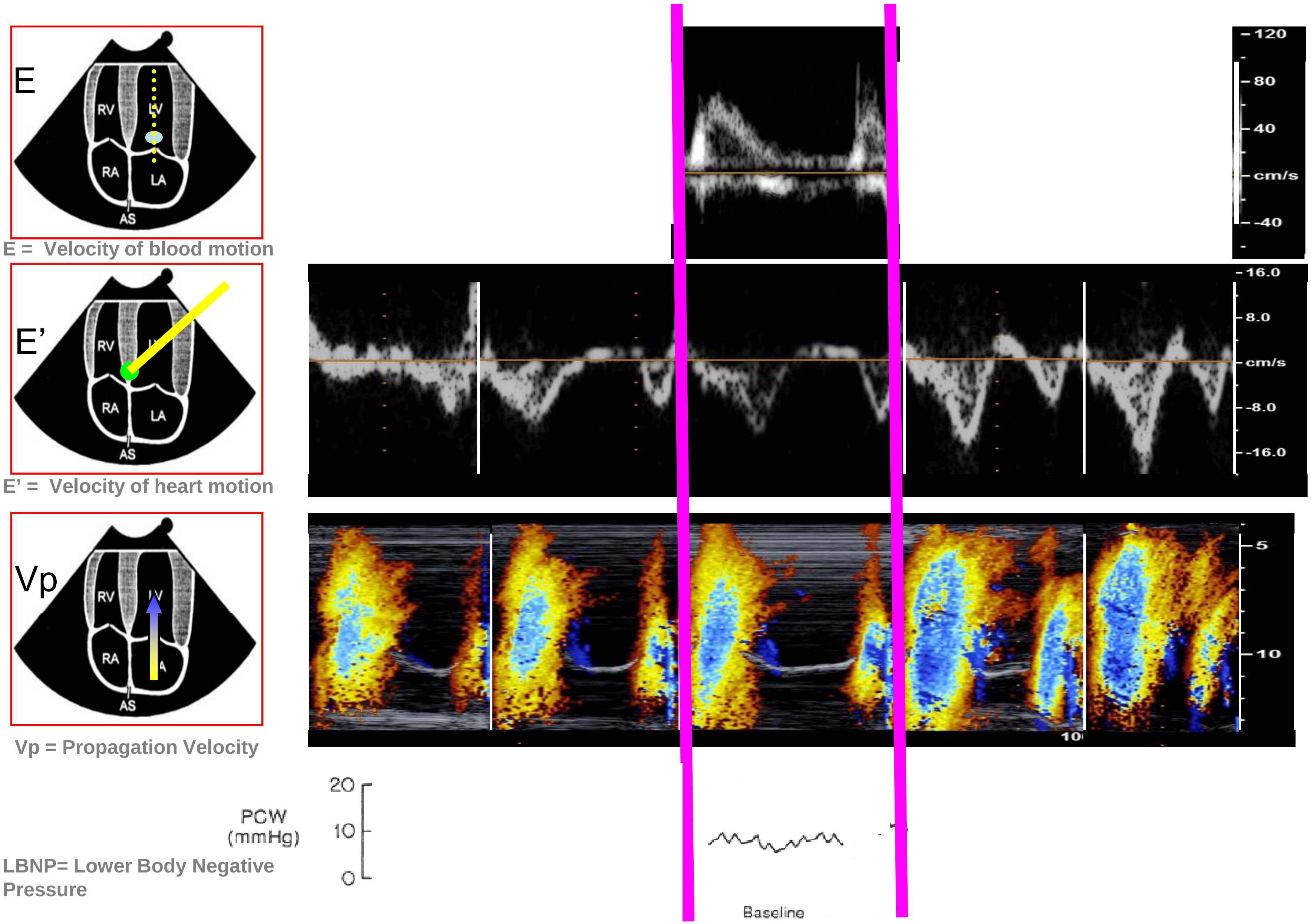





Pre-bedrest
endocardium
midwall
epicardium
100
50
0
-50
-100
degrees/sec
frame interval


Dorfman et al, JAP 2008
-20
-30
-40
-50
-60
-70
-80
max untwisting rates (degrees/sec)
pre bed rest
post bed rest


Post-bedrest
endocardium
midwall
epicardium
100
50
0
-50
-100
degrees/sec
frame interval



Echo/Doppler measurements used to assess diastolic function (how well the heart relaxes) in relation to how much volume is in the heart (pulmonary capillary wedge (PCW) pressure

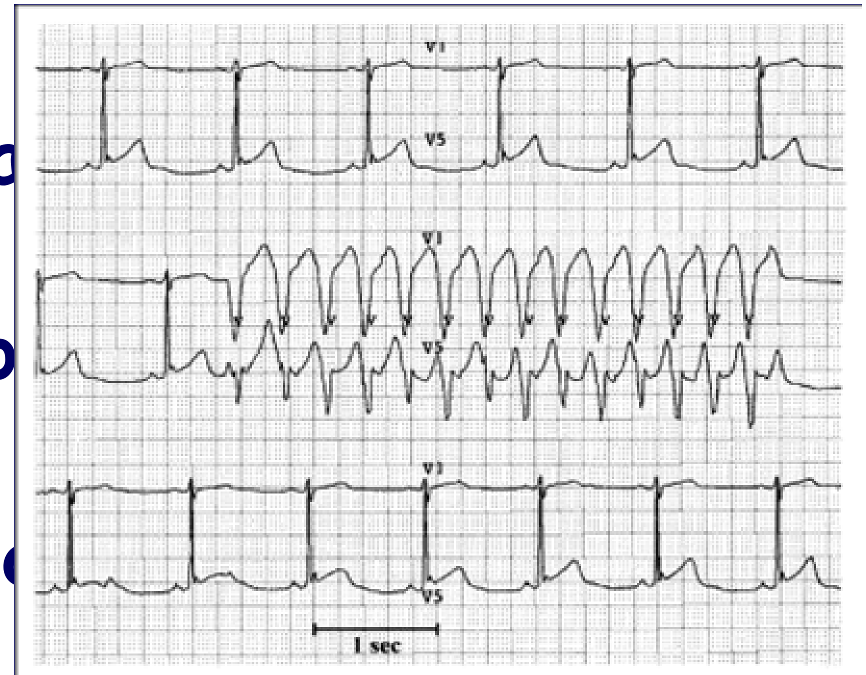
Pacini et al, JACC 2007

Clinical Implications of Cardiac Atrophy for health and safety during long duration spaceflight

1 ? magnitude, rate of cha
time in flight

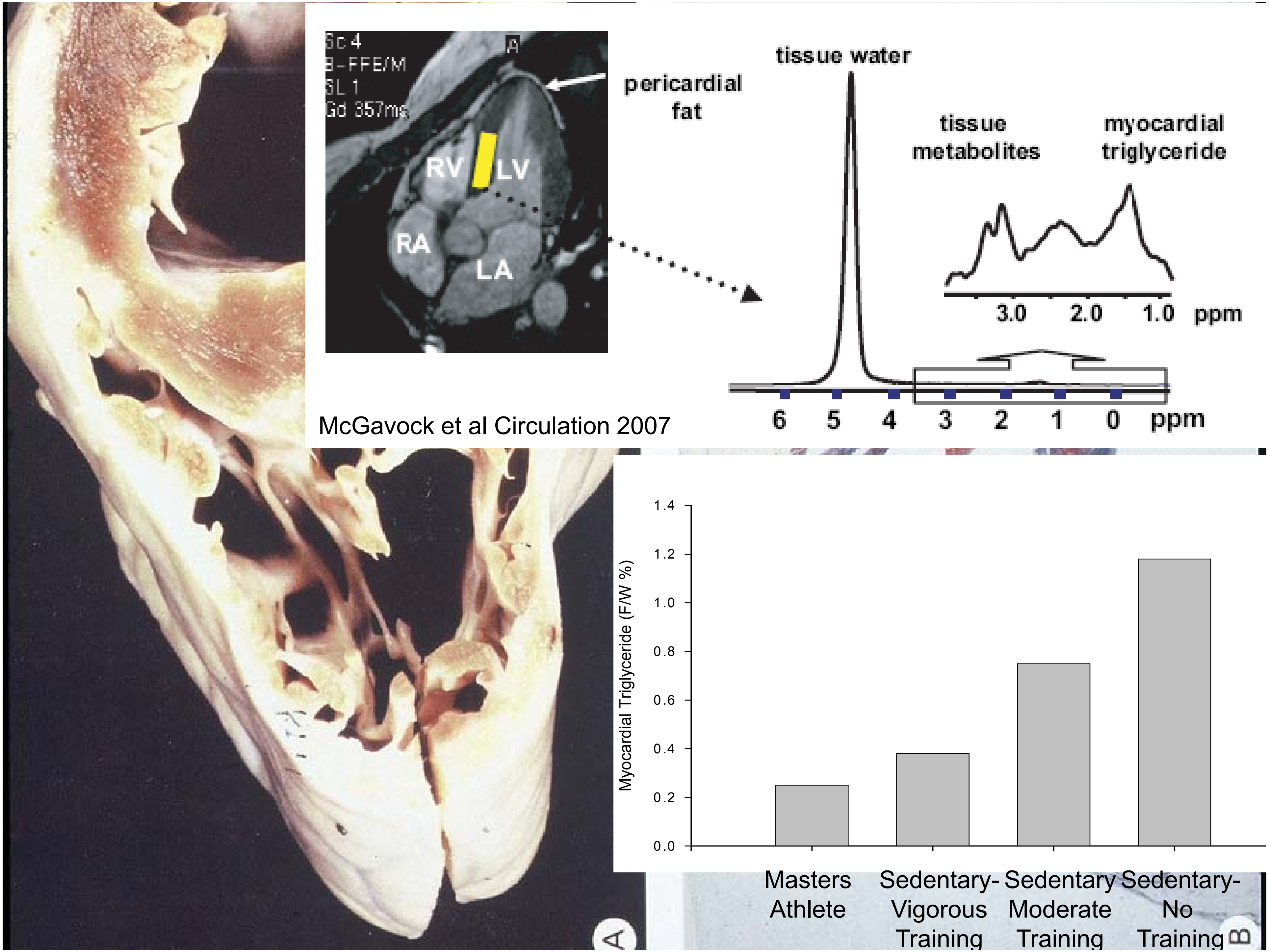
2 ? does more severe atro
orthostatic intolerance

3 ? what are the implicati
diastolic performance

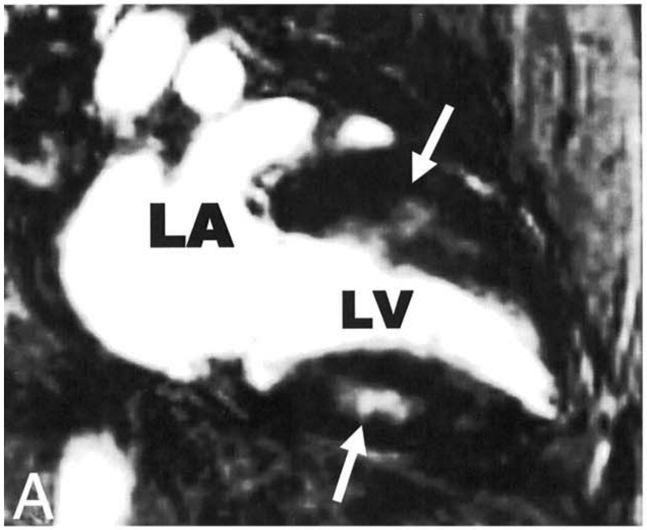


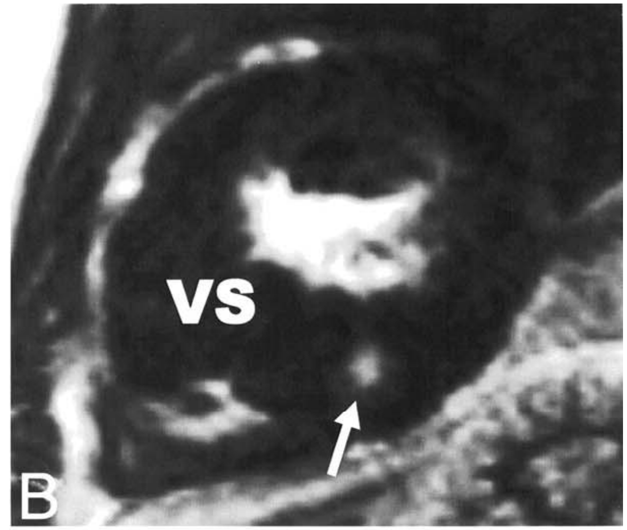
Fritsch-Yelle et al, Am J Cardio 1998

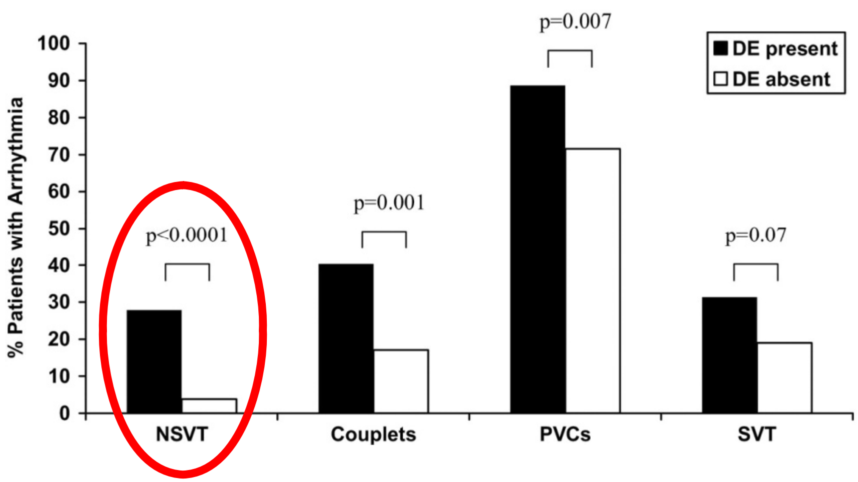
4 ? does atrophy occur by apoptosis (programmed cell death), or fibrosis (scarring), and could this pre-dispose to arrhythmias

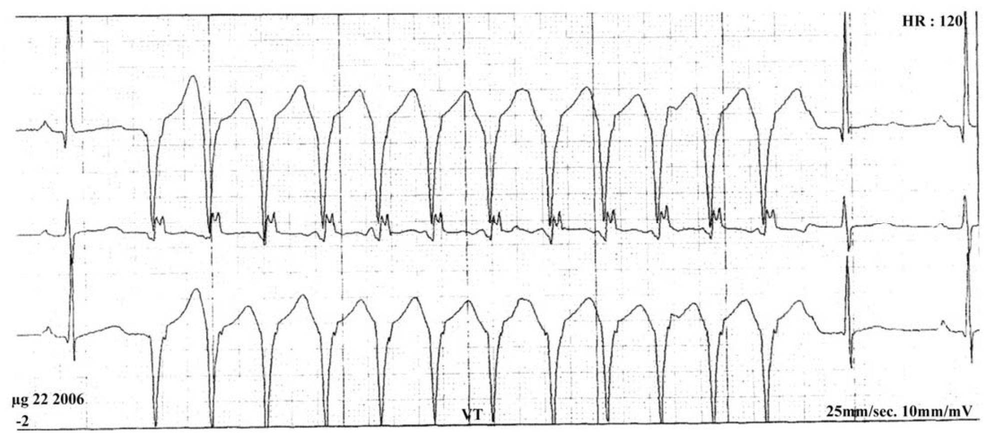

Sc 4
B-FFE/M
SL 1
Gd 357ms
A
RV
LV
RA
LA
pericardial fat
tissue water
tissue metabolites
myocardial triglyceride
3.0 2.0 1.0 ppm
6 5 4 3 2 1 0 ppm
McGavock et al Circulation 2007
Myocardial Triglyceride (F/W %)
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4
Masters Athlete
Sedentary- Vigorous Training
Sedentary Moderate Training
Sedentary- No Training
A
B

Cardiovascular Magnetic Resonance Image From a 36-Year-Old Hypertrophic Cardiomyopathy Patient (heart muscle has become too thick)







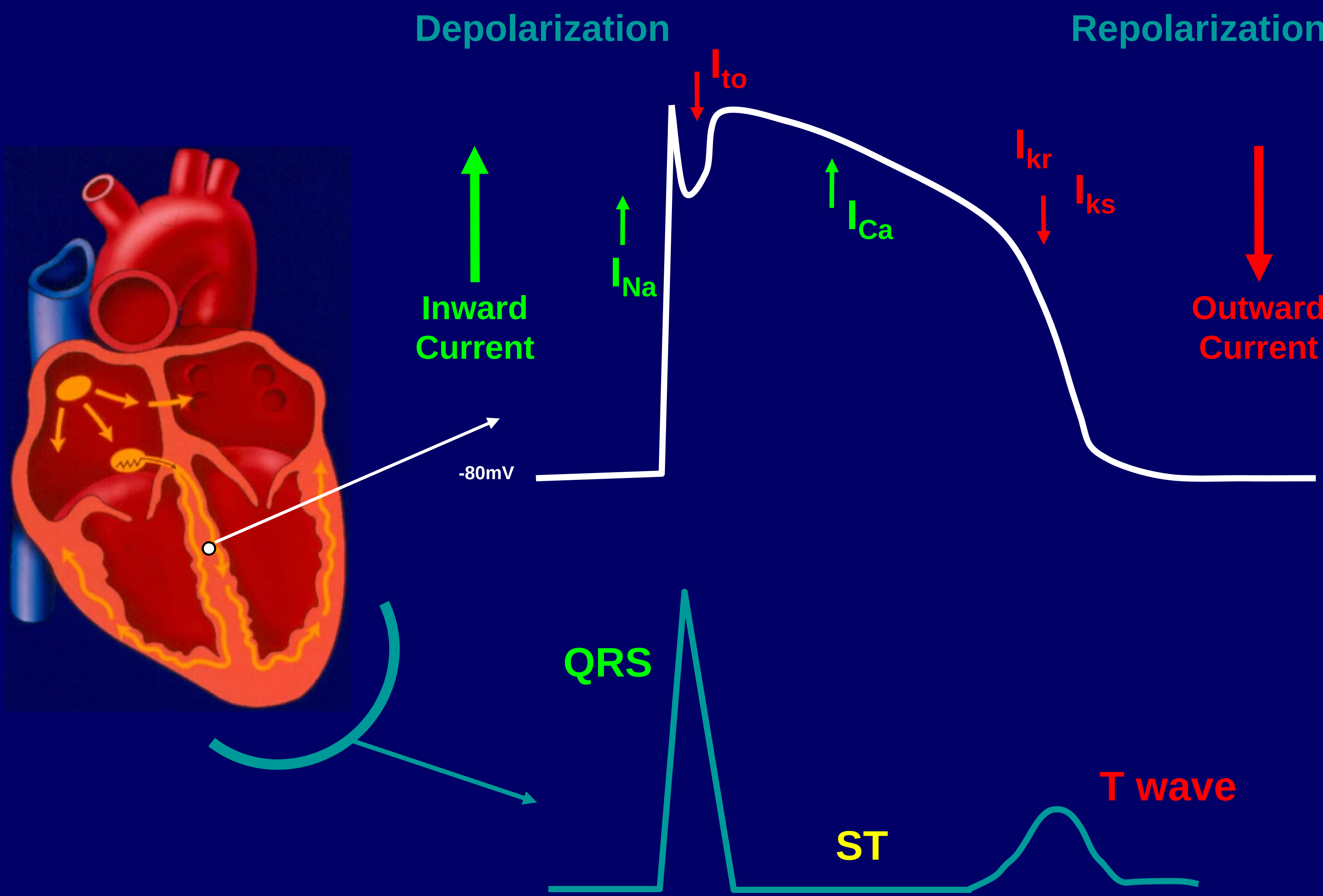


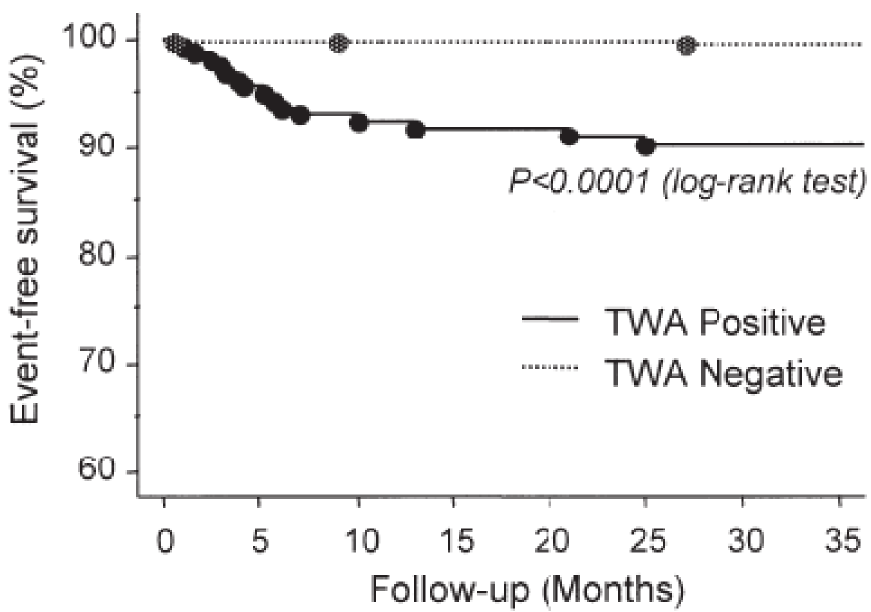
DE = Delayed Enhancement
NSVT = Non-Sustained Ventricular Tachycardia
PVC = Premature Ventricular Contractions
SVT = Supraventricular Tachycardia

HR = Heart Rate

Adabag, A. S. et al. J Am Coll Cardiol 2008;51:1369-1374

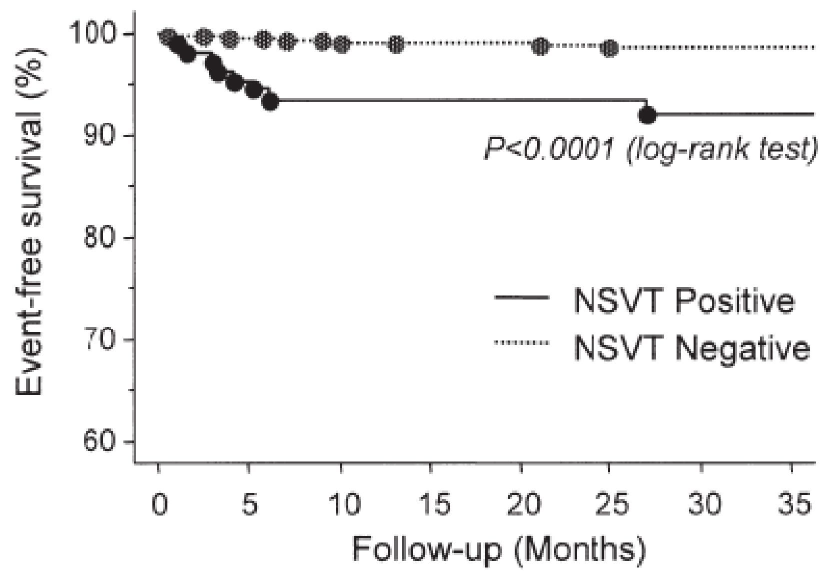
The Cardiac Action Potential



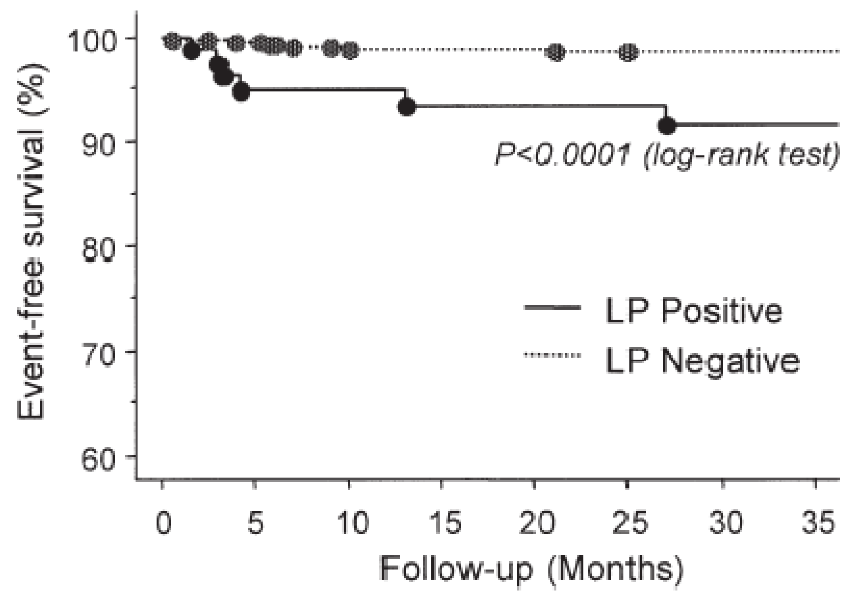


TWA = T-Wave Alternans

~ 1/1000 Negative Predictive Value



NSVT = Non-Sustained Ventricular Tachycardia



LP = late potentials from signal averaged ECG

Ikeda et al, JACC 2006

Hypotheses

1a. Cardiac atrophy occurs in humans after prolonged spaceflight as a function of both the basal hemodynamics of microgravity (reduced wall stress and volume load) and a reduction in physical activity.

1b. Cardiac atrophy develops progressively during long-duration spaceflight, but eventually plateaus in response to a new steady-state of cardiac work.

2. Cardiac atrophy during prolonged spaceflight limits the utilization of diastolic suction and impairs ventricular relaxation and filling both at rest and during gravitational transitions. This impairment of diastolic function leads to impaired systolic function (by limiting cardiac filling) and, in combination with hypovolemia, is the primary mechanism leading to a reduced stroke volume during orthostasis after spaceflight and reduced exercise capacity.

3. Prolonged spaceflight leads to alterations in ventricular conduction, repolarization and refractoriness, and an increase in the frequency of arrhythmias.

Session Descriptions

(Pre/Postflight and Inflight)

48 or 24 hr Blood Pressure (BP)/Holter/Activity Monitoring

Pre-flight (48 hr): Between L-75 & L-60 and between L-21 & L-7 (two total)

Post-flight (24 hr): R+0

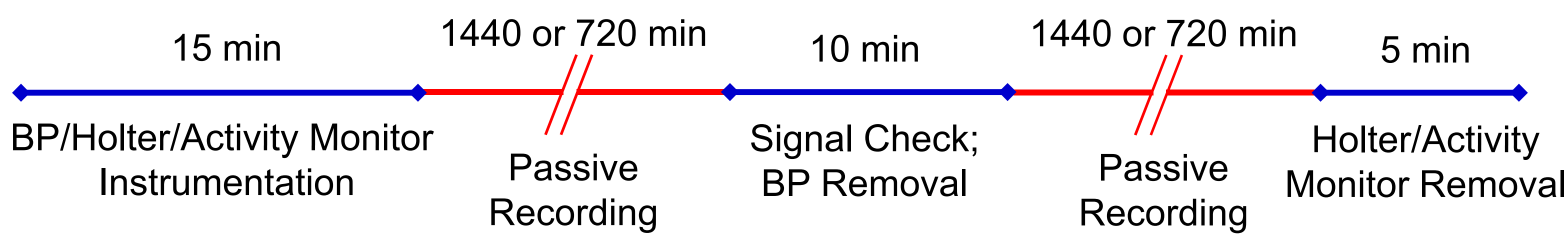
Crew Time – 30 min

Synopsis:

Upon arrival, the crewmember will be instrumented with the Ambulatory BP, Holter Monitor and Activity Monitor (waist and ankle) devices for 48 hours (preflight) or 24 hours (postflight). A signal check and/or memory card change-out will occur part way through the recording period to ensure an adequate signal is being obtained. Preflight, the BP Monitor will be removed at that time. Signal check and hardware removal will be at any location convenient for the crew.

Constraints:

- Hardware cannot be immersed in water. No swimming or showering during session (sponge bath OK).
- No Neutral Buoyancy Laboratory (NBL) runs during the 48 hour period.
- A 10 minute period of quiet rest (indicated by an event marker) is needed during the session.
- Preflight, exercise with heart rate greater than or equal to 120 for at least 10 minutes must be performed at some time during this session.
- Postflight, prefer no high intensity exercise or blood pressure manipulation within first 2 hrs after donning; however, session should not be delayed to accommodate this request




NASSAU BAY
FIRE DEPT.
18:23:30
18:25:24
19:32

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	PIs: Mike Bungo and Ben Levine

24 hr BP/Holter/Activity Monitoring

Within 1 week (preferably ±3 days) of
Resting/Exercise Echo Sessions
(Approx. FD14-15, 30-31, 75-76, 135-136, and R-15-14)

Crew Time – 65 min

Synopsis:
In association with each of the inflight Echocardiogram (Echo) sessions, the subject will prepare the electrode sites (10), apply the electrodes, connect the 12-lead harness, secure the electrodes/lead wires, and set-up the Holter monitor. The subject will then don the activity monitors (one at the waist and one at the ankle), select the appropriate finger cuffs, don the blood pressure monitor and configure it for operation. Operator assistance is requested for a portion of this session. Periodic battery swaps (Makita drill batteries) will be required for the blood pressure monitor. All data collected will be stored digitally. The subject will doff all devices after 24 hours and the data will be downloaded within five days of session completion. This session will ideally be performed 24 hrs before or immediately after the inflight Echo sessions for crew time savings.

Constraints:
- The date of this session must be ± 1 week (preferably within 3 days) of the inflight Echo sessions.
- Time savings can be realized if performed 24 hrs prior to or immediately after a Resting or Exercise Echo session.
- Exercise with heart rate greater than or equal to 120 for at least 10 minutes must be performed at some time during this session. Also, a 10 minute period of quiet rest (indicated by an event marker) is needed.

15 min	20 min	1440 min*	5 min	15 min
Unstow hardware	Hardware Activation and Subject Instrumentation	Passive Recording	Subject De-instrument	Stow Hardware

* Indicates unattended session time

Holter and Ambulatory Blood Pressure Risks

Risks:

None

Discomforts:

- skin irritation from electrodes
- finger cuff is annoying (turns finger blue)
- gets in way of normal activities

Resting Echo/ECG

Crew Time – 30 or 60* min

Pre-flight: Between L-21 and L-7 (one time)

Post-flight: R+7

Synopsis:
Upon arrival, the crewmember will be instrumented and a 12-lead ECG (for Signal Averaged ECG and QT Dispersion) will then be recorded. A Resting Echo for diastolic function will follow (some chest electrodes will be removed for ultrasound probe access). After all measurements are complete, the remaining electrodes will be removed.

Constraints:
- Subjects should have a minimum 6 hours sleep during previous night after no more than an 18 hour work day.
- No caffeine, alcohol, or tobacco for 24 hrs prior to session.
- No over-the-counter cold medication for 36 hrs prior to the session.
- No maximal exercise (≥80% max HR for more than 30 min) for the 12 hrs prior to session.
- No meals within 2 hours preceding this test. A light snack of complex carbohydrates is acceptable within 2 hours.
- Females should wear a sports bra or bikini top for echo probe access.

* It is highly desired that the in-flight operator attend the preflight session with the subject to provide additional ultrasound experience/observational training close to flight.

5 min	20 min	5 min
Subject Instrumentation	Subject Scan (ECG followed by Resting Echo)	Subject De-instrumentation

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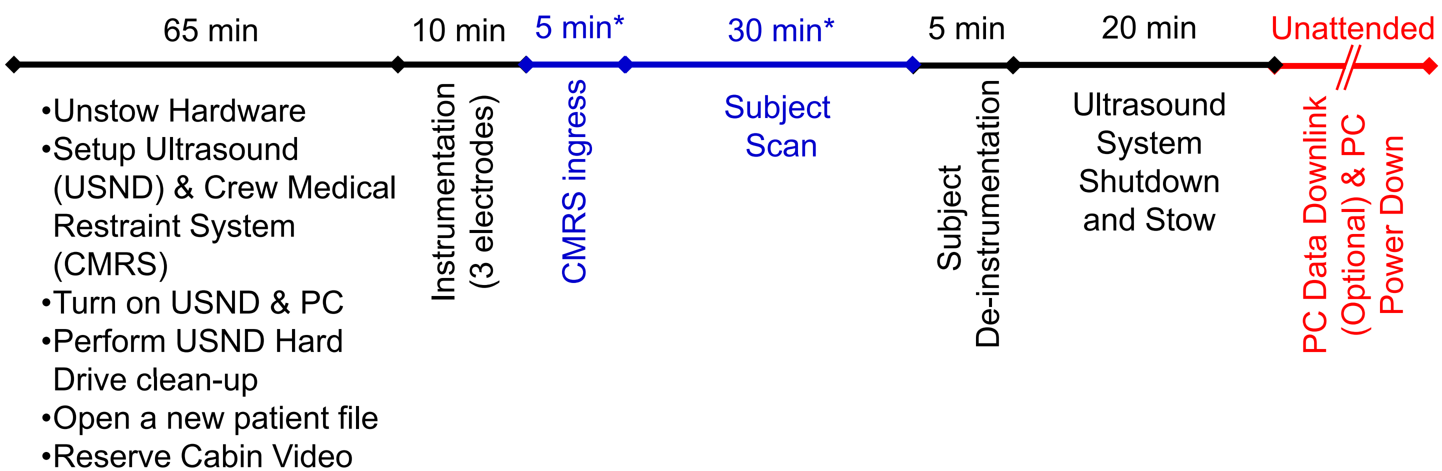
Resting Echo

FD 14 (±4), 30 (±5), 135 (±5), and R-15 (±4)

Crew Time – 170 min

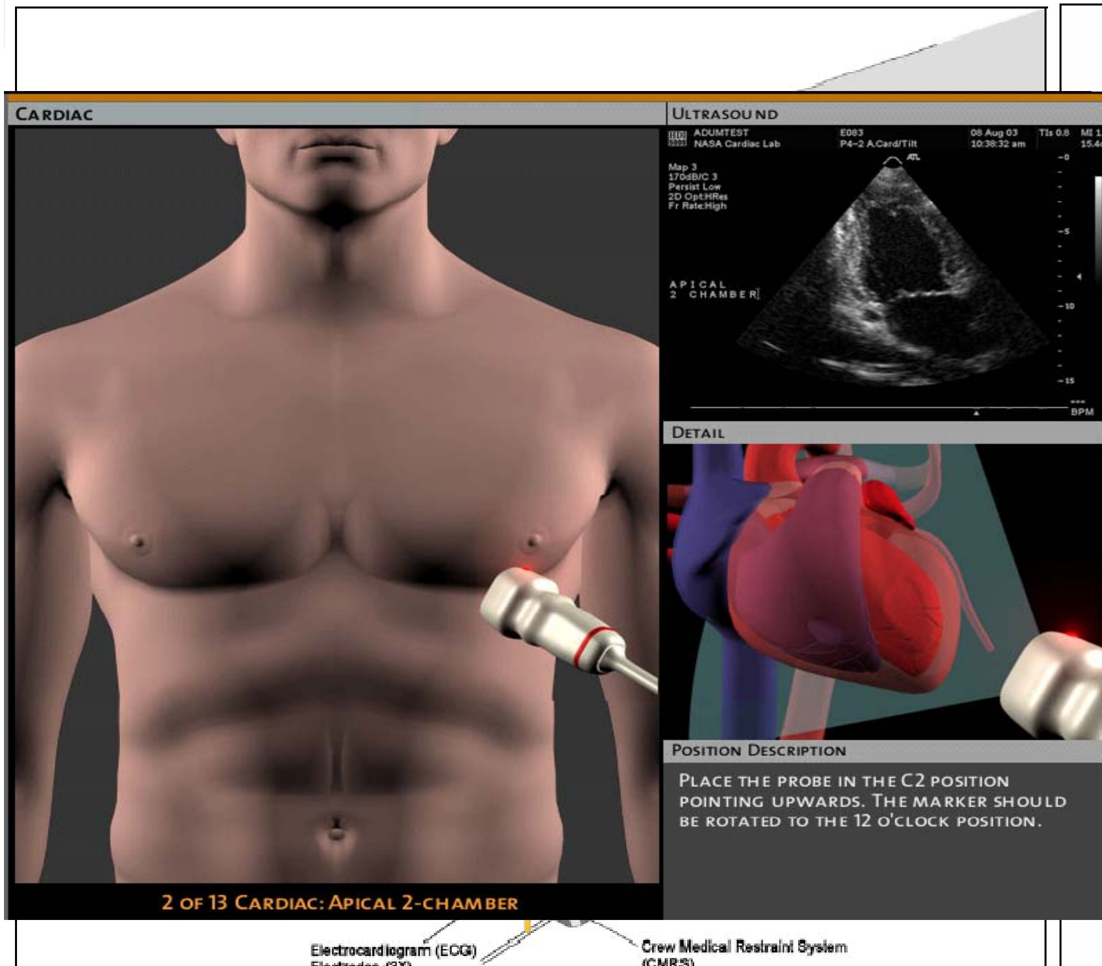


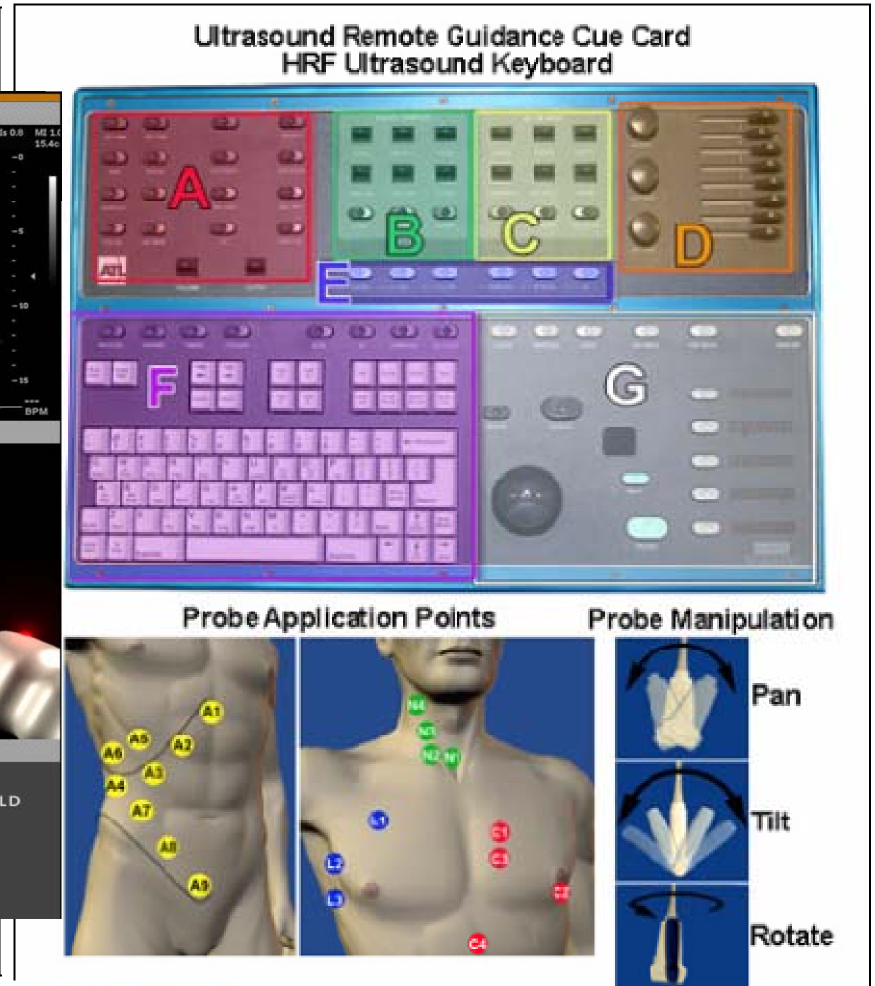
Constraints:

- Ku-band and S-band needed for real-time remote guidance during scanning (downlink of ultrasound video and two-way audio). Real-time (RT) cabin video also requested.
- No exercise, strenuous physical activities, or Extravehicular Activity (EVA) within 4 hrs preceding subject scan.
- No large meal within 2 hours preceding subject scan. A light snack of complex carbohydrates is acceptable within 2 hours.
- Video and audio communications should be private to the Telescience Support Center (TSC) (restricted access is required for video and voice loops due to medically sensitive information).

* Indicates both subject and operator required

Unattended session time


Cardiac
Ultrasound
ADUMTEST
NASA Cardiac Lab
APICAL
2 CHAMBER
Detail
Position Description
Place the probe in the C2 position pointing upwards. The marker should be rotated to the 12 o'clock position.
2 of 13 Cardiac: Apical 2-chamber
Electrocardiogram (ECG)
Crew Medical Restraint System (CMRS)


Ultrasound Remote Guidance Cue Card
HRF Ultrasound Keyboard
A
B
C
D
E
F
G
Probe Application Points
Probe Manipulation
Pan
Tilt
Rotate

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Exercise Echo/ECG

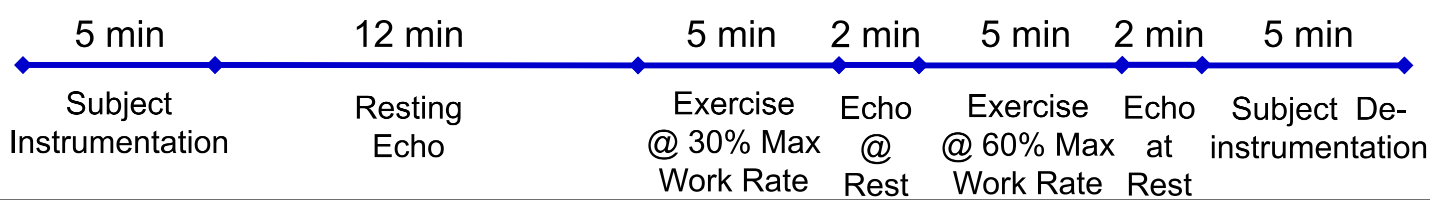
Crew Time – 36 min

Pre-flight: Between L-75 and L-60 (one time)

Post-flight: R+4 and R+14

Synopsis:
Upon arrival, limb leads for ECG will be placed and the area of the chest which provides optimal echo images will be located. Chest electrodes will then be placed, taking care to avoid ultrasound probe-use locations. Baseline measurements of ECG and Echo for diastolic function will be taken. The crewmember will then begin two (2) five-minute submaximal workloads on the bicycle ergometer (one at 30% and the other at 60% of maximum work rate). Echo measurements will be taken with the subject at rest after each workload level while ECG will be recorded throughout the session (both rest and exercise).

Constraints:
- Subjects should have a minimum 6 hours sleep during previous night after no more than an 18 hour work day.
- No caffeine, alcohol, or tobacco for 24 hrs prior to session.
- No over-the-counter cold medication for 36 hrs prior to session.
- No maximal exercise (≥80% max heart rate for more than 30 min) for the 12 hrs prior to session.
- No meals within 2 hrs preceding test. A light snack of complex carbohydrates is acceptable within 2 hours.
- Subject should wear athletic clothing and shoes for the session; females should wear a sports bra or bikini top for echo probe access.
- Approval of crew surgeon for exercise at 30% and 60% maximum work rate needed for R+4 session.



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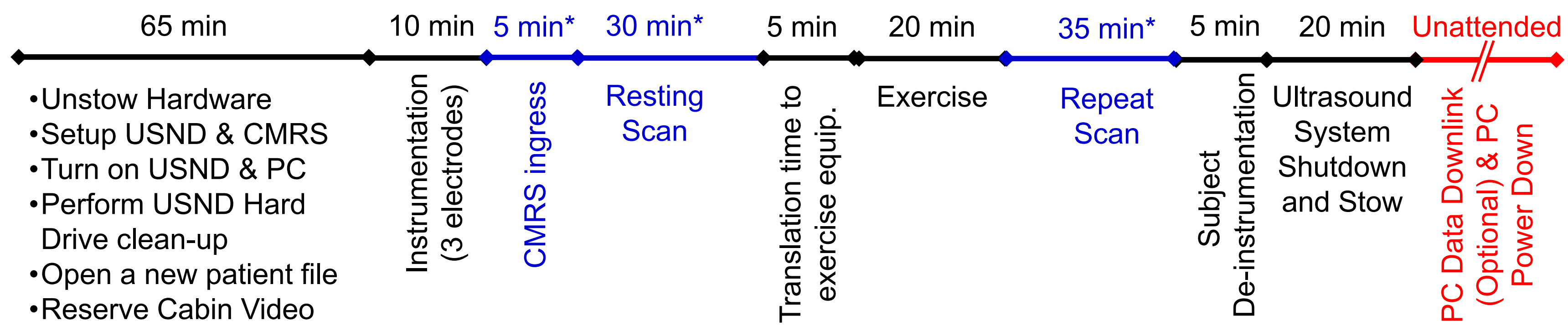
	PIs: Mike Bungo and Ben Levine

Exercise Echo

FD75 (±5)

Crew Time – 265 min



Constraints/Notes:

- Repeat scan must be done immediately (<5 min) after exercise or additional exercise must be performed.
- Exercise must include at least 5 continuous minutes at a heart rate of at least 70% of the max heart rate predicted or achieved during pre-flight testing (exact guidelines established during BDC).
- Ku-band and S-band needed for real time remote guidance during scanning (downlink of ultrasound video and two-way audio). RT cabin video also required.
- No exercise, strenuous physical activities, or EVA within 4 hrs preceding scan.
- No large meal within 2 hours preceding scan. A light snack of complex carbohydrates is acceptable within 2 hours.
- Video and audio communications should be private to the TSC (restricted access is required for video and voice loops due to medically sensitive information).
- Exercise period can be longer (to encompass crewmember's nominal exercise) if certain conditions are met.

* Indicates both subject and operator required

Unattended session time

Echocardiography Session Risks

Risks:

- None for the Echo (Ultrasound) itself
- Exercise rarely causes problems in normal subjects (individuals with heart disease could experience chest pain, dizziness, irregular heart rhythms or even heart attack). Your risk of heart attack is slight (less than 1 in 100,000 tests).

Discomforts:

- ultrasound gel is messy
- skin irritation from electrodes
- exercise can make you tired and uncomfortable

Privacy Concerns

Inflight ultrasound scans will be viewed by more than just the Principal Investigators (PIs):

- one of your crewmates will be the operator and he or she may or may not be able to interpret the scan
- the remote guider will (obviously) need to see the data to direct the on-orbit operator - he/she will be located in JSC's Telescience Support Center (TSC) with 2-way audio and one-way video to communicate with the operator.
- others in the TSC and at PI console locations (such as hardware engineers, PI support personnel, etc.) will see the scans

Mission Control Center-Houston (MCC-H) and Payload Operations Integration Center (POIC) will NOT be able to see the scans (privatized). Neither will your crew surgeon unless you specifically give your permission. ALL personnel in the TSC and at PI console locations (e.g., Dallas) will know that the data itself and any conversations regarding it are to remain strictly confidential.

Integrated Cardiovascular	Human Research Program Informed Consent Briefing
	PIs: Mike Bungo and Ben Levine

Cardiac Function

Crew Time – 75 (preflight) or 60 (postflight) min

Pre-flight: Between L-75 and L-60 (one time)

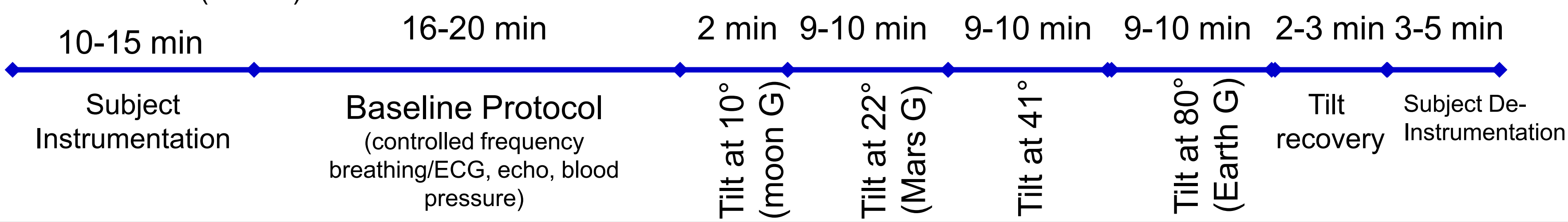
Post-flight: R+0 (some instrumentation/testing in Kazakhstan if possible)

Synopsis:

The subject will be instrumented with a pneumograph, ECG electrodes, Finapres, and blood pressure cuff and a baseline protocol (including controlled frequency breathing, ECG and echo/Doppler recordings) will follow. The tilt table will then be tilted to 10 degrees for 2 minutes while heart rate and blood pressure measurements are taken. The tilt angle will then be increased to 22 degrees for 5 minutes and the echo measurements repeated. The same procedure is followed for tilt angles of 41 degrees and 80 degrees. At all tilt angles other than 10 degrees, measurements will be taken as at baseline, including echo/Doppler, heart rate and blood pressure.

Constraints:

- No caffeine, alcohol, or tobacco for 24 hrs prior to session.
- No over-the-counter cold medication for 36 hrs prior to session; preferably no Midodrine on landing day.
- No meals within 2 hrs preceding test. A light snack of complex carbohydrates is acceptable within 2 hours.
- Females should wear a sports bra or bikini top for echo probe access.
- Preflight, subjects should have a minimum 6 hours sleep during previous night after no more than an 18 hour work day with no maximal exercise (≥80% max HR for more than 30 min) for the 12 hrs prior to session.
- Kentavr suits (if worn) must be removed for this session.



Cardiac Function Session Risks

Risks:

- Slight risk of near fainting during 80 deg tilt (we'll be monitoring your heart rate and blood pressure and stop the test early, if necessary)

Discomforts:

- ultrasound gel is messy
- skin irritation from electrodes
- finger cuff is annoying (turns finger blue)

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Crew Time – 180 min US; 360* min Russia

Magnetic Resonance Imaging (MRI)

Pre-flight: Between L-75 and L-60 in US (one time)

-Additional session in Russia if Russian landing is planned

Post-flight: R+3 (±1 day) and between R+22 and R+30 (two total)

Synopsis:
The crewmember will be picked up and transported to UT-Houston (in the Texas Medical Center) or CRC (in Moscow) for an MRI of their heart. Upon arrival, the crewmember will remove all metal (e.g., jewelry, belt) and magnetically sensitive items (e.g., credit cards, “smart” badges) and don a scrub shirt. An IV will then be started (for later gadolinium administration) and three electrodes will be placed on the chest. Baseline scans (including Magnetic Resonance Spectroscopy or MRS) will then be performed with the crewmember in the supine position. Following the baseline scans, gadolinium will be administered intravenously and a subset of the scans will be repeated. After all scans are complete, the electrodes and IV will be removed and the crewmember will change back into his/her regular shirt, retrieve doffed items, and be transported back to his/her original location.

Constraints:
- Session cannot be scheduled during Blood Pressure/Holter/Activity Monitoring sessions.
- If gadolinium will be administered, documentation of normal renal function (normal serum creatinine levels) is required.
- Pregnancy testing requirements for female subjects will be determined by the crew surgeon prior to each test session.
- Females may wish to wear a sports bra (must not contain metal).

45 (US) or 135 (Russia) min	90 min	45 (US) or 135 (Russia) min
Travel Time	MRI (includes MRS & gadolinium-enhanced scans)	Travel Time


SIEMENS

MRI Risks

Risks:

- **Nephrogenic Systemic Fibrosis** – this is a rare disorder which has occurred in patients with kidney failure getting MRI contrast. It results in hardening of the skin and possibly other organs and has been fatal. It **ALWAYS** occurs in patients who either are on dialysis, or who are in acute kidney failure. It has **NEVER** occurred in more than 220 million patients who have had MRI contrast and have normal kidney function. We will check a simple blood test to ensure your kidney function is normal.
- **Metal implants/embedded metal objects** – these can cause problems (metal can move or burn, etc.) because of the magnets used. Let us know if you have implants or have done a lot of welding/metal grinding or have metallic ink tattoos.

MRI Risks

Risks (continued):

- **Infection/Blood Clot** –very small risk as a result of insertion of the intravenous catheter for the gadolinium (as with any needle "stick", our personnel are trained to do this and they will use the proper equipment to minimize this possibility).

Discomforts:

- claustrophobia
- needle "stick" for IV
- loud machine
- boring

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Exercise/Medication Logs

Pre-flight: L-105 through Launch (daily)
In-flight: Throughout the flight (daily)
Post-flight: R+0 through R+30 (daily)

Crew Time – 0 min

Synopsis:
The subject will log exercise device, duration, and intensity for all exercise performed pre-, in-, and post-flight. Preflight logs will most likely need to be kept by the subject. Inflight and postflight logs are typically obtained via data sharing. Medications will also be logged or obtained via data sharing. Blood parameters (e.g., hematology, chemistry profiles, etc.) will be obtained solely via data sharing from blood analyses performed as part of medical requirements testing.

0 min

Data Sharing (in- and postflight)
Or
Personal Time (preflight)

Constraints:
- Logging should begin 30 days prior to the first Integrated Cardiovascular BDC session.
- Exercise and medication data will be requested via data sharing or logged on personal time (reminder notes may be placed on the crew schedule for the latter). Blood parameters will be obtained solely via data sharing.

Session Summary

PRE-FLIGHT	IN-FLIGHT	POST-FLIGHT
Exercise Echo/ECG • **Between L-75 & L-60**	***OCBT (Reserve)*** • **Within 48 hrs of operator's first scan**	***Cardiac Function*** • **R+0**
48 hr Blood Pressure (BP)/Holter/ Activity Monitoring • **Between L-75 & L-60 and L-21 & L-7**	***Resting Echo*** • **FD14 (±4 days), 30 (±5 days), 135 (±5 days), R-15 (±4 days)**	***24 hr BP/Holter/Activity Monitoring*** • **R+0**
Cardiac Function • **Between L-75 & L-60**	***Exercise Echo*** • **FD75 (±5 days)**	***MRI in Houston*** • **R+3 and between R+22 & R+30**
Magnetic Resonance Imaging (MRI) in Houston • **Between L-75 and L-60**	***24 hr BP/Holter/Activity Monitoring*** • **Within 1 week (preferably 3 days) of echo session (5 sessions)**	***MRI in Russia*** • **R+3 (if Russian landing)**
***MRI in Russia**– if Russian landing* • **Between L-75 & Launch**	***Battery Change and Actiwatch Activation*** • **R-15 (once per increment)**	***Exercise Echo/ECG*** • **R+4 and R+14**
Resting Echo/ECG • **Between L-21 & L-7**	***Actiwatch Activation*** • **Within 5 days of 24 hr BP/Holter/Activity Monitoring session (4 per increment)**	***Resting Echo/ECG*** • **R+7**
Exercise/Medication Logs • **L-105 through launch**	***Hardware Data Download and Downlink*** • **Within 5 days after echo + 24 hr sessions (5 per increment)**	***Exercise/Medication Logs*** • **R+0 through R+30**
	Exercise/Medication Logs • **Throughout Flight**	
Total Time (assuming MRI in Russia is required) **12.4 hrs**	**Total Time** (assuming 6-month mission) **30.1 hrs nominal, 1.5 hrs reserve** NOTE: Includes both subject and operator time	**Total Time** (assuming Russian landing) **12.2 hrs**

Training

Session Title	Session Type	Timeframe	Session Duration	Location of Training	Required for Operators	Required for Subjects
Integrated Cardiovascular Overview and Hardware Demo	Task	L-12 mo	1.5 hrs	JSC	X	X
Integrated Cardiovascular Echocardiography Task Training	Task	L-12 & L-9 mo	2 @ 1.5 hrs each	JSC	X	
Integrated Cardiovascular BP/Holter/Activity Monitor Nom Ops Training	Nominal	L-9 mo	1.5 hrs	JSC	X	X
Integrated Cardiovascular Exercise Echo Task Training	Task	L-6 mo	2 hrs	JSC	X	
Integrated Cardiovascular Echocardiography Nom Ops Training	Nominal	L-6 mo	3 hrs	JSC	X	X
Integrated Cardiovascular Integrated Training	Proficiency	L-3 mo	3 hrs	JSC	X	X
Integrated Cardiovascular OCBT (Reserve)	OBT	FD13	1 hr	ISS	X	
Total: 14 hrs for subject-operator (both roles), 9 hrs as subject only						

Experiment Success

- Quality images from inflight ultrasound sessions is key. Requires patience, and careful attention to the instructions of the remote guider;
- Lying still during MRI image acquisition. These can be long studies and it is easy to become restless;
- While wearing Holter monitor, need to do some routine fitness exercise, and lie quietly for 10 minutes before you go to sleep

Experiment Benefits

- Better understanding of the function of the heart and blood vessels after spaceflight.
- Possible retirement of a number of cardiovascular “risks” of prolonged spaceflight (such as arrhythmias) and/or determination that current hazard controls are sufficient for protection.
- Possible improvements in medical management on earth, particularly for conditions regarding blood pressure control during standing or sudden cardiac death in otherwise healthy individuals.