	RCM	PV
SL 2		-3.4 %
SL 3		-13 %
SL 4	-6.8 %	-16 %

1

ALL COMPARED TO PREFLT VALUES. ALL INCONSTANT

M 171

HR's INFLT – TENDENCY TOWARD ↓ DURING REST + RECOVERY STAGES

MIN. VOL. " – " " ↑ " "

DIAST. BP. " " " ↓ DURING EXERCISE

VITAL CAPACITY – ↓ 2-10% INFLT. – NORMAL POST FLT.
(SPT 4 SL-4 RET. TO PREFLT. NORMAL AT END OF FLT. – NOT OTHERS)

POST FLT. ↓ EXERCISE RESPONSE – MANIFESTED BY

(25-35%) BUT 0 IN 2/3 SL-4 – ↓ C.O. ($\dot{Q}$)
(45%) BUT 0 IN 2/3 SL-4 – ↓ STROKE VOL.
ALL ↑ H.R.

} FOR A GIVEN $\dot{V}O_2$ (O_2 CONSUMPTION)

ALSO ↑ RESTING VENTILATIONS (MIN. VOL.) + ↑ EXERCISE (Ballard) VENTILAT. IN SOME (4/9)

SL-4 (ONLY) MAX. EXERCISE IN FLT, O_2 CONSUMPTION > PREFLT.
(TOTAL WORK PREFLT. vs INFLT. NOT SHOWN)

~~VITAL CA~~

RET. OF EXERCISE RESPONSE TO PREFLT. VALUES:

SL 1/2 – 18-21 DAYS
SL 3 – 5 DAYS
SL 4 – 4 DAYS

PROB. RELATED TO INFLT. PERSONAL EXERCISE

PERSONAL EXERCISE: – ERGOMETER ONLY

SL 1/2 AVE 31 WATT-MIN/Kg BODY WT.
SL 3 " 65 " . . . . (107% > SL 1/2)
SL 4 " 71 . . . . – (130% > SL 1/2)
(– ± 10% > SL 3)

+ MINIGYM + METAL SPRINGS – SL-3
+ " " + TREADMILL – SL-4

M 071 – Ca Loss 115 mg/day > Preflt. → 3.5-4 Gm/Mo. loss
UNABATED THROUGH FLT.

P Loss 32% > preflt. (24, 42 + 32%, resp., in each astronaut)

N_2 Loss 3.5 Gm/DAY > preflt – (also lost unabated)

Ave. for 3 flts, ± 150 mg/day Ca balance

Ca Loss = .35-.4% /Mo.

All despite Bi-Exercise Levels

Sl. Neg Na + K Balances (Hypo)

M078 - Vogel & Roy Atropinemetry
or Calcio

SL-3 SPT - - 7.4 ?
SL-4 PAT - - 7.9 ?
SPT - - 4.5 ?

} All others Neg

Rodriguez & Velez - No Lactose

M073 LEACH

BL. PRESERV. - Na EDTA
CHEM. ANAL. BY { RADIOASSAY
FLUOROMETRIC
GAS CHROMATOG.
STATISTICAL ANALYSIS BY { COVARIANT ANALYSIS
PAIRED T TEST

CHANGES (PLASMA & SERUM) ALL ≈ IN CLASSIC. NORMS.

SERUM & PLASMA CH:

↑ INFLT & IMMED. POST. FLT

Ca
P
K - v. sl.
Creatinine (F.)
* Cortisol
Angiotensin I
Aldosterone

POST FLT ↑

CO_2
PROT.
TSH
T4
ALDO

↓ INFLT & IMMED. POST. FLT

Na
Cl.
Osmol.
* ACTH

↓ INFLT & ↑ POST FLT

Glucose
Insulin

↓ POST FLT

Cholesterol
Uric Acid
Mg
Lactic Dehydrogenase (LDH)
Bili

URINES:

INFLT ↑ BUT VARIABLE

Na, K, Ca, P, N
Aldo
Cortisol
17 Ketos
OH PROLINE
OH LYSINE

POST FLT ↑

Epi.
Norepi.
Aldo
Cortisol
IMMED POST FLT
OH PROLINE
OH LYSINE

INFLT 17 OHC's NO CH.

INFLT ↓ - (TRENDS)
ADH, Epi, Norepi. Uric Ac.

POST FLT ↓
Na Cl K P Mg, Uric Ac.
ADH & 17 ~~Hydroxy~~

(3)

M073 (CONT.) - LEACH

FLUID & ELECT. BALANCE

No H_2O DIURESIS 1 → 6 DAYS — URINE OSMOL. > PLASMA

∴ ↑ SOLUTE EXCRETION

ADH ↑ !! (BUT 15 DAY ANALYSIS COULD NOT BE DONE ← REFRIGERATION ~~FAILURE~~ LACK IN CM)

POST FLT. - TBW ↓ 1.7%
ECF ↓ 1.9% } BUT THESE ↑/WT. BASIS.

EXCH. K (^{42}K & ^{43}K) { SL2 - -7.7 %
SL3 - -3.4 %
SL4 - -8.2 %
MIN. -1.1 SL3 SPT
MAX. -12.3 SL4 PLT

NONE OF ABOVE RELATED TO FLT. DURATION

M113 BODY FLUID & RCM LOSSES

SL-4 7% RCM LOSSES (MEAN)
16% PV LOSSES (MEAN) - SL-3 = -13%
SL-2 = -3.4%

Lang D.
SL2 9.5 -?
SL3 8.0 -?
SL4 6.8 ?

SL-2 - 14.3% AVG
SL-3 - 12.2%
SL-4 - 6.8%

SL2 RCM ↓ 15% (MEAN)
SL3 " 16% (MEAN) } FROM MEMORY SPEC

~~PV LOSSES ?? ↓ 16% I [illegible]~~

RADIATION

MEAN TOTALS (REM):

	SKIN	LENS	BE. FORM.
SL-2	3½	2½	1½
SL-3	8	6½	4
SL-4	14-17	9-12	7

(> .1 REM/DAY)

CAREER DOSE ALLOWABLE

SKIN	LENS	BFO
1200	600	400

TOXICOLOGY

± 300 Compds ~~identified~~ found in OWS Atmosph.
(107 identified)

SL-2 not entered until after series of purges
due to probable (G/B tank) build up of
Tol. Diisocyanate + CO_2 ∴ Heating of Urethane
~~foam~~

All materials reviewed carefully – esp. for CO outgas
+ testing of fluorinated polymers.
∴ Non-metallic matls for CO_2 & organics
Level of acceptance ~~established~~ based on
ECS capability, + leak rate vs. outgas rate.
~~Pyrolysis~~ Products also (not toxicity)

Loss of Δ shield → Skin temp of 350° F outside
160° F internally

MICROBIOL.

OWS AIR – SL-2 LOW 100 (END OF MISSION)
SL-3 LOWER 75
SL-4 HIGH 350 ← COLONY FORMING UNITS/m^3 air

DUE ALMOST ENTIRELY TO SERRATIA MARCESCENT
RECOV. ∴ ALL 3 SL-4 CREW POST FLT (NOT PREFLT.)
– PERSISTED IN PLT THRU POST FLT
QUARANT ~~LINE~~ (IN NASAL PASSAGES)

OWS SAMPLE SITES

SL-2 ↓ AEROBES (← Δ STRESS?)
↑ (10X) ANAEROBES
(ENVIRONS STAYED CLEAN HOWEVER (conclusion of analysis))

SL-3 ↑ AEROBES + ANAEROBES BY 1-2 LOG UNITS (← DURATION OF FLT.)

SL-4 AEROBES CONSTANT } AS MISSION PROGRESSED
ANAEROBES ↓
← LOSS OF PROPIONIBACTERIUM ACNES
ALSO ↓ ∴ SKIN OF CREW (RESERVOIR)

CM'S showed No Variation PRE + POST FLT – THO DIFF. ∴ EACH OTHER
(OWS CHANGES NOT REFLECTED IN CM'S)

FUNGUS ∴ OWS SAMPLE SITES – LOW UNTIL SL-4
← MILDEW GROWTH IN LIQ. COOLED GARMENTS
(SAME IN AIR) (SAME ON CREW SKIN)
EVEN UNUSED LCG'S MILDEWED IN CONTAINERS (RETURNED ~~FOR SPLIT~~)

CREW – AEROBIC – IMMED. POST FLT. ANALYSES – OFTEN ↑ BEYOND PREFLT
WHEN 30, DUE TO ↑ NO.S BACTY, BUT ↓ IN TYPES (GENERA) + SPECIES
ANAEROBIC VARIATIONS NOT DEPENDENT ON MISSION DURATION (API 4 + SL-4 ARE ≅)
– FEWER NOS. + GENERA POST FLT. (EXCEPTION – SOME SPL ARRAS SL-3) – P. ACNES

BODY MASS LOSSES (LAUNCH TO R+0) & INFLT. CURVES

SL-2 CDR 136½ − 132½ = 4#

SPT 170½ − 163½ = 7#

PLT 175½ − 167½ = 8#

SL-3

CDR 151½ − 142½ = 9#

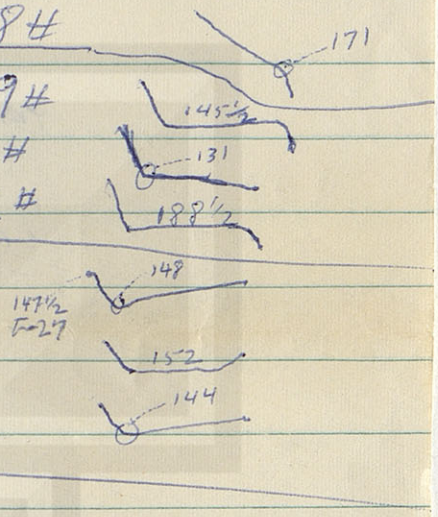
SPT 136½ − 128½ = 8#

PLT 195 − 185½ = 9½#

SL-4 CDR 150 − 149½ = ½#

SPT 157 − 154 = 3#

PLT 149 − 146 = 3#



AVERAGES: SL-2 = 6⅓# LOSS

SL-3 = 9# LOSS

SL-4 = 2# LOSS (MEAN = CLOSER TO 3#)

SL-3 SHOWED GREATEST LOSS (59 DAYS)

SL-4 " LEAST " (84 DAYS)

MAX. LOSS (SL-3 PLT) − 9½#

MIN. LOSS (SL-4-CDR) − ½#

MICROBIOL. (CONT.)

CONCLUSIONS

NUMERICAL CHANGES IN AUTOFLORA NOT CORRELATED ≈ MISSION DURATION

TOTAL NOS. TEND TO ↑ FOR AEROBES, ↓ FOR ANAEROBES

NO. OF GENERA & SPECIES CHANGES LITTLE FOR AEROBES, DECREASES FOR ANAEROBES

YEASTS & FUNGI — BUT REL. ↑ IN C. ALBICANS

+ POST FLT. IN AP; ALSO SKYLAB. - EXCEPTION SL-3 (NOT DECREASED) + SL-4

POST FLT. MICROB. SHOCK - NO EVIDENCE

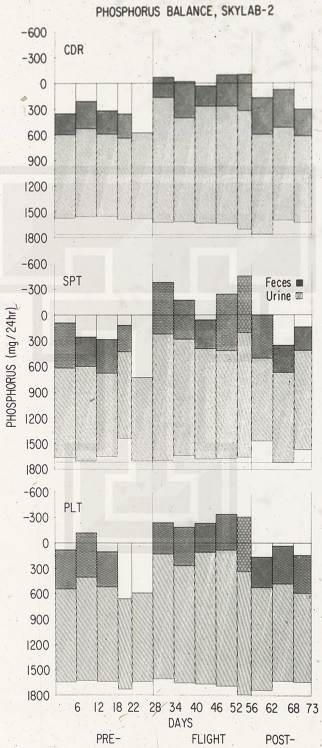
CROSS CONTAM. - NO (SL-2 PILOT'S STAPH AUREUS NOT ~~→~~ OTHER CREW MEMBERS)

~~YES (SL-3 SPT CDR'S S. AUREUS PHAGE TYPE 3A~~

BUT NOT PLT'S 29/79

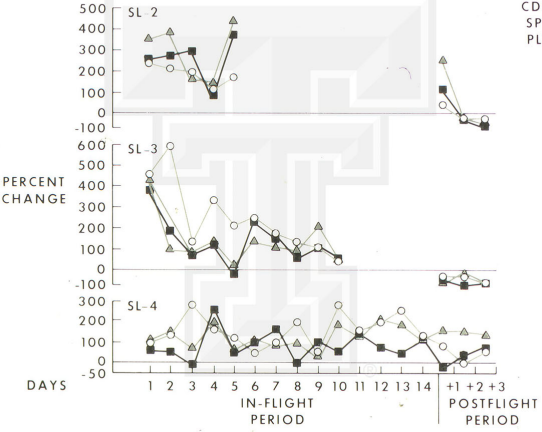
CDR DEVEL. AXILLARY FURUNCLE (WAS A T. CARRIER)

PLT DEVEL. HORDEOLUM (" - - -)


PHOSPHORUS BALANCE, SKYLAB-2
CDR
SPT
PLT
Feces
Urine
PHOSPHORUS (mg/24hr)
-600
-300
0
300
600
900
1200
1500
1800
6 12 18 22 28 34 40 46 52 56 62 68 73
DAYS
PRE-
FLIGHT
POST-

NASA S-74-4376

URINARY ALDOSTERONE



NASA-S-74-4375

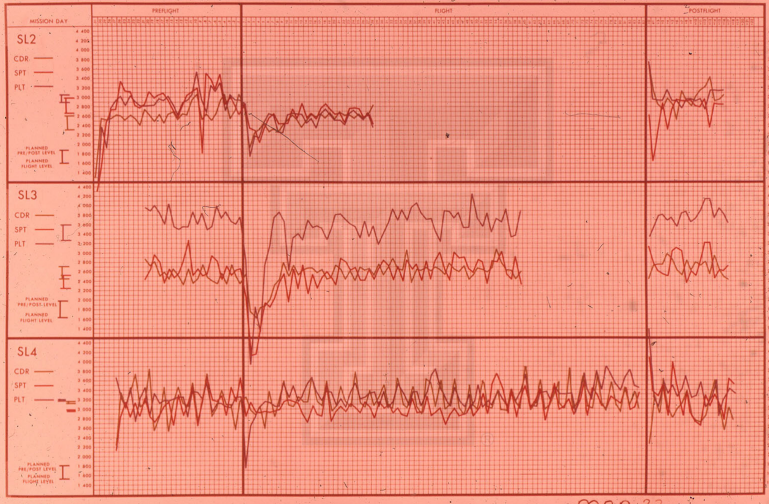
SKYLAB SUMMARY

PLASMA/SERUM BIOCHEMICAL CHANGES
SUBSTANCE INCREASED

IN-FLIGHT	POSTFLIGHT	
POTASSIUM	POTASSIUM (R+0)	INSULIN
CALCIUM*	CALCIUM*	ALDOSTERONE*
PHOSPHORUS*	PHOSPHORUS*	CHOLESTEROL
CREATININE	CREATININE	TRIGLYCERIDES
CORTISOL*	CORTISOL	S-GLUTAMIC OXALOACETIC TRANS
ANGIOTENSIN I*	ANGIOTENSIN I	CREATINE PHOSPHOKINASE
	THYROID STIMULATING HORMONE*	TOTAL PROTEIN*
	THYROXINE*	CARBON DIOXIDE*
	GLUCOSE*	

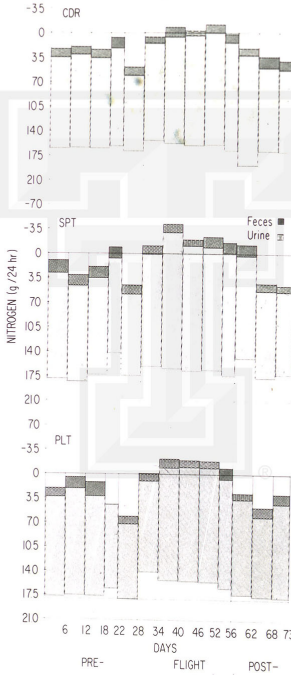
* $P \leq 0.05$

SKYLAB CREW HEALTH TREND - CALORIE INTAKE (CAL/DAY)



MAR 22

NITROGEN BALANCE, SKYLAB-2



NASA-S-74-4370

SKYLAB SUMMARY

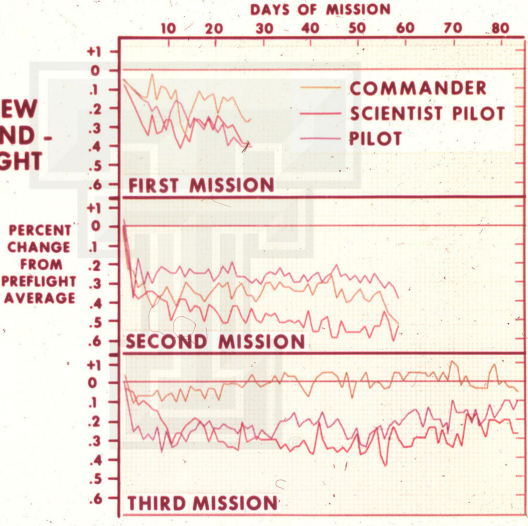
PLASMA/SERUM BIOCHEMICAL CHANGES

SUBSTANCE/PROPERTY DECREASED	
IN-FLIGHT	POSTFLIGHT
SODIUM*	SODIUM
CHLORIDE*	CHLORIDE*
OSMOLALITY*	OSMOLALITY
GLUCOSE*	ADRENOCORTICOTROPHIC HORMONE
INSULIN*	BLOOD UREA NITROGEN
ADRENOCORTICOTROPHIC HORMONE*	CHOLESTEROL
ALDOSTERONE	URIC ACID
	MAGNESIUM
	LACTIC DEHYDROGENASE
	TOTAL BILIRUBIN
	ALBUMIN

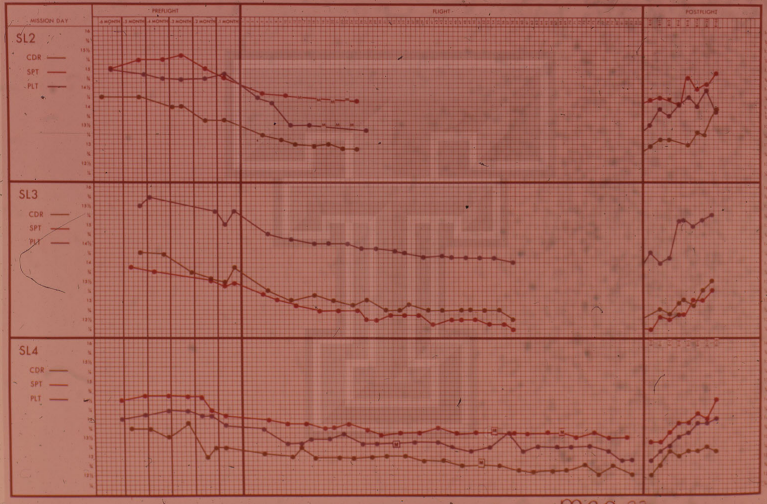
* $P \leq 0.05$

NASA-S-74-4432

SKYLAB CREW HEALTH TREND - BODY WEIGHT

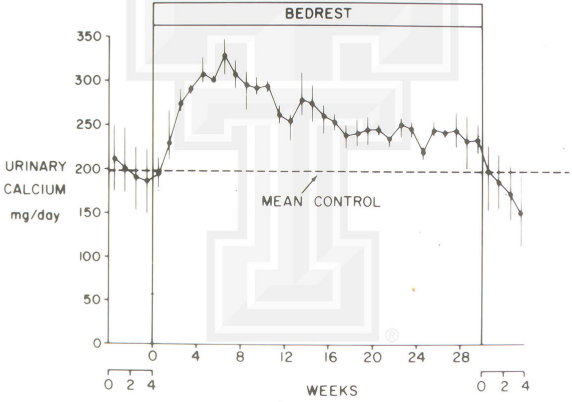


SKYLAB CREW HEALTH TREND – CALF CIRCUMFERENCE (INCHES)



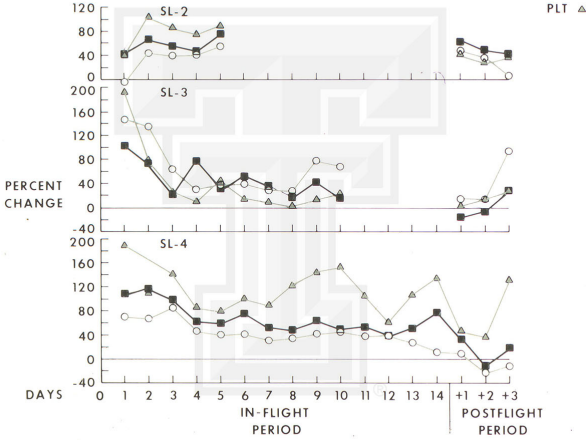
MAR 22

THE EFFECT OF PROLONGED BEDREST ON
MEAN URINARY CALCIUM EXCRETION
(3 SUBJECTS)



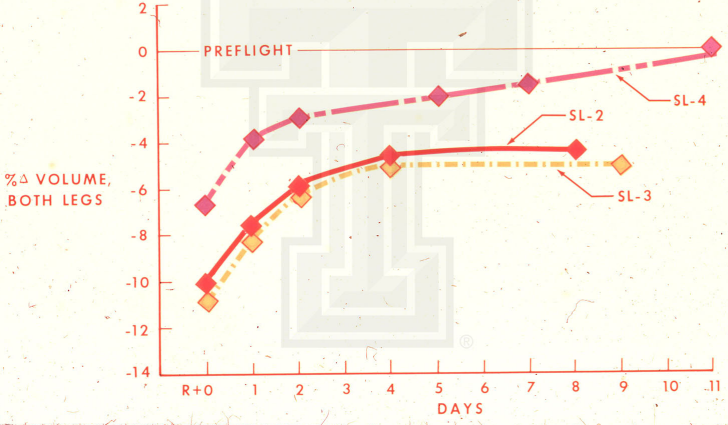
NASA-S-74-3890

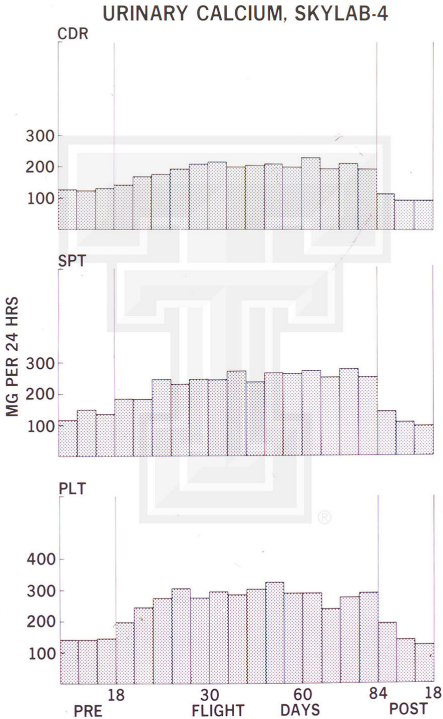
URINARY CORTISOL



NASA-S-74-4803

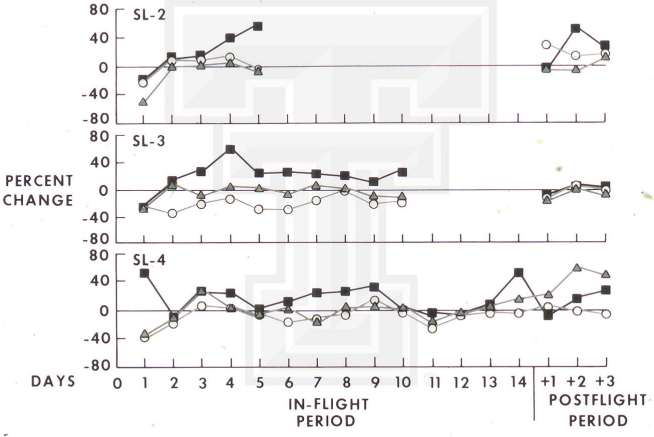
AVERAGE LEG VOLUME CHANGE, POSTFLIGHT - SKYLAB




URINARY CALCIUM, SKYLAB-4
CDR
SPT
PLT
MG PER 24 HRS
300
200
100
400
18
30
60
84
18
PRE
FLIGHT
DAYS
POST

NASA-S-74-3891

URINE VOLUME



NASA-S-74-4372

SKYLAB SUMMARY

24-HOUR URINE RESULTS

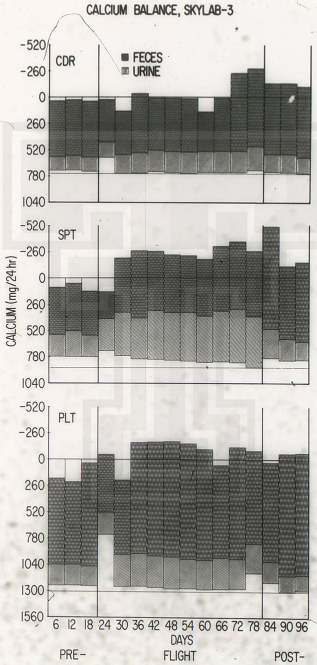
SUBSTANCE/PROPERTY INCREASED	
IN-FLIGHT	POSTFLIGHT
SODIUM	EPINEPHRINE
POTASSIUM	NOREPINEPHRINE
CHLORIDE	ALDOSTERONE
OSMOLALITY	CORTISOL
CALCIUM	TOTAL 17-KETOSTEROIDS
PHOSPHORUS	
ALDOSTERONE	
CORTISOL	
17-KETOSTEROIDS	

NASA-S-74-4915

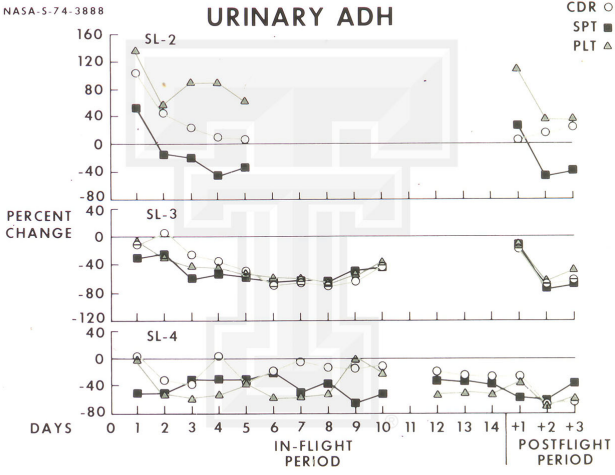
RED CELL MASS

MEAN % CHANGE

SKYLAB	2	3	4
R + 0	-14.3	-12.2	-6.8
R + 14	-15.6	-7.5	-4.5
R + 42, 45	- 5.2	+2.6	+3.7
R + 67	+0.2	--	--


CALCIUM BALANCE, SKYLAB-3
FECES
URINE
CDR
SPT
PLT
CALCIUM (mg/24hr)
-520
-260
0
260
520
780
1040
1300
1560
6 12 18 24 30 36 42 48 54 60 66 72 78 84 90 96
DAYS
PRE-
FLIGHT
POST-

NASA-S-74-3888



NASA-S-74-4371

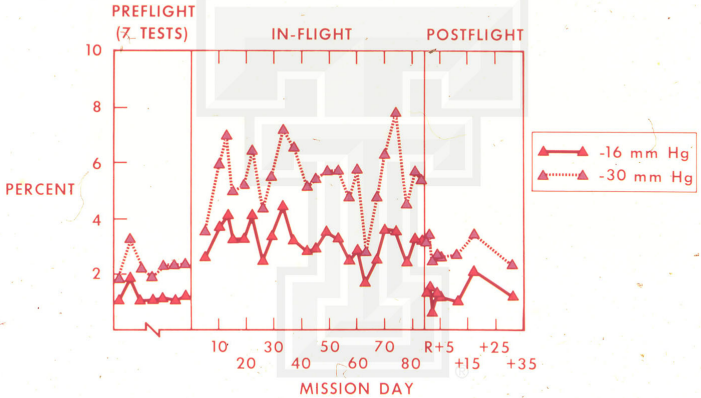
SKYLAB SUMMARY

24-HOUR URINE RESULTS

SUBSTANCE/PROPERTY DECREASED	
IN-FLIGHT	POSTFLIGHT
ANTIDIURETIC HORMONE ±	SODIUM
EPINEPHRINE ±	POTASSIUM
NOREPINEPHRINE	CHLORIDE
TOTAL 17-HYDROXYCORTICOSTEROIDS ±	OSMOLALITY
URIC ACID	PHOSPHORUS
	MAGNESIUM
	URIC ACID
	ANTIDIURETIC HORMONE
	TOTAL 17-HYDROXYCORTICOSTEROIDS
	TOTAL 17-KETOSTEROIDS

NASA-S-74-4511

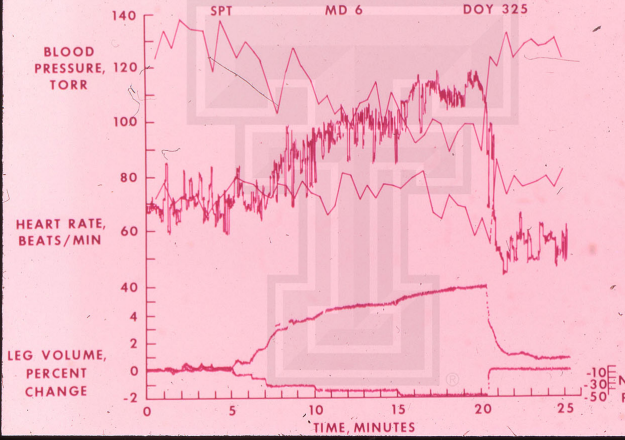
M092, LOWER BODY NEGATIVE PRESSURE
CHANGE IN CALF VOLUME, SL-4 PLT



NASA-S-74-4344

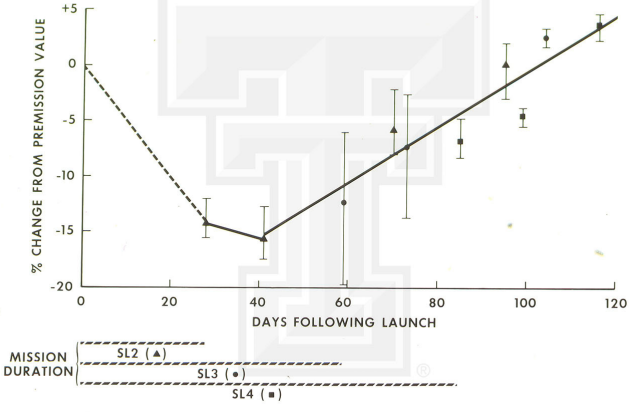
M092 LOWER BODY NEGATIVE PRESSURE

SKYLAB 4

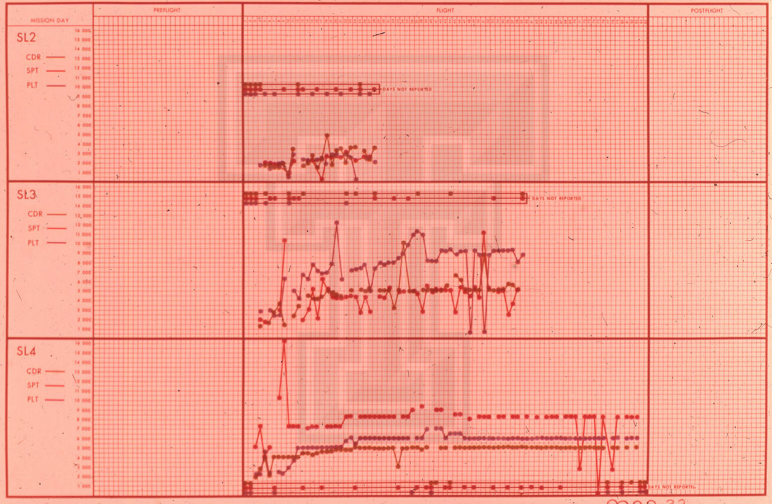


NASA-S-74-3108

RED CELL MASS/SKYLAB



SKYLAB CREW HEALTH TREND – INFLIGHT EXERCISE (WATT-MIN)

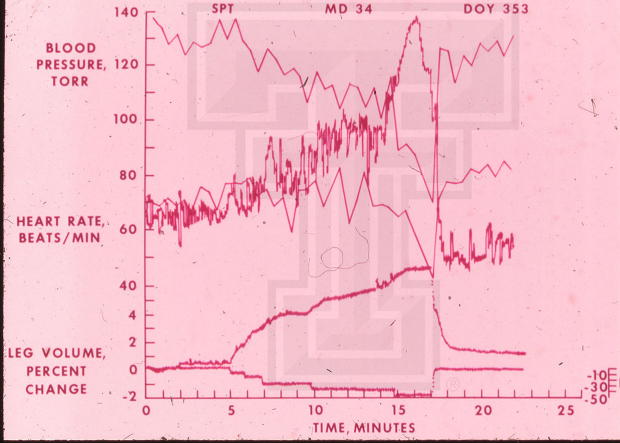


MAR 22

NASA-S-74-4347

M092 LOWER BODY NEGATIVE PRESSURE

SKYLAB 4



NASA-S-74-4920

SKYLAB CREWS RETICULOCYTE COUNTS

PERCENTAGE OF PREMISSION MEAN

DAY	MISSION 2	MISSION 3	MISSION 4
R + 0	44	69	88
R + 1	53	--	117
R + 3	67	87	87
R + 7	80	184	143
R + 14	86	227	184
R + 21	93	234	180

HISTORY OF MOTION SICKNESS AND VESTIBULOMETRIC FINDINGS IN THE NINE ASTRONAUTS

ASTRONAUT	AGE	HISTORY OF MOTION SICKNESS								CANAL FUNCTION		OTOLITH FUNCTION	CORIOLIS SICKNESS SUSCEPTIBILITY INDEX
		AIRCRAFT		PARABOLIC FLIGHT (OG)		SPACE FLIGHT		SEA MOD TO HEAVY		CANAL THRESHOLDS OF RESPONSE	MODIFIED FITZGERALD-HALLPIKE	OCULAR COUNTER ROLLING	
		EXPERIENCE	SYMPTOMS	EXPERIENCE	SYMPTOMS	EXPERIENCE	SYMPTOMS	EXPERIENCE	SYMPTOMS		PREPONDERANCE		
1	42	>2000 h	–	~8 TIMES	–	GEMINI V, APOLLO XII	–	1-5 TIMES	SLIGHT	WITHIN NORMAL LIMITS	INSIGNIFICANT	158 LOW NORMAL	10 2
2	40	>1000 h	–*	>10 TIMES	†NAUSEA & VOMITING	NONE	N A‡	1-5 TIMES	SLIGHT	WITHIN NORMAL LIMITS	INSIGNIFICANT	300 NORMAL	8 2
3	40	>2000 h	–	>10 TIMES	†NAUSEA & VOMITING	NONE	NA	>100 TIMES	–	WITHIN NORMAL LIMITS	SIGNIFICANT (RETEST INDICATED)	374 NORMAL	19 8
4	40	>1000 h	–*	>20 TIMES	–	APOLLO XII	–	10-50 TIMES	SLIGHT	WITHIN NORMAL LIMITS	SIGNIFICANT (RETEST INDICATED)	365 NORMAL	23 1
5	41	>1000 h	–	~3 TIMES	–	NONE	NA	>100 TIMES	MOD	WITHIN NORMAL LIMITS	INSIGNIFICANT	158 LOW NORMAL	26 4
6	36	>2000 h	–	>10 TIMES	†NAUSEA & VOMITING	NONE	NA	5-10 TIMES	SLIGHT	WITHIN NORMAL LIMITS	INSIGNIFICANT	332 NORMAL	19 2
7	40	>1000 h	–*			NONE	NA	10-50 TIMES	SLIGHT	WITHIN NORMAL LIMITS	INSIGNIFICANT	494 NORMAL	7 5
8	36	>1000 h	–*			NONE	NA	1-5 TIMES	SLIGHT	WITHIN NORMAL LIMITS	INSIGNIFICANT	261 NORMAL	8 9
9	43	>1000 h	–*	3 TIMES	–*	NONE	NA	0	NA	WITHIN NORMAL LIMITS	INSIGNIFICANT	254 NORMAL	52 8

* MILD SYMPTOMS ON RARE OCCASIONS

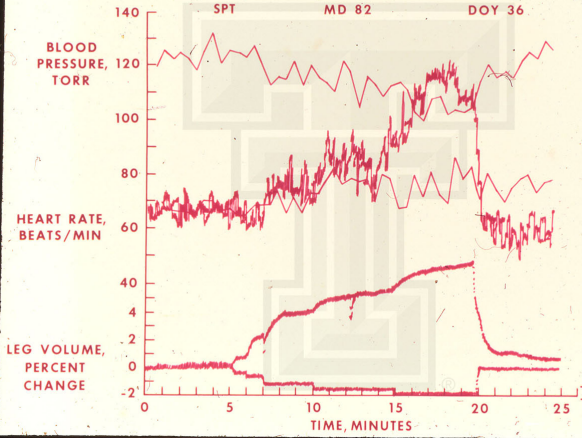
† REPORTED BY FLIGHT CREW

‡ NOT APPLICABLE

NASA-S-74-4352

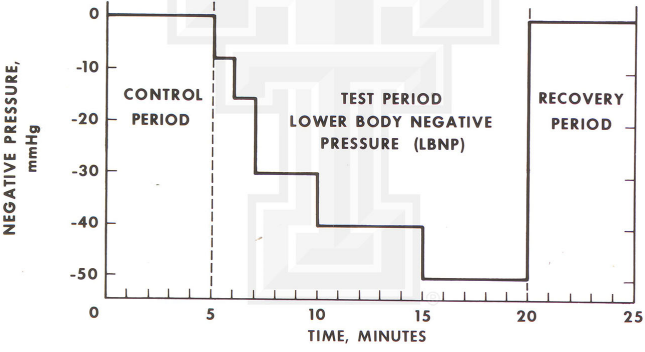
M092 LOWER BODY NEGATIVE PRESSURE

SKYLAB 4



NASA-S-74-3245

THE LOWER BODY NEGATIVE PRESSURE PROTOCOL USED FOR SKYLAB CARDIOVASCULAR EVALUATIONS ASSESSING ORTHOSTATIC TOLERANCE

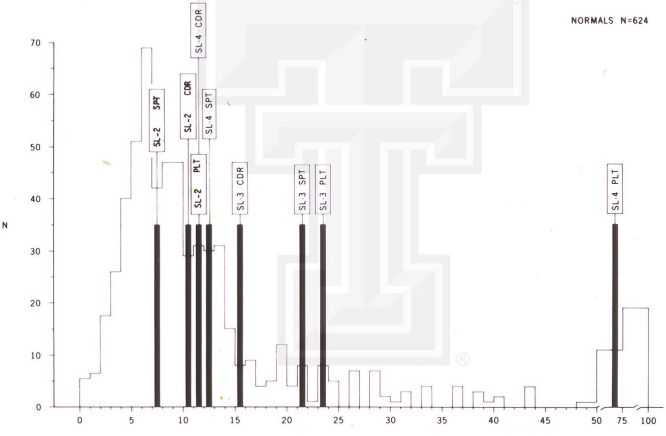


NASA-S-74-4911

RED CELL MASS

MISSIONS	MEAN % CHANGE
GEMINI 5	-21
GEMINI 7	-14
APOLLO 7-8	- 2
APOLLO 14-17	-10 ± 1
SKYLAB 2	-14
SKYLAB 3	-12
SKYLAB 4	- 7
CONTROLS	-0.4

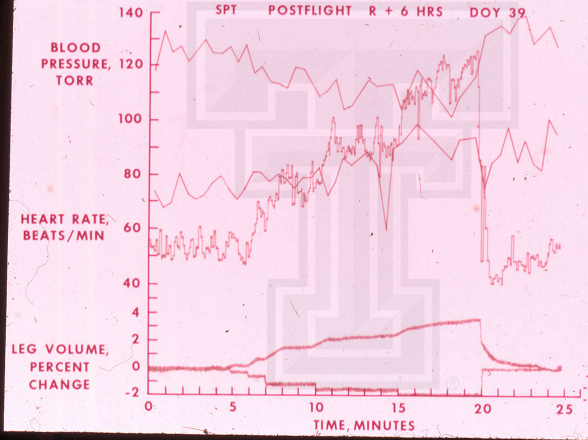
FREQUENCY DISTRIBUTION OF MOTION SICKNESS SUSCEPTIBILITY SCORES OF THE NINE SKYLAB ASTRONAUTS



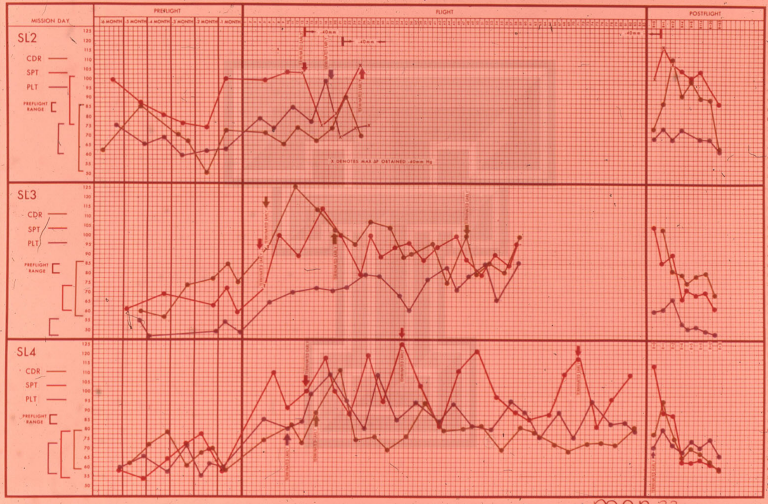
NASA-S-74-4364

M092 LOWER BODY NEGATIVE PRESSURE

SKYLAB 4

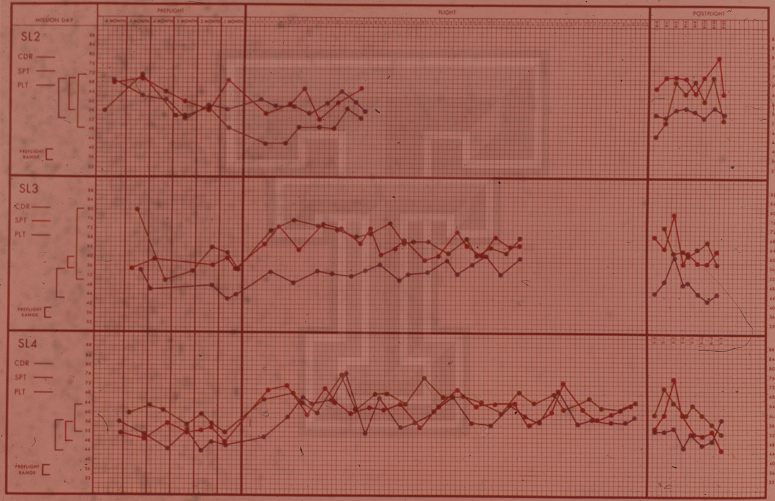


SKYLAB CREW HEALTH TREND - M092 HEART RATE AT MAX LBNPD (BPM)



MAR 22

SKYLAB CREW HEALTH TREND - MOP2 RESTING HEART RATE (BPM)



MAR 22

DIAGNOSTIC CATEGORIZATION OF DIFFERENT LEVELS OF ACUTE MOTION SICKNESS

Category	Pathognomonic 16 points	Major 8 points	Minor 4 points	Minimal 2 points	AQS* 1 point
Nausea syndrome	Nausea III,† retching or vomiting	Nausea II	Nausea I	Epigastric discomfort	Epigastric awareness
Skin		Pallor III	Pallor II	Pallor I	Flushing/Subjective warmth =II
Cold sweating		III	II	I	
Increased salivation		III	II	I	
Drowsiness		III	II	I	
Pain					Headache (persistent) =II
Central nervous system					Dizziness (persistent)
					Eyes closed =II
					Eyes open III

Levels of Severity Identified by Total Points Scored

Frank Sickness (FS) =16 points	Severe Malaise (M III) 8 – 15 points	Moderate Malaise A (M IIA) 5 – 7 points	Moderate Malaise B (M IIB) 3 – 4 points	Slight Malaise (M I) 1 – 2 points

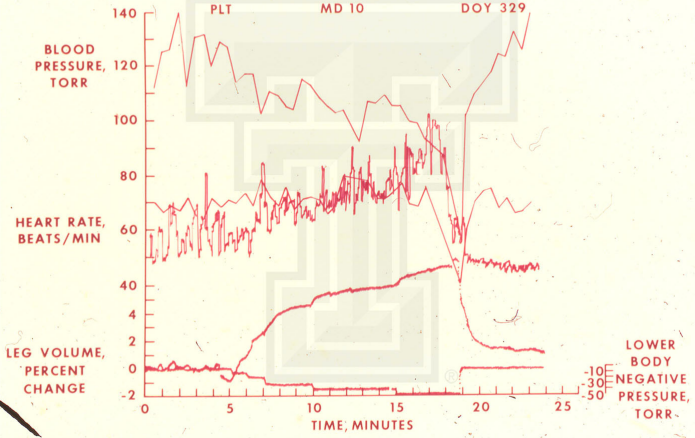
*AQS – Additional qualifying symptoms

†III – severe or marked, II – moderate, I – slight

NASA-S-74-4353

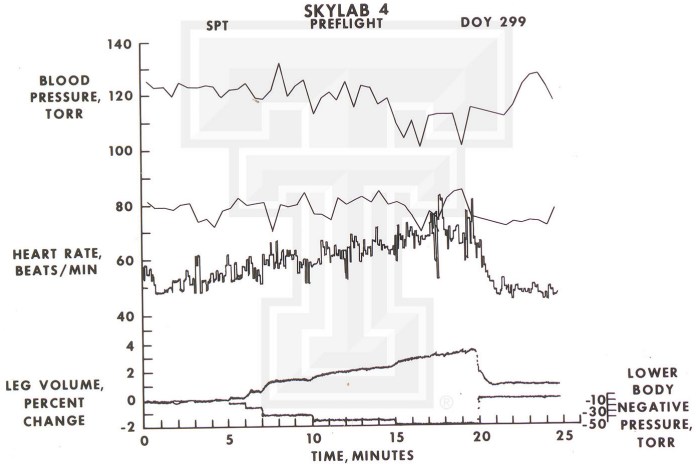
M092 LOWER BODY NEGATIVE PRESSURE

SKYLAB 4

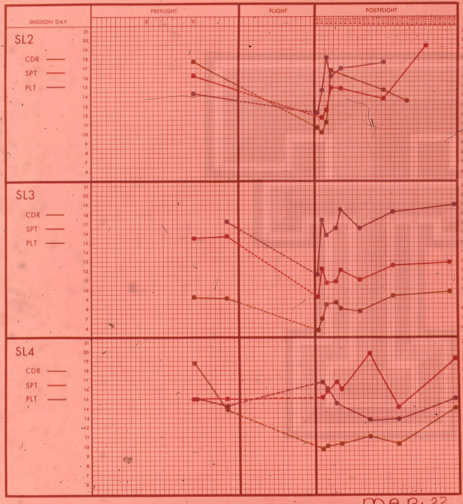


NASA-S-74-4336

M092 LOWER BODY NEGATIVE PRESSURE



SKYLAB CREW HEALTH TREND – CARDIAC OUTPUT (L/MIN)

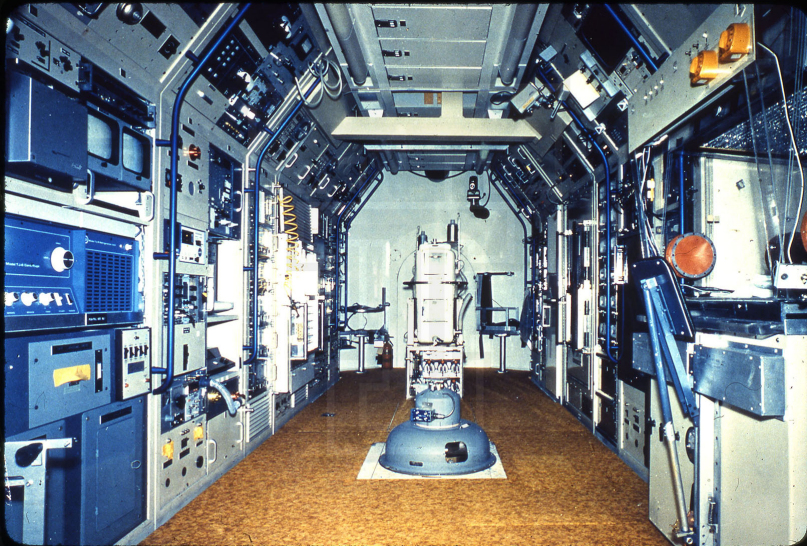


MAR 22

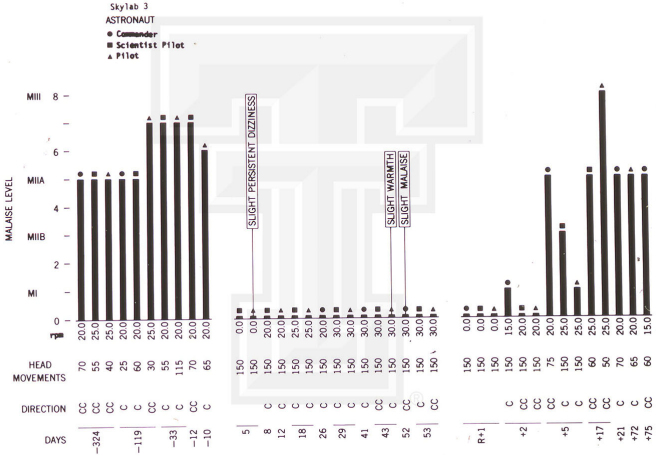
NASA-S-74-4809

SKYLAB GENERAL SUMMATION

- BIOMEDICAL RESULTS SHOW THAT MAN CAN ADAPT AND FUNCTION EFFECTIVELY IN WEIGHTLESS ENVIRONMENT FOR EXTENDED PERIODS
- DAILY IN-FLIGHT PERSONAL EXERCISE REGIMENS COUPLED WITH APPROPRIATE DIETARY INTAKE AND PROGRAMED ADEQUATE SLEEP/WORK/RECREATION PERIODS ESSENTIAL FOR MAINTAINING CREW HEALTH AND WELL-BEING
- NO UNTOWARD PHYSIOLOGICAL CHANGES NOTED THAT WOULD PRECLUDE LONGER DURATION MANNED SPACE FLIGHTS; HOWEVER, RESEARCH REQUIRED TO UNDERSTAND THE MECHANISMS RESPONSIBLE FOR MANY OBSERVED CHANGES
- REMEDIAL OR PREVENTIVE MEASURES MAY BE REQUIRED FOR MISSION DURATIONS IN EXCESS OF 9 TO 12 MONTHS (E.G., BONE DEMINERALIZATION COUNTERMEASURES)
- IDEALLY, FURTHER OBSERVATIONS OF MAN IN EARTH ORBIT FOR AN UNINTERRUPTED PERIOD OF 6 MONTHS SHOULD PRECEDE A MARS-TYPE MISSION.



MOTION SICKNESS SYMPTOMATOLOGY OF SL 3 ASTRONAUTS



SKYLAB 4 ANTIMOTION SICKNESS MEDICATION

MISSION EVENT	APPROX TIME (HOURS C.S.T.)	COMMANDER	SCIENTIST PILOT	PILOT
LAUNCH DAY (MD 1)				
AFTER INSERTION	0900		A	B
AFTER NC-1*	1100	A		
AFTER DOCKING	1700	B	B	B
	2300			B
MD-2 & MD-3	0600	A	A	B
ON ARISING	1000	A	A	
	1400	B	B	B
MD-4	0600	A	A	B
ON ARISING	1400			B
MD-8	BEDTIME		B	
MD-33	BEDTIME		B	
MD-82	BEDTIME		B	
MD-84 ABOUT 2 HOURS PRIOR TO SPLASH (ENTRY)		A	A	A

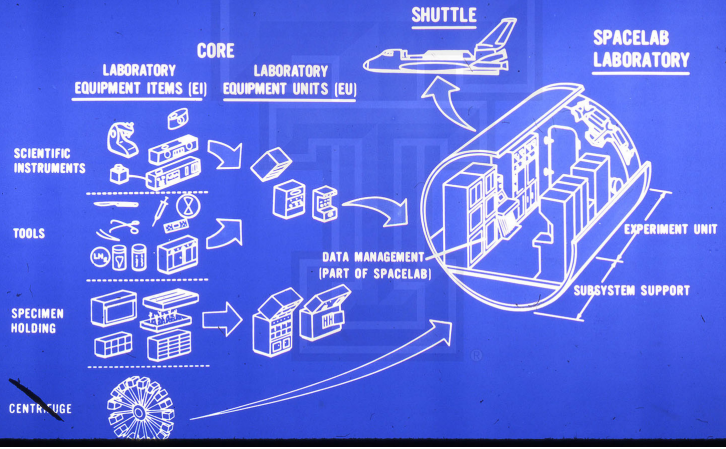
A SCOPOLAMINE / DEXEDRINE (0.35/5.0 mg)
B PROMETHAZINE / EPHEDRINE (25/50 mg)
* FIRST PHASING MANEUVERS

NASA-S-74-4856

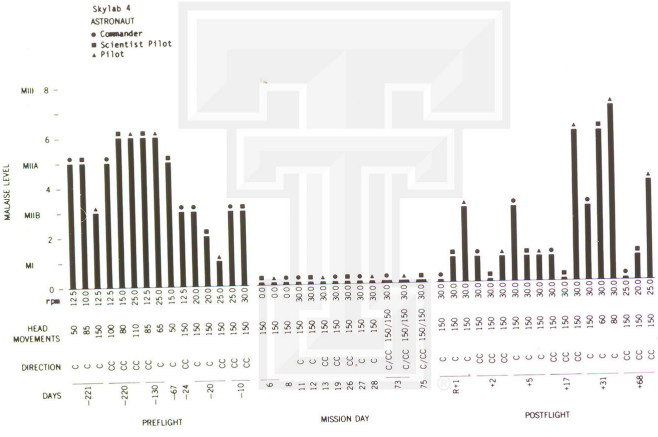
HEMATOLOGIC SYSTEM

- FINDING
  - RED CELL MASS LOSS
- ETIOLOGICAL FACTOR(S)
  - INCREASED DESTRUCTION - NO EVIDENCE
  - MARROW SUPPRESSION
    - ? TOXIC
    - ? PHYSICAL (INCREASED BLOOD VOLUME, MARROW VENOUS PRESSURE)
- CANDIDATE FUTURE STUDIES
  - GROUND-BASED MARROW-SUPPRESSION FACTORS
  - VALIDATE SKYLAB RESULTS ON LONGER EARTH-ORBITAL FLIGHTS

LIFE SCIENCES CORE CONCEPT
(COMMON OPERATIONS RESEARCH EQUIPMENT)



MOTION SICKNESS SYMPTOMATOLOGY OF SL 4 ASTRONAUTS



SUSCEPTIBILITY TO MOTION SICKNESS UNDER OPERATIONAL CONDITIONS

ASTRONAUT	SL	MISSION DAY 1			2	3	4	5	6	7	SPLASH DOWN	CARRIER RECOVERY & DAYS R+0	R+1	R+2	LAND
		COMMAND MODULE (CM) PREDOCK[1]		POSTDOCK[2]	WORKSHOP										
1	2	–		–	–	–	–	–	–	–	–	–	–	–	–
2	2	C[1] L[2]+15 MIN		–	–	–	–	–	–	–	MARKED N[3]	MARKED N B V[4]	MOD	SL	–
3	2	–		–	–	–	–	–	–	–	MARKED N	SL	SL	SL	–
4	3	(CM) 1: L+60 MIN A	2:	MOD A L+21 h B	MOD C 1300 CDT C 1700 CDT	WORKSHOP SL	? B D	?		–	? B C 40 MIN PRIOR H-F[5]	–	–	–	–
5	3	–		MARKED	MOD C 1300 CDT C 1700 CDT	MOD 2C E	SL D	?	?	–	? C 90 MIN PRIOR H-F	–	–	–	–
6	3	MARKED N L+70 MIN C	MARKED	MARKED V 1720 CDT L+21 h B	MARKED N&V C 1030 CDT C 1700 CDT	MARKED 3C 30 MIN BEFORE MEALS	MOD	SL	?	–	? C F 40 MIN PRIOR H-F	C 2100 CDT	C 0900 CDT	–	–

* DEMONSTRATED BY SYMPTOMS OR NEED FOR PREVENTATIVE MEASURES ? SLIGHT, MODERATE, OR MARKED INCREASE IN SUSCEPTIBILITY

1 DURATION SL-2, 11 h 36 MIN, SL-3, 8 h 40 MIN
2 DURATION SL-2, 18 h SL-3, 1 h 5 MIN
3 NAUSEA
4 VOMITING
5 HEAD FIXED

† DRUG TAKEN

A ASPIRIN (320 mg)
B SECONAL (100 mg)
C SCOP/DEX (0.35/5.0 mg)
D NASAL EMOLLIENT
E MELANTA
F CHLORAL HYDRATE

‡ LAUNCH

NASA-S-74-4917

SKYLAB 2
(28 DAY MISSION)

RED CELL MASS
% CHANGE

	CDR	SPT	PLT
R + 0	-15.2	-15.6	-12.1
R + 13	-17.5	-16.4	-12.8
R + 42	- 8.2	--------	- 2.2
R + 67	-3.0	+ 1.5	+ 2.0

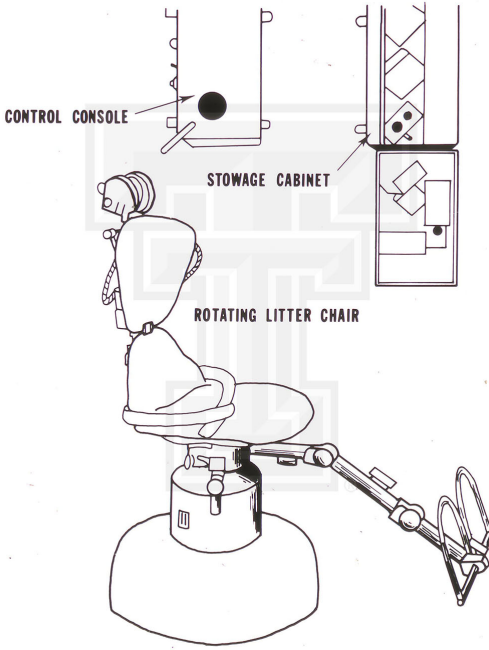
NASA-S-74-4861

CARDIOVASCULAR SYSTEM (CONCL)

- RULE OUT
  - PERMANENT MYOCARDIAL DAMAGE (CELLULAR LEVEL) - REMOTE

- CANDIDATE FUTURE CARDIOVASCULAR STUDIES
  - IN-DEPTH, NONINVASIVE CARDIOVASCULAR DYNAMICS MONITORING
  - INVASIVE PRESSURE/VOLUME/FLOW CHANGES IN EARLY FLIGHT (ANIMAL)
  - DEMONSTRATE PRESENCE OR ABSENCE OF GAUER-HENRY REFLEX
  - TOTAL BODY EXERCISE REGIMEN TO MAINTAIN INTEGRITY OF ANTIGRAVITY AS WELL AS MAJOR MUSCLE GROUPS
  - ASSESS ROLE OF VENOUS (CAPACITANCE) VESSELS IN OBSERVED DECONDITIONING PROCESS
  - ASSESS ROLE OF FATIGUE

THE ROTATING LITTER CHAIR (RLC) IN THE MOTION SICKNESS TEST MODE



NASA-S-74-4919

SKYLAB 3
(59 DAY MISSION)

RED CELL MASS
% CHANGE

	CDR	SPT	PLT
R + 0	-6.1	-19.8	-10.6
R + 14	-2.7	-13.8	- 5.9
R + 45	+3.0	+ 1.7	+3.1

NASA-S-74-4860

CARDIOVASCULAR SYSTEM

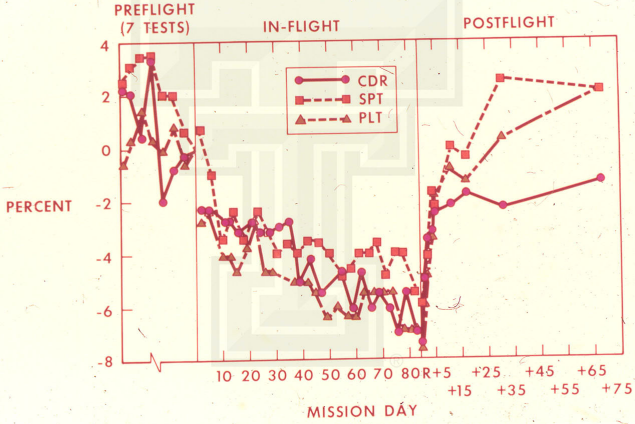
- FINDINGS
  - POSTFLIGHT ORTHOSTATIC INTOLERANCE
  - POSTFLIGHT DIMINISHED EXERCISE CAPACITY

- PROBABLE ETIOLOGICAL FACTORS
  - DECREASED EFFECTIVE CIRCULATING BLOOD VOLUME POSTFLIGHT
  - DIMINISHED VENOUS RETURN AT ONE g
  - MUSCULAR IMBALANCE CAUSED BY FUNCTIONAL DISUSE ATROPHY OF ANTIGRAVITY MUSCLES
  - ALTERED INTERNAL MILIEU (FLUID/ELECTROLYTE DYNAMIC FLUX) DURING EARLY POSTFLIGHT PERIOD
  - ? ALTERED VENOUS REFLEXES/TONE
  - FATIGUE

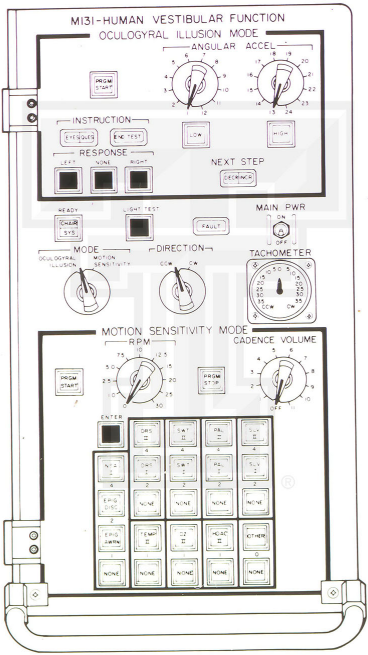
NASA-S-74-4510

M092, LOWER BODY NEGATIVE PRESSURE

CHANGE IN RESTING-CALF CIRCUMFERENCE, SL-4 CREW



CONTROL CONSOLE USED IN CONNECTION WITH THE RLC



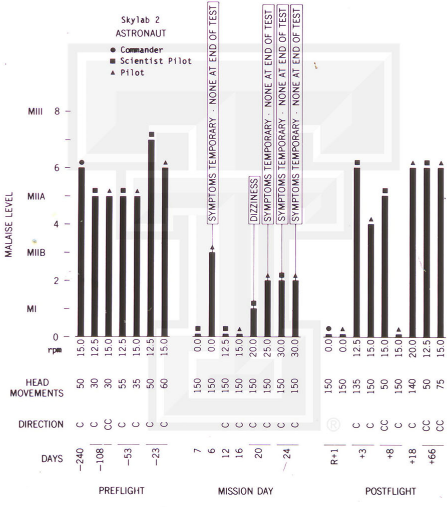
NASA-S-74-4916

SKYLAB 4
(84 DAY MISSION)

RED CELL MASS
% CHANGE

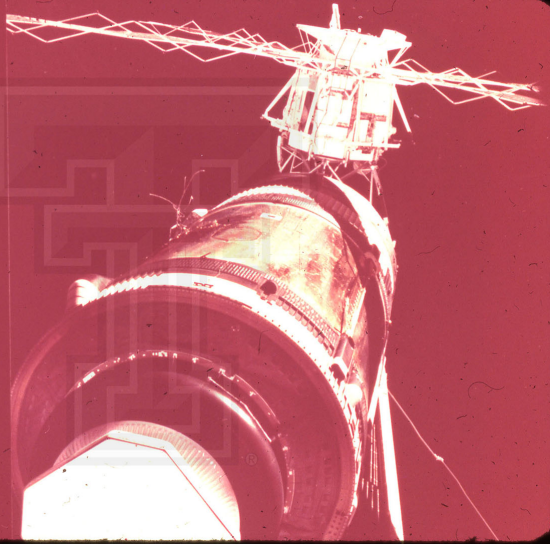
	CDR	SPT	PLT
R + 0	-4.8	-8.3	-7.4
R + 14	-4.0	-3.9	-5.5
R + 31	+4.7	+2.3	+4.0

MOTION SICKNESS SYMPTOMATOLOGY ON SL 1/2 ASTRONAUTS



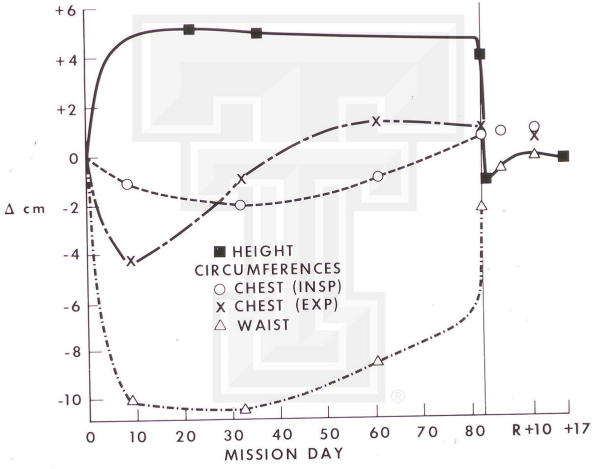
NASA-S-74-4837

DAMAGED ORBITAL WORKSHOP



NASA-S-74-4790

ANTHROPOMETRIC CHANGES SL-4 PLT



NASA-S-74-4914

SKYLAB

IRON KINETICS AT RECOVERY

	CREW	CONTROL
SERUM Fe	92	109
T 1/2	127	164
TURNOVER	0.32	0.30

NASA-S-74-4775

SPECIAL IN-FLIGHT TESTS (ORIGINALLY APPROVED)

- ENVIRONMENTAL MICROBIOLOGY
- RADIATION MEASUREMENTS
- WATER POTABILITY
- CO_2/DEWPOINT MONITOR
- CREW MICROBIOLOGY
- ORAL HEALTH

NASA-S-74-4909

SKYLAB CREWS AT RECOVERY

- NORMAL
  - RBC SURVIVAL
  - IRON KINETICS
- DECREASED
  - RED CELL MASS
  - RETICULOCYTES

NASA-S-74-4913

^{14}C-GLYCINE MEAN RED CELL LIFE TIME

DAYS

	MEAN ± S.E.
CREW	123 ± 2
CONTROL	121 ± 4

NASA-S-74-4910

SKYLAB RBCM CHANGE THEORY

- INCREASED SPLENIC RETICULOENDOTHELIAL ACTIVITY
- DECREASED PLASMA VOLUME
- INCREASED PHOSPHORUS
- NO ERYTHROPOIETIN CHANGE
- RELATIVE BONE MARROW INHIBITION

NASA-S-74-4748

SKYLAB INFLIGHT MEDICAL SUPPORT SYSTEM

IMSS SUBSYSTEMS

INCUBATOR
SLIDE STAINER
RESUPPLY CONTAINER

IMSS KITS

DRUG SUPPLY
IV FLUIDS
TOPICAL DRUG
BOTTLE DRUGS
MICROSCOPE
MINOR SURGERY (2)
MICROBIOLOGY
HEMATOLOGY/URINALYSIS
DIAGNOSTIC
BANDAGE
DENTAL
THERAPEUTIC

NASA-S-74-4912

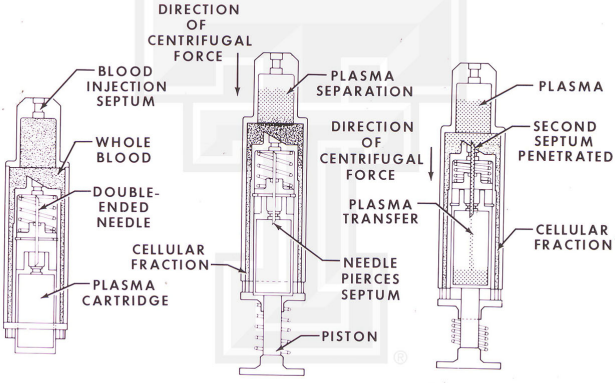
MEAN ^{51}Cr RED CELL HALFTIMES

DAYS

	CREW	CONTROL
PRE	26.1	24.2
POST	24.2	22.9
DELTA	-1.9	-1.3

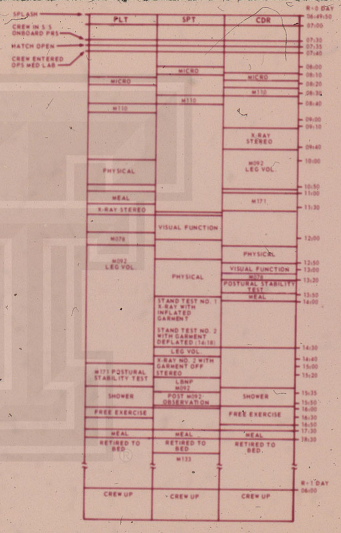
NASA-S-73-3295

SKYLAB BLOOD SAMPLE PROCESSOR



NASA-S-74-4784

SKYLAB 2 RECOVERY DAY MEDICAL TESTING



NASA-S-74-4918

BLOOD DRAWN
SKYLAB MISSIONS

MISSION	DAYS	TOTAL ml	MEAN ml/DAY
SL2	28	794	10
SL3	59	805	8
SL4	84	889	6

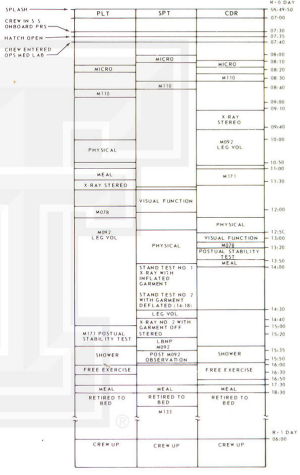
NASA-S-74-4735

SIGNIFICANT BIOMEDICAL FINDINGS IN GEMINI PROGRAM

- MODERATE LOSS OF RED CELL MASS
- MODERATE ORTHOSTATIC INTOLERANCE
- MODERATE LOSS OF EXERCISE CAPACITY
- MINIMAL LOSS OF BONE DENSITY
- MINIMAL LOSS OF CALCIUM AND MUSCLE NITROGEN
- HIGH METABOLIC COST OF EXTRAVEHICULAR ACTIVITY

NASA-S-73-3293

SKYLAB II
RECOVERY DAY
MEDICAL TESTING



NASA-S-74-4858

FLUID/ELECTROLYTE AREA

- PRESKYLAB WORKING HYPOTHESIS

- PARADOXICAL SKYLAB URINARY FINDINGS
  - ↓ ADH SECRETION (↑ SKYLAB 2)
  - ↓ ALDOSTERONE SECRETION
  - ↑ Na^+ K^+ EXCRETION
  - ↓ OSMOLALITY
  - ↓ CORTISOL

- INTERPRETATION
  - INTERNAL HOMEOSTASIS MAINTAINED
  - RENAL FUNCTION MAINTAINED
  - INTERACTION OF COMPLEX HUMORAL (AND ? HEMODYNAMIC) FACTORS REQUIRED TO MAINTAIN HOMEOSTASIS DURING WEIGHTLESSNESS

- FUTURE STUDIES
  - DEMONSTRATE GAUER-HENRY REFLEX
  - RENAL HEMODYNAMICS IN ZERO g
  - RENAL RESPONSE TO WATER/SALT LOADS, DEHYDRATION IN ZERO g
  - HUMORAL INTERACTIONS INVOLVED IN ABOVE

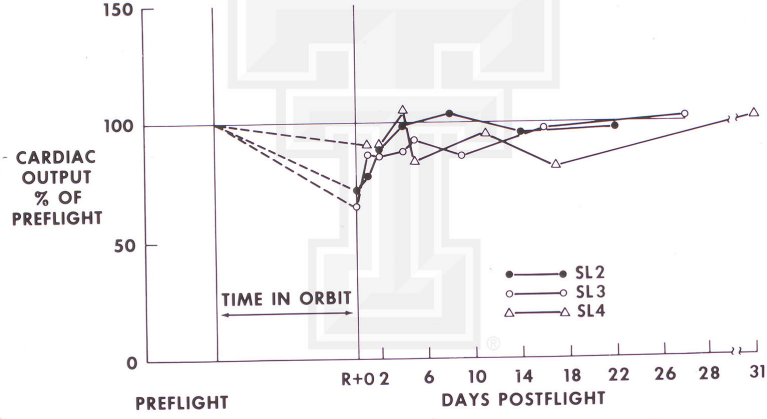
NASA-S-74-4807

SKYLAB MINERAL/CALORIC, FLUID/ELECTROLYTE SUMMARY

- MODERATE LOSSES OF CALCIUM, PHOSPHORUS, AND NITROGEN HAVE BEEN OBSERVED COMPARABLE TO THOSE SEEN IN BED-RESTED SUBJECTS: 6 GRAMS/MONTH CALCIUM OR 0.5 PERCENT/MONTH TOTAL BODY CALCIUM
- RATE OF CALCIUM LOSS WOULD NOT PRECLUDE EXTENDED MISSIONS OF 8 TO 9 MONTHS' DURATION. LONGER MISSIONS MAY REQUIRE REMEDIAL MEASURES
- SIGNIFICANT OS CALCIS MINERAL LOSS:
  SKYLAB 3: SPT: 7.4 PERCENT
  SKYLAB 4: SPT: 4.5 PERCENT; PLT: 7.9 PERCENT
- CALORIC REQUIREMENTS DURING FLIGHT IDENTICAL WITH INDIVIDUAL REQUIREMENTS AT ONE G
- RENAL FUNCTION UNIMPAIRED; HOWEVER, APPARENTLY UNIQUE ADAPTIVE FUNCTIONAL CHANGES OBSERVED REQUIRE FURTHER STUDY
- SKYLAB 4 ANTHROPOMETRIC STUDIES CONSISTENT WITH PREDICTED SHIFT OF BODY FLUIDS DURING WEIGHTLESS FLIGHT

NASA-S-74-3041

CARDIAC OUTPUT DURING SUBMAXIMAL EXERCISE



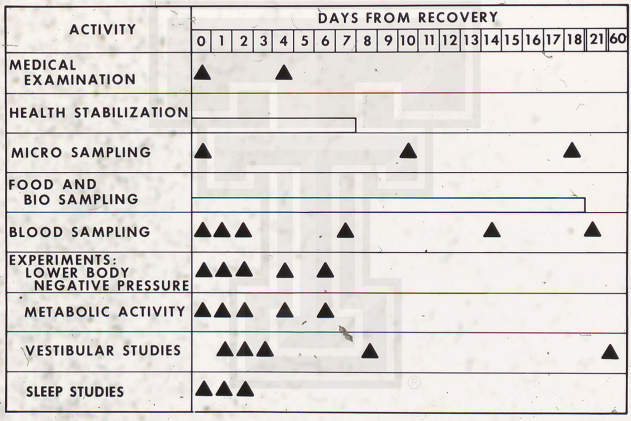
NASA-S-74-4857

MUSCULOSKELETAL SYSTEM

- FINDING
  - MODERATE LOSSES OF CALCIUM, NITROGEN, AND PHOSPHORUS
- POSSIBLE ETIOLOGICAL FACTORS
  - PRIMARY -LOSS OF GRAVITY GRADIENT
  - SECONDARY
    - ABSENCE OF WEIGHT BEARING
    - ABSENCE OF HYDROSTATIC VENOUS GRADIENT
    - ? HORMONAL IMBALANCE (ELEVATED CORTISOL SECRETION)
    - COMBINATIONS OF ABOVE
- CANDIDATE FUTURE STUDIES
  - ABSOLUTE CATABOLIC IN-FLIGHT CHANGES (BONE, MUSCLES) IN ANIMALS
  - COUNTERMEASURE EVALUATION
    - DIETARY
    - PHYSICAL
    - ? HORMONAL
  - SELECTION CRITERIA FOR PROLONGED MISSIONS (PREDICTION FORMULA)

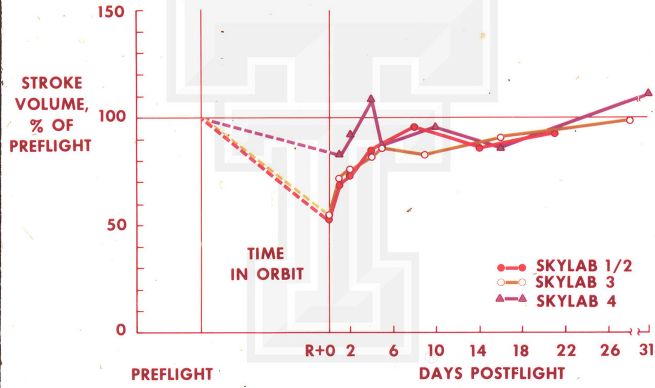
NASA-S-74-4779

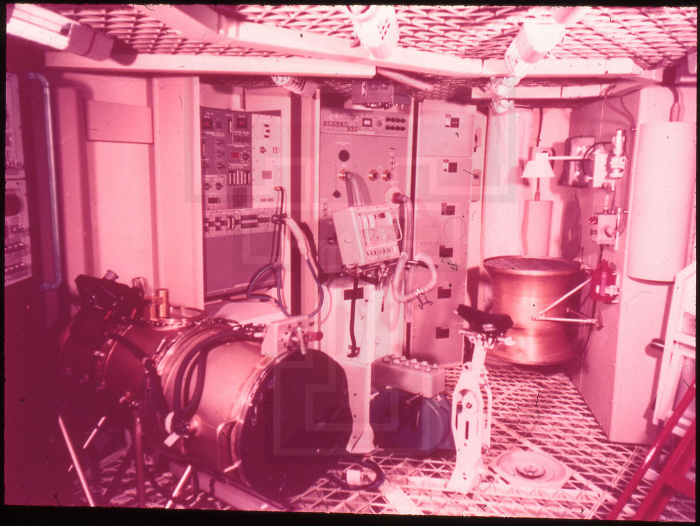
SKYLAB POSTFLIGHT ACTIVITIES (TYPICAL)



NASA-S-74-4605

STROKE VOLUME DURING SUBMAXIMAL EXERCISE





NASA-S-74-4808

SKYLAB NEUROPHYSIOLOGICAL/ PERFORMANCE SUMMARY

- AFTER INITIAL IN-FLIGHT ADAPTIVE PERIOD, ALL CREWMEN SHOW MARKED INCREASED TOLERANCE TO MOTION SICKNESS MEASURED BY ROTATION AND HEAD MOVEMENTS. TOLERANCE THRESHOLD GRADUALLY REVERTS TO BASELINE POSTFLIGHT. ANTIMOTION MEDICATIONS HELPFUL IN CONTROL OF SYMPTOMS
- NO MAJOR DISTURBANCES NOTED IN QUANTITY OR QUALITY OF SLEEP
- CAREFULLY REGULATED CREW WORK/REST CYCLES ESSENTIAL FOR MAINTAINING CREW EFFICIENCY
- POSTFLIGHT HYPERREFLEXIA CONFIRMED AND QUANTITATED
- IMPROVED IN-FLIGHT PERFORMANCE EFFICIENCY EXHIBITED BY ALL CREWS
- OVERLEARNING RECOMMENDED FOR CRITICAL TASKS ON SHORT-DURATION MISSIONS

NASA-S-74-4733

SKYLAB HEMATOLOGY/IMMUNOLOGY/ CYTOLOGY SUMMARY

- LOSS OF RED CELL MASS OBSERVED POSTFLIGHT - APPEARS TO BE SUPPRESSION OF RED CELL PRODUCTION RATHER THAN DESTRUCTION
- RED BLOOD CELL MASS LOSS NOT RELATED TO MISSION DURATION
- NO SIGNIFICANT CHANGES OBSERVED IN HUMORAL OR CELLULAR IMMUNE RESPONSES
- CELLULAR PROLIFERATION (TISSUE CULTURE) NORMAL DURING SPACE FLIGHT

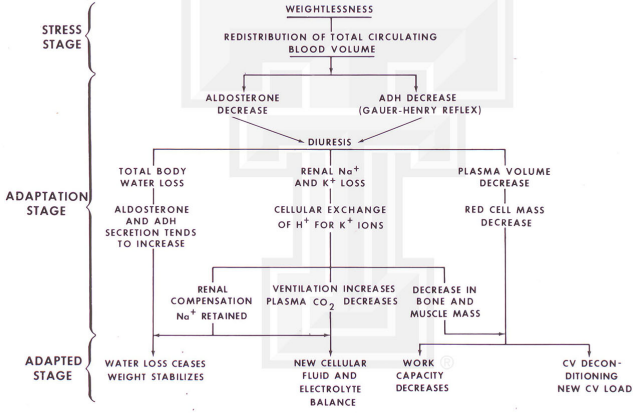
NASA-S-74-3827

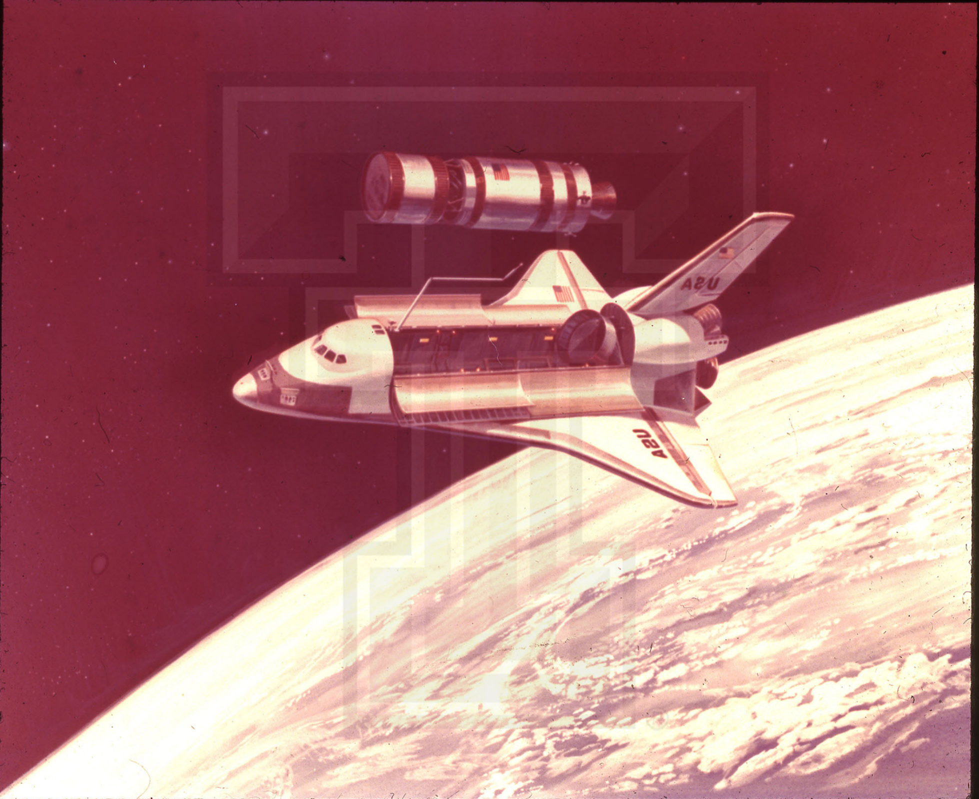
DAILY PERSONAL EXERCISE PROTOCOL SELECTED BY EACH SL-4 CREWMAN

EXERCISE	CDR	SPT	PLT
LEG ERGOMETRY (WATT-MIN)	5000	8337	6000
MINIGYM (TOTAL REPETITIONS)	100	200	200
SPRINGS (TOTAL REPETITIONS)	75	0	120
TORSO ISOMETRICS (TOTAL REPETITIONS)	20	0	20
TREADMILL			
WALK (MIN)	10	0	10
RUN (MIN)	1	0	0
SPRINGS (REPETITIONS)	300	1000	100
TOE RISES (REPETITIONS)	200	200	75

NASA-S-74-4810

ADAPTIVE RESPONSES TO WEIGHTLESSNESS-PRESKYLAB HYPOTHESIS





NASA-S-74-4951

SKYLAB VESTIBULAR FINDINGS

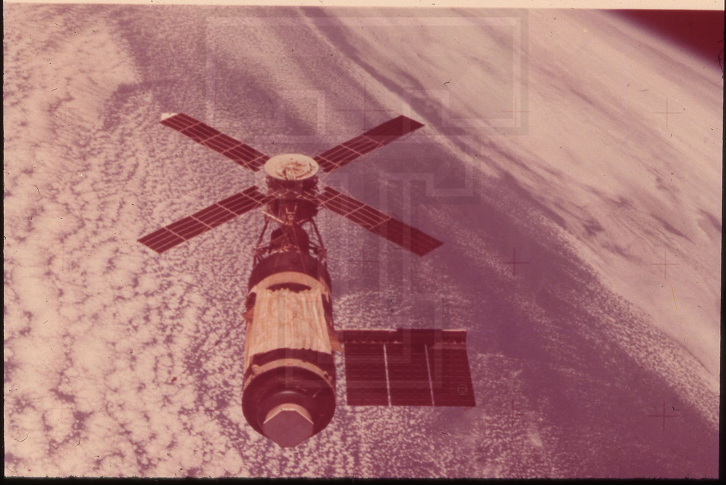
- POSSIBLE ETIOLOGICAL FACTORS
  - OTOLITH RECEPTOR PHYSIOLOGICAL DEAFFERENTATION

    ↓ MODULATING INFLUENCE ON CANALS

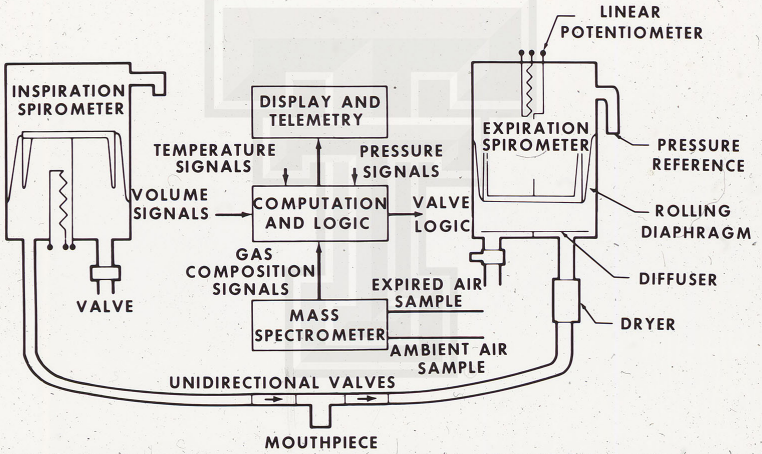
    DIRECT INTERACTION WITH CANALS
- RULE OUT:
  - INFLUENCE OF HYPERVOLEMIA (TRANSIENT ↑ VENOUS PRESSURE) ON VESTIBULAR SYSTEM

NASA-S-74-4811

ORBITAL WORKSHOP WITH THERMAL SHIELDS DEPLOYED



METABOLIC ANALYZER FUNCTIONAL SCHEMATIC



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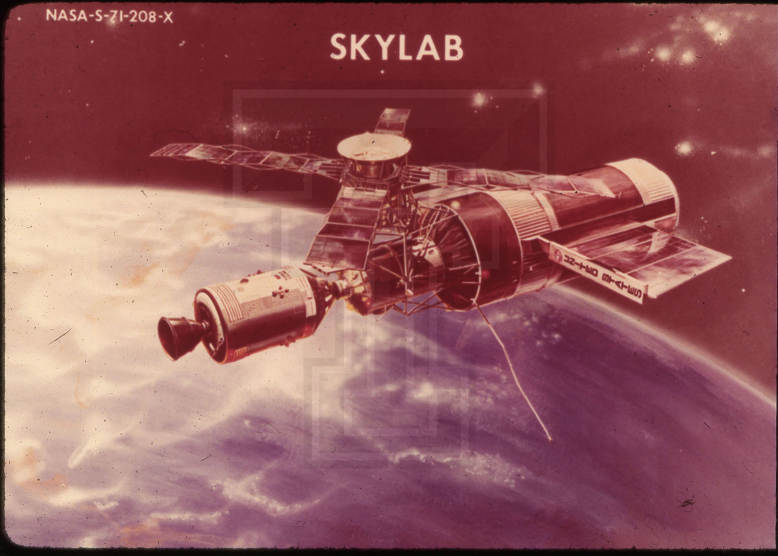
SKYLAB



NASA-S-74-4952

SKYLAB VESTIBULAR FINDINGS (CONCL)

- CANDIDATE FUTURE STUDIES
  - ROLE OF ALTERED CUES: VISUAL, KINESTHETIC OTHER SENSORY
  - EFFECT OF OVERHYDRATION, DEHYDRATION AND INCREASED VENOUS PRESSURE ON MOTION SICKNESS THRESHOLD
  - PREDICTIVE TEST FOR ZERO g SPACE SICKNESS SUSCEPTIBILITY (? PARABOLIC FLIGHTS)
  - BASIC STUDIES REGARDING ETIOLOGY
  - ROLE OF ONE g TRAINING IN PREVENTION
  - IMPROVED MEDICATIONS FOR PREVENTION/CONTROL

NASA-S-74-4736

SKYLAB CARDIOVASCULAR SUMMARY

- CARDIOVASCULAR DECONDITIONING WAS OBSERVED DURING FLIGHT; CHANGES APPEAR ADAPTIVE IN NATURE AND TEND TO STABILIZE AFTER 4 TO 6 WEEKS
- CARDIOVASCULAR CHANGES DO NOT IMPAIR CREW HEALTH OR ABILITY TO FUNCTION EFFECTIVELY IN WEIGHTLESS FLIGHT
- LOWER-BODY NEGATIVE-PRESSURE TESTS PROVIDE FAIRLY RELIABLE PREDICTIVE INDEX OF POSTFLIGHT CARDIOVASCULAR STATUS
- CARDIAC ELECTRICAL ACTIVITY AS MEASURED BY VECTOR-CARDIOGRAM WAS NOT SIGNIFICANTLY ALTERED AND REMAINED WITHIN PHYSIOLOGICAL LIMITS
- DECREASED CARDIAC OUTPUT NOTED IN CREWMEN POSTFLIGHT; THOUGHT TO BE RELATED TO REDUCED VENOUS RETURN
- SINGLE EPISODE OF SIGNIFICANT CARDIAC ARRHYTHMIA IN ONE SKYLAB 2 CREWMAN DURING EXERCISE EARLY IN MISSION
- NO SIGNIFICANT IN-FLIGHT DECREMENT IN WORK CAPACITY OR PHYSIOLOGICAL RESPONSES TO EXERCISE
- ALL CREWMEN HAVE SHOWN POSTFLIGHT DECREASE IN EXERCISE CAPACITY AND ALTERED PHYSIOLOGICAL RESPONSES
- SKYLAB 3 AND 4 CREWS RETURNED TO PREFLIGHT CARDIO-VASCULAR STATUS BY R+5 AND R+4; SKYLAB 2 CREW AT R+21; INCREASED EXERCISE BY SKYLAB 3 AND 4 CREWMEN THOUGHT TO BE FACTOR IN IMPROVED RECOVERY RATE

NASA-S-74-4822

M171 EXPERIMENT PROTOCOL

5 MINUTES	REST
5 MINUTES	25 PERCENT OF MAXIMUM $\dot{V}_{O_2}$
5 MINUTES	50 PERCENT OF MAXIMUM $\dot{V}_{O_2}$
5 MINUTES	75 PERCENT OF MAXIMUM $\dot{V}_{O_2}$
5 MINUTES	RECOVERY

3 CREWMEN

5 TIMES IN 28 DAY MISSION

8 TIMES IN 56 DAY MISSION