August 27, 1971

APOLLO 15
LOWER BODY NEGATIVE PRESSURE
PRELIMINARY RESULTS

Lower Body Negative Pressure (LBNP) was used previously in pre- and postflight orthostatic evaluations on crewmen of Apollo Missions 7, 8, and 9. The same equivalent protocol and measurement techniques were used on this mission with the addition of two measurements: the vectorcardiogram (instead of the two electrocardiographic chest leads) and the precordial vibrocardiogram (VbCG) to estimate cardiac stroke volume.

Preflight data were technically of good quality and each crewmember demonstrated minimal variability between his three baseline tests. These data were used for comparison with individual postflight results.

Resting supine heart rates immediately postflight (R+3-5 hours) were significantly ($p < 0.05$) elevated in the CMP (+14 bpm, +20%) and the LMP (+11 bpm, +20%). All three crewmembers showed increases in heart rate during application of LBNP, with maximal delta values (pre- versus postflight) of:

CDR Scott:	+16 bpm	+27% (-50 mm. Hg.)
CMP Worden:	+51 bpm	+64% (-50 mm. Hg.)
LMP Irwin:	+27 bpm	+49% (-40 mm. Hg.)

The LMP experienced presyncope during the -40 mm. Hg. level of LBNP.

All crewmembers demonstrated a tendency to return to their baseline preflight heart rates at R+42-44 Hr., but remained statistically well elevated while both CDR and LMP experienced presyncope. The same pattern continued at R+71-73 Hr. without presyncopal events.

By R+122 Hr. the CDR was completely within his preflight envelope with respect to heart rate response. LMP did not reach this level till his test at R+210 Hr. CMP was not tested between R+121 and R+310 Hr., over which interval he demonstrated a distinct alteration of his response profile from incrementally increased heart rate with each successive level of LBNP to an essentially flat heart rate elevation across all levels of LBNP stress. This constant elevation was, however, still statistically above his preflight baseline during LBNP.

Blood pressure values have not been completely analyzed, but supine resting, clinically obtained values before each LBNP test showed significant elevations postflight for both CDR and CMP. Blood pressure values for LMP tended to be somewhat elevated before flight and a similar postflight elevation in him was not evident.

All three crewmen showed considerably decreased maximal calf circumferential dimensions immediately postflight:

CDR	-	0.44 inches	-	2.8%
CMP	-	0.31 inches	-	2.2%
LMP	-	0.51 inches	-	3.5%

This decrease in calf size remained evident beyond R+121-137 hours, whereas they had regained their weight losses by R+42-44 hours. Indeed, calf size seemed to closely parallel their LBNP responses. However, changes in leg volume during LBNP were again quite variable without a consistent pattern.

Cardiac stroke volume was decreased immediately postflight in the supine resting state for CMP and LMP only:

CDR	- 1 ml	- 1%
CMP	-24 ml	-29%
LMP	-13 ml	-16%

but showed decrements (maximal) during LBNP for all:

CDR	-21 ml	-31% (-40 mm. Hg.)
CMP	-28 ml	-58% (-50 mm. Hg.)
LMP	-27 ml	-38% (-40 mm. Hg.)

Gradual progression toward preflight baseline values was observed with time after splashdown. This measurement very closely approximated other evidences of their recovery to preflight status.

A significant postflight decrement in supine resting cardiac output occurred only in the CMP, but all showed decrements at the higher levels of LBNP stress. A significant increase in cardiac output was seen after R+137 hours for the LMP. This decrease in cardiac output implies an insufficient compensation for decreased stroke volume by increased heart rate.

Vectorcardiograms are awaiting computer analysis.

G W Hoffler

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APOLLO 15

EXERCISE RESPONSE TESTS

PRELIMINARY SUMMARY

8/27/71

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In this scheme we directly measure work, oxygen consumption, minute volume, and heart rate. We indirectly measure cardiac output and blood pressure and calculate A-V O_2 difference, total peripheral resistance and stroke volume.

The experimental protocol utilizing heart rate as the independent variable was originally proposed and implemented because of the lack of acceptance of the (work load based) Gemini exercise capacity test and the advantage of having the same relative cardiovascular stress pre- and postflight. This protocol enabled the detection of major changes that occurred in the Apollo program. However, clamping heart rate permits the other dependent variables to float and makes elucidation of mechanisms more difficult since interrelationships change at different levels of exertion. During Apollo 15 an attempt was made to reduce this problem by having a hybrid protocol in which a prescribed heart rate level was attempted during the first 2 minutes of each 4-minute step, then the resulting work load was clamped for the remaining 2 minutes. Although this was an improvement over previous protocols, 2 minutes at a set work load was not sufficient to obtain the steady state conditions required to adequately follow through the physiological response diagram (Figure 1) utilizing work load as the independent variable. This point should be kept in mind during the evaluation of future exercise response protocols.

1.0 Data reduction

All data collected during Apollo 15 exercise tests have been reduced and placed on computer cards for further analysis. These data have not been re-verified. This step should be completed within the next 10 days. Particular attention will be paid to blood pressure measurements which show more preflight statistical variability than anticipated. It is not expected that any of the present trends will be changed but it is possible that some postflight blood pressure data points now within preflight variability limits will become statistically significant.

Overall, more exercise response data have been collected during this flight than on any previous flight. This may account in part for detection of some of the changes observed on this particular mission.

2.0 General background

Figure 1 represents an overall flow diagram of the basic homeostatic mechanisms involved in the physiological response to work. A physical work load produces cellular oxygen demands which are supplied by the product of cardiac output and A-V O_2 difference. The cardiac output is the result of heart rate and stroke volume. The resultant cardiac output determines a mean systemic blood pressure depending on the total peripheral resistance.

3.0 Return to preflight baseline

Figure 2 shows the return to preflight baselines ($\dot{V}_{O_2}$ @ 160 H.R.) for those Apollo crewmen who have shown a significant postflight decrease in exercise response. There is apparently a significant difference in the time course of return to preflight baseline for the Apollo 15 CDR and LMP. The CMP for Apollo 15 had a much larger postflight decrement, but a slope similar to that for previous Apollo crewmembers, which accounts for his longer time to return to preflight level. The apparent different slope for the CDR and LMP cannot be explained. The CDR's contention that his recovery profile is a result of higher preflight levels cannot be disputed or supported by the present data. The LMP was not near the level of aerobic capacity exhibited by the CDR, but previous Apollo crewmen with greater aerobic capacity than the LMP have not shown the same time course of return postflight.

Functionally, the postflight differences observed in this flight are probably not significant; i.e., the absolute changes are small and were not of a compromising nature. However, because they are different from that previously noted, and because other inflight data indicated a different cardiovascular condition, an attempt should be made to explain the mechanism of these changes. Since each crewmember responded differently, separate discussions will be made.

4.0 CDR

The Apollo 15 CDR had a higher aerobic capacity than any previous Apollo crewman. The only abnormal physiological response was an apparent fall in systolic blood pressure on two occasions (F-14 and R+0) during the exercise protocol without any subjective feelings or concurrent changes in heart rate. At R+0, the CDR showed a small increase in resting heart rate while sitting on the ergometer and subjectively this investigator expected a fairly normal exercise response. However, at each increasing level of exercise the subject's response was progressively worse.

Figure 3 and Table 1 summarize the results to date. There were no indications of a change in peripheral resistance either at a given heart rate or at specified levels of oxygen consumption. There is a strong indication of decreased stroke volume immediately postflight, with progressive return to preflight levels. This can be seen by looking at the cardiac output at 160 heart rate. Systolic blood pressure also decreased postflight with the result that peripheral resistance did not change. The small changes in M.V. for 2.0 l/min $\dot{V}_{O_2}$ are considered to be insignificant.

Thus, the picture on the CDR at the present time indicates that the decreased exercise response was the result of a decreased stroke volume and a resultant increase in heart rate to supply the same cardiac output for a given oxygen demand. This would explain the normal responses at low work levels and a progressively degraded response at higher heart rate levels. A decreased stroke volume could result from a decreased venous return or changes in myocardial function. There is nothing to indicate a decreased venous return.

5.0 CMP

The CMP demonstrated a response which is more typical of previous Apollo crewmembers (Figure 4 and Table 2). The resting heart rate increased from 75 beats/minute preflight to 113 beats/minute on recovery day. Significant decreases were indicated in peripheral resistance by a large blood pressure decrease for the same cardiac output level and the increased cardiac output for a given level of oxygen consumption. A concurrent decrease in stroke volume is indicated by a decreased cardiac output at 160 heart rate. The decreased peripheral resistance for a set level of oxygen consumption fits the pattern and hypothesis derived from the Apollo 14 data. The decreased stroke volume agrees with the findings in the CDR.

6.0 LMP

The LMP's response is difficult to interpret. First, the initial test on R+0 did not include high heart rate levels due to intermittent bradycardia and the overall condition of the subject. Thus, extrapolation to higher levels is perhaps misleading. Secondly, this subject showed large preflight variability in the measured parameters which may mask any true changes postflight.

However, the LMP's response appears to resemble the CDR's response. Resting heart rate on the ergometer postflight was 87 beats/minute, up from a preflight mean of 60 beats/minute. As in the case of the CDR the response progressively degraded at higher heart rate levels (after R+0). Although not statistically significant, there was a definite trend indicating a decreased stroke volume.

7.0 Summary

At this point, there has not been sufficient time to understand or to integrate these results into a total picture. Preliminary indications are that two separate mechanisms may be at work. The first is a statistically significant decrease in stroke volume observed in two of the three crew-members, and strongly suspected in the third. A change in myocardial function (general tissue atrophy and/or electrolyte imbalance causing a decreased inotropic effect) would be the first factor to suspect, but impaired venous return (due to decreased venous tone) cannot be ruled out at this time. The second mechanism is the decreased peripheral resistance indicated in the CMP but not in the CDR or LMP. We might speculate the following: The CDR and LMP lunar EVA activity levels may have been of sufficient magnitude to offset decreased peripheral resistance such as that observed in the CMP. However, this increased EVA activity perhaps aggravated a potassium imbalance (due to loss from skeletal and cardiac muscle - documented in the literature) and produced changes in myocardial function as evidenced by the ECG abnormalities and significant stroke volume changes observed in the CDR. Again there were also indications of decreased stroke volume in the LMP but his preflight variability precluded demonstrable statistical significance. Please remember that these thoughts are preliminary and could change after more detailed analysis of the data.

PHYSIOLOGICAL RESPONSE TO WORK

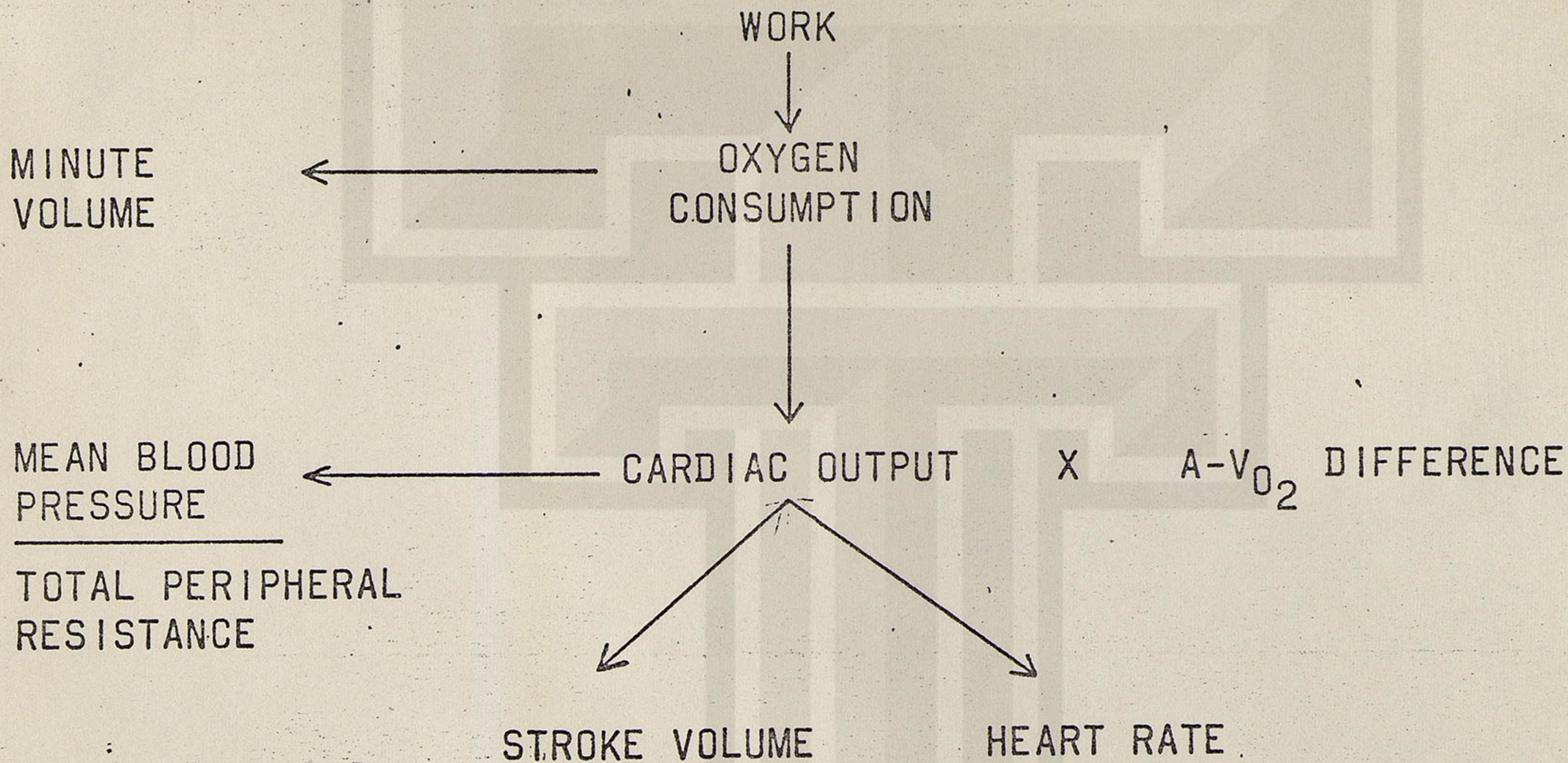


FIGURE 1

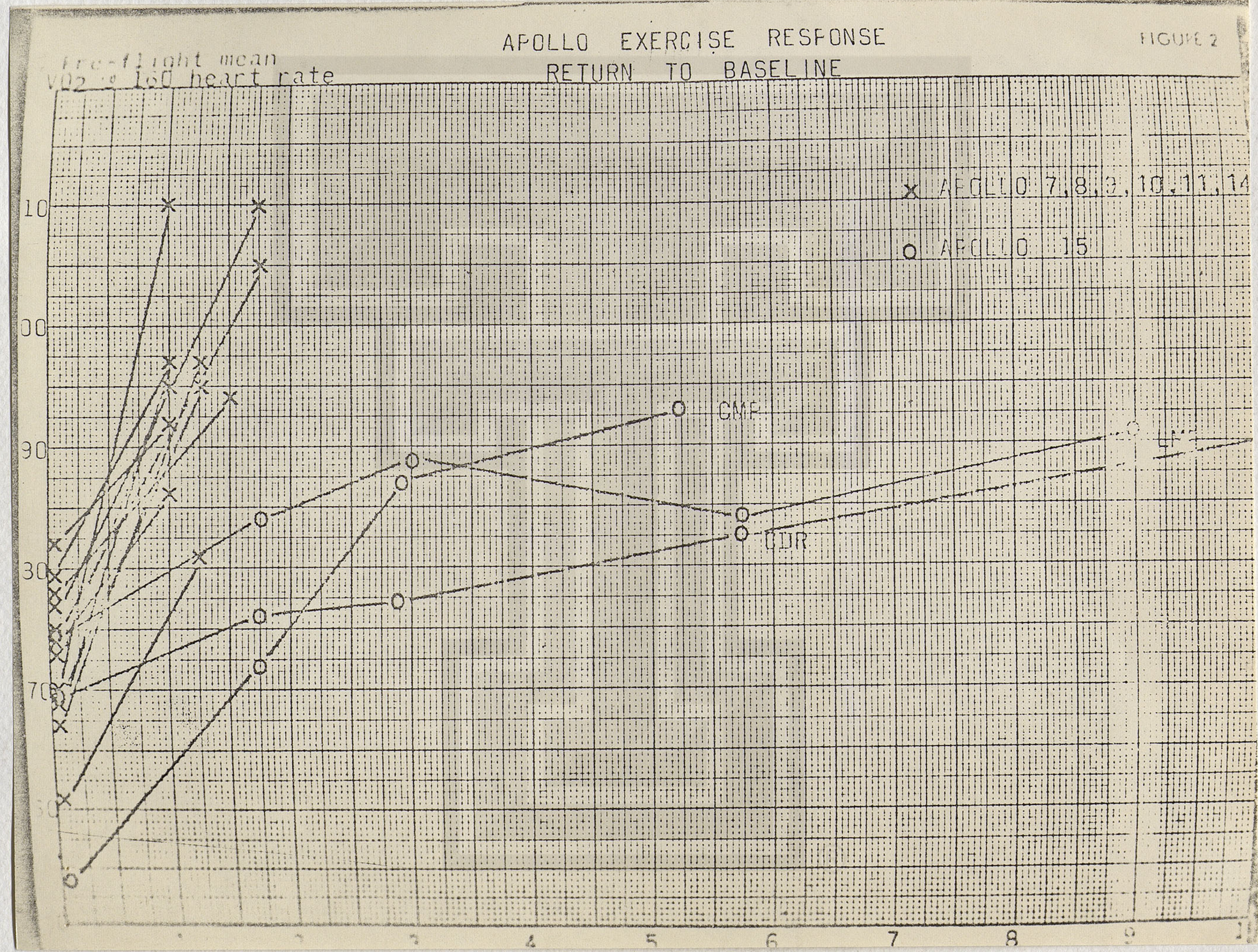
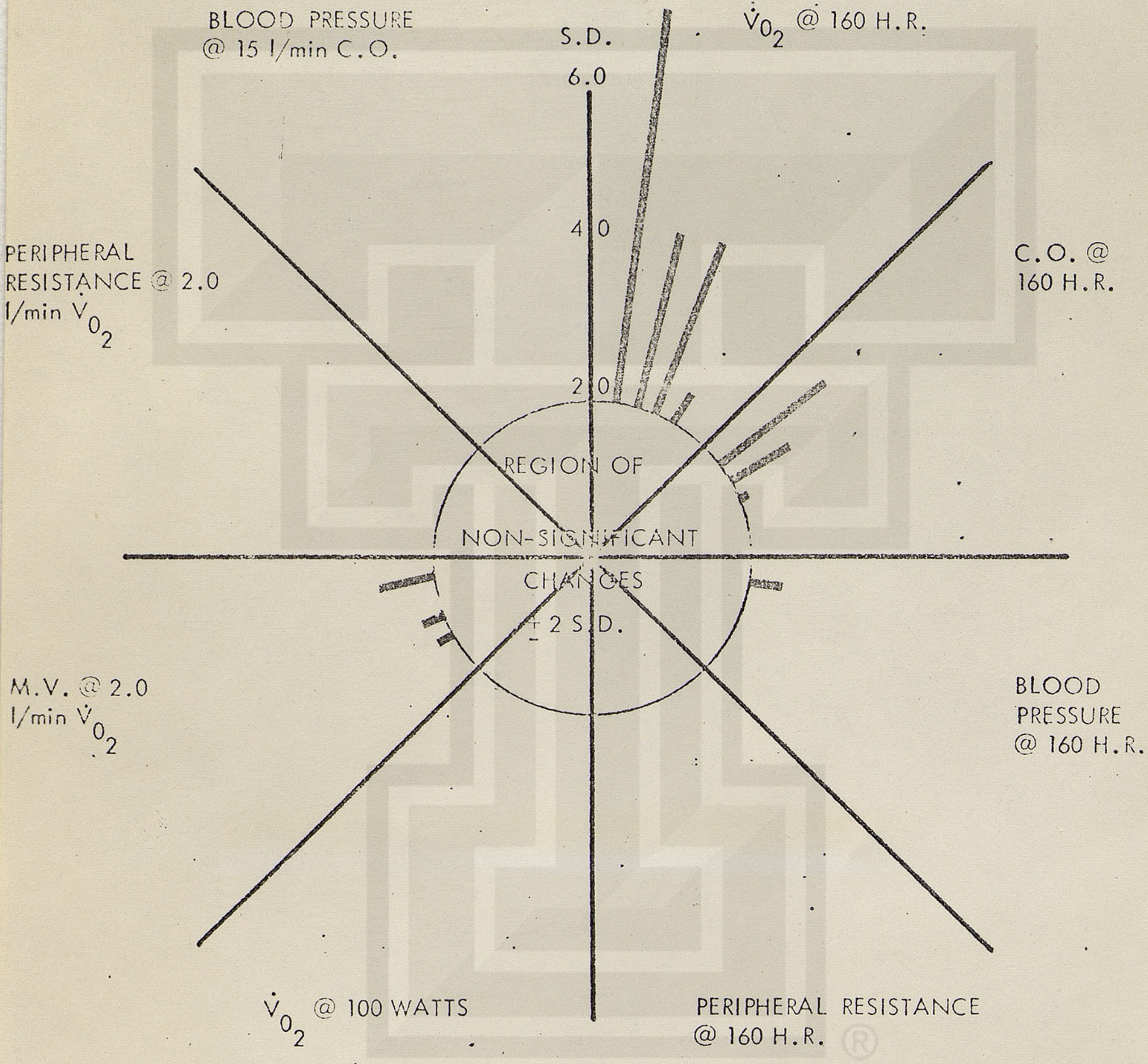


FIGURE 2
APOLLO EXERCISE RESPONSE
RETURN TO BASELINE
Pre-flight mean
VO2 @ 160 heart rate
X APOLLO 7,8,9,10,11,14
O APOLLO 15
CMP
CDR
LMP

FIGURE 3

APOLLO 15
EXERCISE CAPACITY TESTS
POSTFLIGHT RESPONSES

CDR



EACH SECTOR REPRESENTS SUCCESSIVE POSTFLIGHT TESTS AT R+4.5, R+43, R+75, R+138, R+312 HOURS (CLOCKWISE)

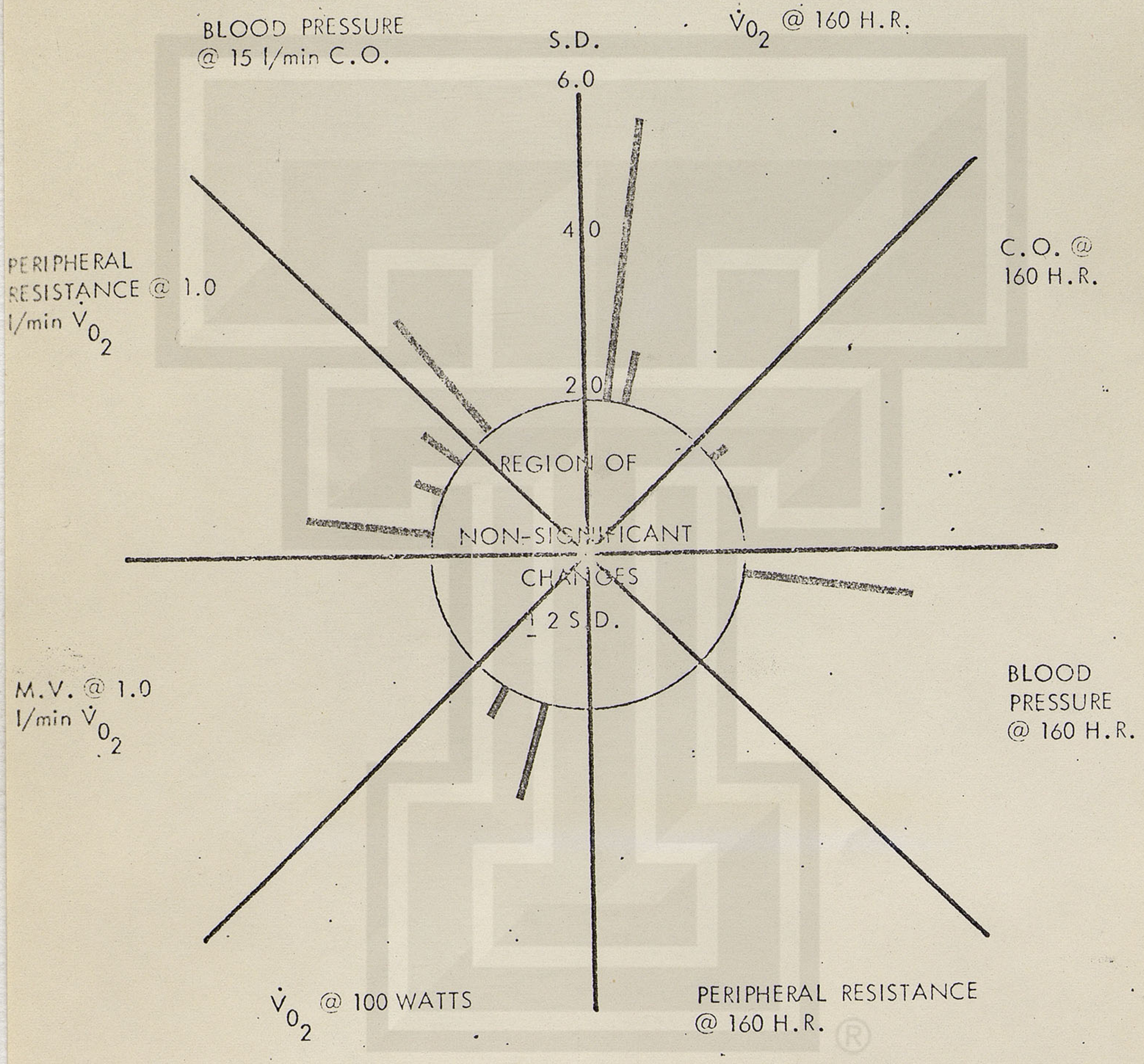
CENTER OF GRAPH REPRESENTS PREFLIGHT MEAN

DECREASE

INCREASE

FIGURE 4

APOLLO 15
EXERCISE CAPACITY TESTS
POSTFLIGHT RESPONSES
CMP



EACH SECTOR REPRESENTS SUCCESSIVE POSTFLIGHT TESTS AT R+4., R+43, R+72, R+122, R+ HOURS (CLOCKWISE)

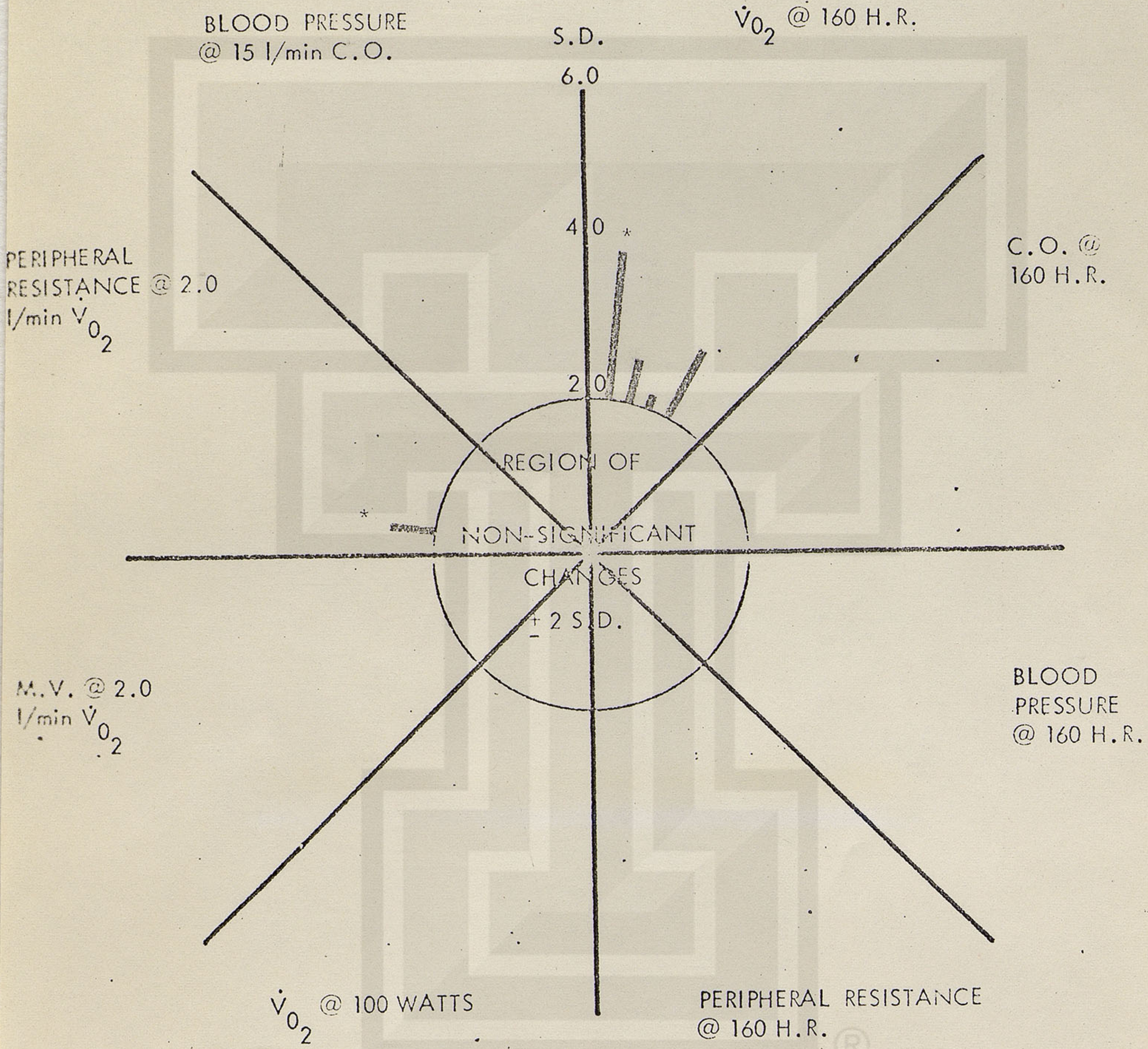
DECREASE

INCREASE

FIGURE 5

APOLLO 15
EXERCISE CAPACITY TESTS
POSTFLIGHT RESPONSES

LMP



EACH SECTOR REPRESENTS SUCCESSIVE POSTFLIGHT TESTS AT R+4.5, R+46, R+74, R+138, R+218 HOURS (CLOCKWISE)

CENTER OF GRAPH REPRESENTS PREFLIGHT MEAN

DECREASE

INCREASE

* Extrapolated

DAVE SCOTT - CDR

@ H.R. 160:	PREFLIGHT		PREFLIGHT S.D.	R+0	R+33 Hrs.	R+3	R+6	R+13
$\dot{V}_{O_2}$	3.68	±	0.16	2.49	3.00	2.90	3.07	3.25
C.O.	20.5	±	1.3	15.6	16.7	17.7	18.6	
Syst. B.P.	226	±	24	168	242	261	246	217
PRU	0.36	±	0.08	0.28	0.50	0.52	0.41	
PRU @2.0 l/min $\dot{V}_{O_2}$	0.57	±	0.07	0.44	0.59	0.64	0.65	
$\dot{V}_{O_2}$ @ 100 watts	1.1	±	0.3	1.23	0.8	0.8	1.0	1.2
M.V. @ 2.0 l/min $\dot{V}_{O_2}$	52.6	±	2.4	51.6	58.1	58.2	57.0	59.4
C.O. @ 2.0 l/min $\dot{V}_{O_2}$	13.1	±	1.0	13.0	12.4	13.2	12.5	
Syst. B.P. @ 15 l/min C.O.	186	±	20	171	222	239	231	

AL WORDEN - CMP

@ H.R. 160:	PREFLIGHT		PREFLIGHT S.D.	R+0	R+33 Hrs.	R+3	R+5
$\dot{V}_{O_2}$	2.67	±	0.21	1.44	2.10	2.35	2.5
C.O.	25.1	±	3.14	17.9	20.6	25.6	26.2
Syst. B.P.	231	±	22	136	188	212	200
PRU	0.26	±	0.10	0.26	0.28	0.28	0.26
PRU @ 1.0 l/min $\dot{V}_{O_2}$	0.63	±	0.07	0.38	0.52	0.46	0.44
$\dot{V}_{O_2}$ @ 100 watts	1.0	±	0.24	1.1	1.8	1.5	1.58
M.V. @ 1.0 l/min $\dot{V}_{O_2}$	23.8	±	3.7	22.0	27.4	26.7	25.7
C.O. @ 1.0 l/min $\dot{V}_{O_2}$	9.5	±	2.4	14.6	10.9	12.0	11.6
Syst. B.P. @ 15 l/min $\dot{V}_{O_2}$	178	±	20	121	158	154	150

TABLE 2

JIM IRWIN - LMP

@ H.R. 160:	PREFLIGHT		PREFLIGHT S.D.	R+0 *	R+33 Hrs.	R+3	R+6	R+13
$\dot{V}_{O_2}$	2.53	±	0.13	2.00	2.19	2.24	2.13	2.32
C.O.	20.1	±	2.48	20.0	18.7	20.3	20.4	20.5
Syst. B.P.	265	±	21	250	245	258	239	252
PRU	0.38	±	0.30	0.08	0.37	0.26	0.38	0.26
PRU @ 2.0 l/min $\dot{V}_{O_2}$	0.53	±	0.27	-0.17	0.38	0.38	0.41	0.33
$\dot{V}_{O_2}$ @ 100 watts	1.20	±	0.16	1.3	1.58	1.63	1.54	1.46
M.V. @ 2.0 l/min $\dot{V}_{O_2}$	52.1	±	2.8	57.7	55.1	59.4	57.7	57.8
C.O. @ 2.0 l/min $\dot{V}_{O_2}$	16.9	±	2.1	20.3	18.0	18.1	19.0	18.7
Syst. B.P. @ 15 l/min C.O.	220	±	32	184	208	221	202	209

* Extrapolated

TABLE 3

APOLLO 15 FOOD SYSTEM

The food system for the Apollo 15 Command Module (CM) included a new stowage area in the A-7 locker, in addition to the lower equipment bay (LEB) and the left hand equipment bay (LHEB) food containers. Three new stowage areas were also utilized in the Lunar Module (LM). One container was located in the ascent stage (A/S) on the aft bulkhead and 2 stowage areas in the descent stage (D/S). Tables 1 and 2 outline the food orientation for the CM and LM, respectively.

The CM food for the first 10 days of the mission was arranged in meal packages, with supplemental foods available from the pantry. For the remainder of the mission the crewmen selected food for their meals from the pantry on a realtime preference basis. The 4-day menu cycle for the Command Module is shown in Table 3 and the contents of the pantry are listed in Table 4. The Lunar Module menus are shown in Table 5.

The menus were designed to provide approximately 2400 Kilocalories per man per day, with 400 additional calories in beverages and foods supplied in the pantry for a total of 2800 calories per man per day. Preliminary estimations of food consumption, derived from the onboard logs and returned foods, indicate that an average of 2801 2372, and 2568 Kilocalories per day were consumed by the CDR, CMP, and LMP, respectively. Average daily inflight nutrient consumption is presented in Table 6.

New foods included in the menu for this mission were: a) freeze dehydrated Romaine Soup and Crab Mushroom Soup, b) thermostabilized (wet pack) Beef Steak and Hamburger, c) intermediate moisture Apricot

Food Bar and Tropical Chocolate Bar, d) a Citrus flavored beverage powder and e) irradiated bread. The white, rye and cheese breads were pasteurized with ionizing radiation (0.5 Mrad using Cobalt 60) to prevent mold growth. As on Apollo 14, the flour used in these products was also irradiated at the 0.5 Mrad level.

There were a total of 562 primary food packages in the CM food system and 99 in the LM. The package types and quantities are outlined in Table 7.

PREFLIGHT

The crew selected their menu after evaluating about 100 available flight food items. Crewmembers were briefed on spacecraft stowage, food preparation procedures, opening the canned food items, and waste storage.

As on the previous 4 missions, after suiting up and prior to departure for the launch pad on F-0, each crewman was supplied with a specially prepared and packaged frozen sandwich, a package of bacon squares and a beverage powder. These items were stowed in a suit pocket for consumption within 6 to 8 hours after launch. The sandwiches were prepared in the MSC Food and Nutrition Laboratory with Quality Control inspection and met all applicable spacecraft and food system requirements.

INFLIGHT

Comments on the quality of the inflight foods and the food systems were favorable. The crew commented that they were very satisfied with the food supplied for this mission. They recommended that additional food be stowed on the LM. The crew supplemented the LM food supply with food from the CM pantry. The inflight food consumption logs were maintained by the crew throughout most of the mission. All crewmembers adhered to and consumed the food as presented in the programmed menu plus additional food items, snacks, and beverages from the pantry. The crew commented that they would have preferred to have packaged meals throughout the mission, but the pantry should not be eliminated.

As on Apollo 14, evaluation and observations were made on the use of nominal moisture thermostabilized food items packaged in aluminum cans with full pull-out lids. This crew reported that they carefully removed the lids and encountered difficulty initially with some dispersion of food and liquid, however, after the initial opening there were no problems in consuming the food.

The crew reported the flavor of both the CM and LM water was good, however, there was some gas in the CM water supply. The amount of gas increased with utilization, but the quantity apparantly did not interfere with food rehydration.

The crew encountered problems with using the in-suit drinking device, thus, the quantity of water consumed during the EVA periods was less than anticipated. On EVA-1, the CDR consumed about 16 ounces, while the LMP was unable to drink water from the device. During EVA-2, the CDR's drinking device slipped under the neck ring and he was unable to drink water. Following EVA-2, both the CDR and the LMP consumed the contents, approximately 32 ounces, to conserve vehicle water. The in-suit drinking device was not used during the third EVA.

The in-suit food bar assembly was utilized successfully on both EVA-1 and 2. The assembly consisted of an apricot food bar, measuring 9"x1"x1/4", in an elastic pouch dispenser. The assembly is attached to the in-suit drinking device and then is installed in the suit where it is attached to the helmet neck ring as shown in Figures 1 and 2.

APOLLO 15 CM - 112 FOOD ORIENTATION

STOWAGE LOCATION	P/N	VOLUME CU.IN.	WEIGHT LBS	CONTENTS
A7	14-0150	2815	30.70	33 overwrapped meals with associated wet packs Day 1 Meal C thru Day 5 Meal A; Oral Hygiene Kit (1) and Spoons (3)
LEB (B1)	14-0122	2080	29.73	28 overwrapped meals with associated wet packs Day 5 Meal B thru Day 8 Meal B for CMP and Day 8 Meal C thru Day 10 Meal B for CDR, CMP, and LMP
LHEB (L3)	14-0123	2923	36.64	Pantry Stowage 236 primary food packages Gum (10), Wet Wipes (20), and Contingency Feeding System (1)

Table 1

APOLLO 15 LM-10 FOOD ORIENTATION

LOCATION	P/N	WEIGHT LBS	CONTENTS
A/S	14-0121-301	7.4	3 overwrapper meals, Day 3 Meal B and Day 6 Meals A and B In-Suit Drinking Device (2) In-Suit Food Bar Assembly (6), Extra Beverages (6) and Spoons (2)
D/S Pallet No. 1	14-0121-302	4.1	Day 7 Meals A and B
D/S Pallet No. 2	14-0121-303	3.9	Day 8 Meals A and B

Table 2

APOLLO XV - CSM-112

David R. Scott, CDR - RED VELCRO
Alfred M. Worden, CMP - WHITE VELCRO
James B. Irwin, LMP - BLUE VELCRO

MEAL	DAY 1*, 5**, 9		DAY 2, 6**, 10***		DAY 3, 7**		DAY 4, 8**	
A	Peaches	RSB	Fruit Cocktail	R	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grapefruit Drink	R	Orange Drink	R	Grape Drink	R	Pineapple-Grapefruit Drink	R
	Cocoa	R	Cocoa	R	Cocoa	R	Cocoa	R
B	Hamburger	WP	Turkey & Gravy	WP	Lobster Bisque	RSB	Chicken & Rice Soup	RSB
	Pea Soup	RSB	Cranberry-Orange	RSB	Bread Slices (2)		Meatballs w/Sauce	WP
	Salmon Salad	RSB	Pineapple Fruitcake(4)	DB	Sandwich Spread	WP	Lemon Pudding	WP
	Applesauce	RSB	Vanilla Pudding	WP	Butterscotch Pudding	RSB	Sugar Cookie Cubes (4)	DB
	Cheese Cracker Cubes (4)	DB	Citrus Beverage	R	Pineapple-Orange Drink	R	Grape Punch	R
	Orange-Grapefruit Drink	R						
C	Cream Tomato Soup	RSB	Cream Chicken Soup	RSB	Shrimp Cocktail	RSB	Beef & Gravy	WP
	Spaghetti & Meat	RSB	Frankfurters	WP	Beef Steak	WP	Pork & Scalloped Potatoes	RSB
	Peach Ambrosia	RSB	Banana Pudding	RSB	Peaches	IMB	Chocolate Pudding	RSB
	Chocolate Bar	IMB	Brownies (4)	DB	Caramel Candy	IMB	Apricots	IMB
	Grape Drink	R	Pineapple-Grapefruit Drink	R	Orange-Grapefruit Drink	R	Grapefruit Drink	R

*Day 1 consists of Meal C only
**Day 5 Meal B thru Day 8 Meal B for White only
***Day 10 consists of Meals A and B only

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

Table 3

APOLLO XV

PANTRY STOWAGE

P/N: 14-0123
Line Item 17-T & 17-U

BEVERAGES	QTY
Cocoa	6
Coffee (B)	8
Coffee (C&S)	8
Grape Drink	3
Grapefruit Drink	6
Grape Punch	3
Orange-Grapefruit Drink	3
Orange Juice	16
Pineapple-Grapefruit Drink	3
Pineapple-Orange Drink	3
Citrus Beverage	11
	70

BREAKFAST ITEMS	
Bacon Squares (8) (IMB)	9
Peaches (RSB)	3
Spiced Fruit Cereal (RSB)	2
Cornflakes (RSB)	2
Fruit Cocktail (R)	3
Sausage Patties (R)	2
Scrambled Eggs (RSB)	6
Apricot (IMB)	6
Peaches (IMB)	6
	39

CUBES/CANDY	
Brownies (4)	3
Caramel Candy (4)	3
Chocolate Bar	3
Cheese Cracker (4)	6
Cheese Sandwiches (4)	3
Beef Sandwiches (4)	3
Jellied Fruit Candy	3
Apricot Food Bar	3
Pecans (6)	3
Date Fruitcake (4)	2
Sugar Cookies (4)	3
	35

DESSERTS	
Applesauce (RSB)	3
Butterscotch Pudding (RSB)	3
Chocolate Pudding (RSB)	3
Peach Ambrosia (RSB)	3
Lemon Pudding (WP)	3
	15

SALADS/SOUPS	QTY
Chicken & Rice Soup (RSB)	3
Lobster Bisque (RSB)	3
Crab Mushroom Soup	3
Romaine Soup	3
Shrimp Cocktail (RSB)	3
Tomato Soup (RSB)	3
Tuna Salad (RSB)	3
Salmon Salad (RSB)	3
	24

SANDWICH SPREADS/BREAD	
Bread (Slice) Rye	6
Chicken Salad (8 oz.)	1
Cheddar Cheese (2 oz.)	3
Jelly	3
Peanut Butter	3
Ham Salad (8 oz.)	1

MEAT ITEMS	
Beef Stew (RSB)	2
Beef & Vegetables (RSB)	2
Chicken & Rice (RSB)(LRP)	3
Chicken Stew (RSB)(LRP)	2
Pork & Scalloped Potatoes (RSB)(LRP)	3
Spaghetti w/Meat Sauce (RSB)(LRP)	3
	15

WET PACK FOOD	
Beef & Gravy	2
Beef Steak	2
Frankfurters	2
Hamburger	2
Meatballs w/Sauce	2
Turkey & Gravy	2
Catsup	3
Mustard	3

ACCESSORIES	
Chewing Gum	10
Wet skin cleaning towels	20
Contingency Feeding System	1
3 food restrainer pouches	
3 beverage packages	
1 valve adapter (pontube)	
Germicidial Tablets (42)	2
Index Card	1

Table 4

APOLLO XV - LM-10 MENU

David R. Scott, CDR - RED VELCRO
James B. Irwin, LMP - BLUE VELCRO

MEAL	A/S FOOD ASSEMBLY 14-0121-301 DAY 5		A/S FOOD ASSEMBLY 14-0121-301 DAY 6		PALLET NO. 1, 14-0121-302 DAY 7		PALLET NO. 2, 14-0121-303 DAY 8	
A			Peaches	RSB	Apricots	IMB	Peaches	IMB
			Bacon Squares (8)	DB	Beef Steak	WP	Bacon Squares (8)	DB
			Scrambled Eggs	RSB	Sausage Patties	R	Cinn. Toasted Bread (6)	DB
			Graham Cracker Cubes(6)	DB	Cornflakes	RSB	Pork & Scalloped Potatoes	RSB
			Orange-Pineapple Drink	R	Grapefruit Drink	R	Beef Steak	WP
			Cocoa	R	Cocoa	R	Orange-Pineapple Drink	R
							Cocoa	R
B	Cream Tomato Soup	RSB	Salmon Salad	RSB	Shrimp Cocktail	RSB	Tuna Salad	RSB
	Bread Slice (2) and Ham Salad Spread	WP	Frankfurters	WP	Ham & Applesauce	RSB	Chicken & Rice	RSB
	Caramel Candy	IMB	Chocolate Bar	IMB	Meatballs w/Sauce	WP	Turkey & Gravy	WP
	Pineapple-Grapefruit Drink	R	Pecans	IMB	Brownies (6)	DB	Chocolate Pudding	RSB
	Grapefruit Drink	R	Peach Ambrosia	RSB	Cheese Crackers(6)	DB	Grape Punch	R
			Orange-Grapefruit Drink	R	Orange Drink	R		
					Grape Drink	R		

In-Suit Food Bar Assembly (1)	6 ea P/N: SEB13100218-301
In-Suit Drink Device (1)	2 ea P/N: 14-0151-01
Spoon Assembly (2)	1 ea P/N: 14-0144-01
Germicidal Tablets Pouch (42)	1 ea P/N: 14-02166
Beverages (6)*	

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

* 4 Citrus flavor
2 Orange-Grapefruit

Table 5

Item	Water gms	Calorie	Protein gms	Fat gms	Carbohydrate Total gms	Carbohydrate Fiber gms	Ash gms	Ca mgs	P mgs	Fe mgs	Na mgs	K mgs	Mg mgs
osed Menu		2455	100.1	86.7	333.6	4.64	19.8	791	1492	12.65	5135	2643	205.
		2801	120.9	109.1	345.7	5.94	24.6	857	1718	16.7	5822	3324	256.
		2372	94.2	84.7	311.5	4.59	18.9	725	1444	14.4	4921	2482	190.
		2569	109.0	92.3	328.6	5.66	20.8	778	1500	14.5	5036	2928	198.

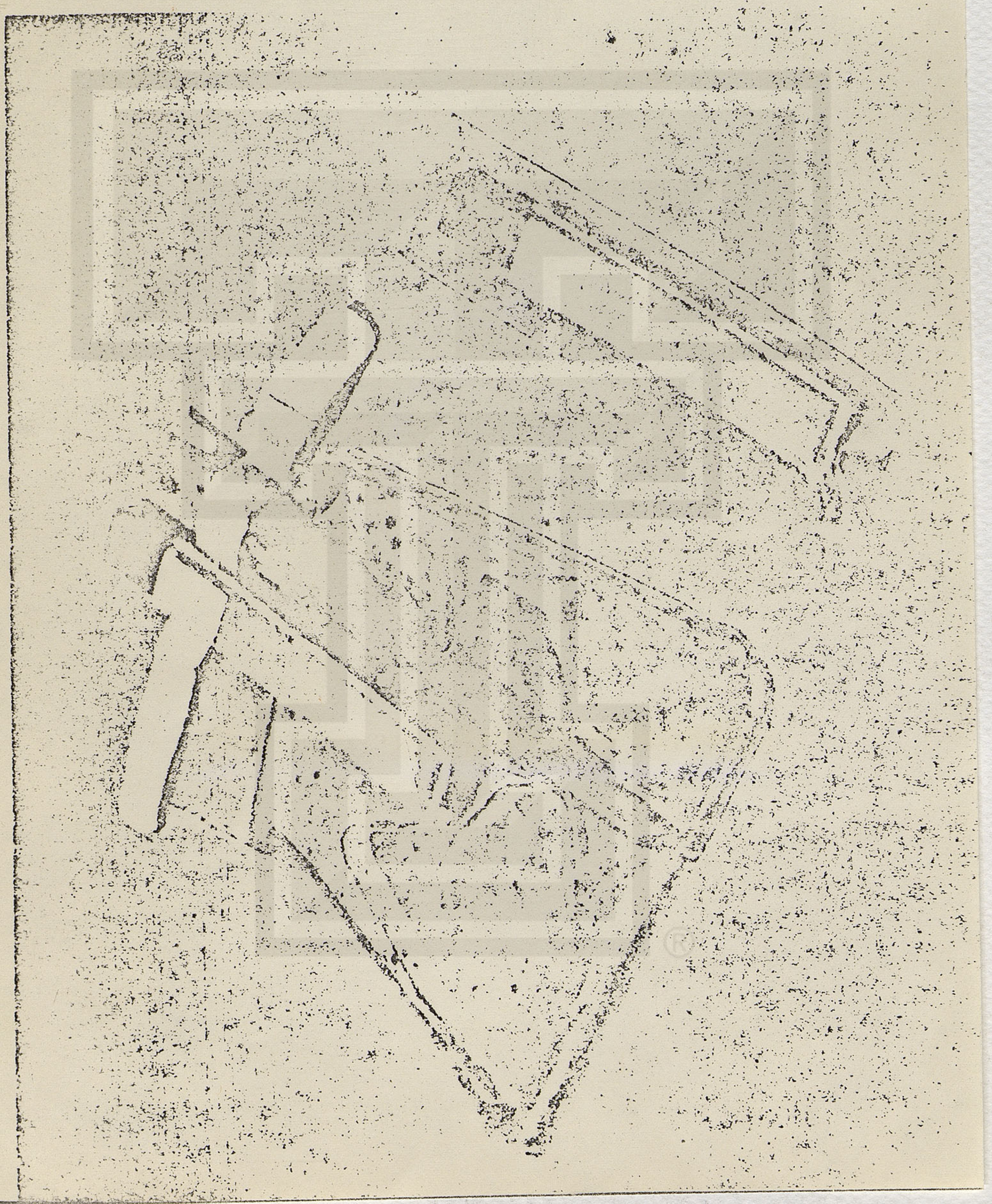
Table 6

APOLLO 15 FOOD PACKAGE INVENTORY

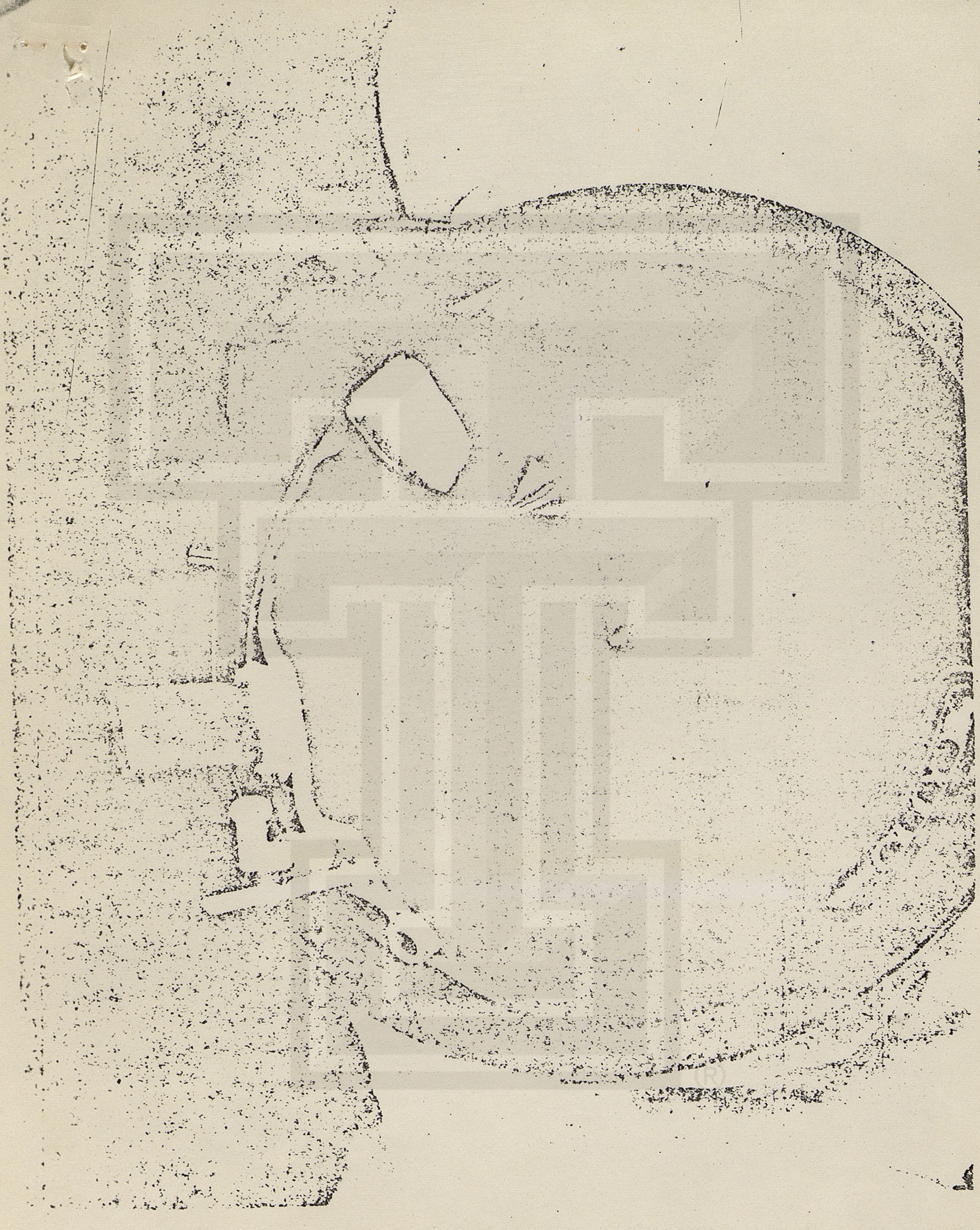
FOOD PACKAGES	CSM	LM
Rehydratable	46	8
Rehydratable Spoon Bowl	171	24
Beverage	125	24
Bite Size	106	22
Wet Packs		
Flexible - meat items	44	10
- misc.*	23	
Rigid - cans/tubes	29	1
Bread	18	4
Food Bar Assembly	0	6
TOTAL	562	99
Overwraps	61	11

*Jelly, Mustard, Catsup
Peanut Butter, Cheese

Table 7



NASA



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

REPLY TO ATTN OF: DC71/8/M58/71 (F&N)

August 25, 1971

MEMORANDUM

TO: DA/Director of Medical Research and Operations

FROM: DC71/Food and Nutrition

SUBJECT: Apollo 15 Bone Mineral Results

Measurement of os calcis by iodine-125 photonabsorptiometry indicated the following percent changes from the mean baseline established preflight:

	R+0	R+1	R+6	R+14
Scott	-6.1	-2.5	-2.3	-0.4
Worden	-7.0	-5.3	-3.2	-1.3
Irwin	-0.4	-1.5	+0.5	-
Controls:				
Jernigan	-1.4	-0.3	-1.9	-
LaPinta	-1.1	-1.6	-0.8	+1.8
Vogel	-	-	-2.4	+0.5
Alexander	-1.0	-0.5	-2.3	-1.3

The following readings were obtained on the radius:

	R+0	R+1	R+6	R+14
Scott	+0.1	-1.5	+1.3	+0.4
Worden	-3.1	+0.2	-1.3	-0.3
Irwin	-0.4	-0.3	+1.7	-
Jernigan	-0.6	-	-	-
LaPinta	-	+1.0	-	+0.4
Vogel	+0.7	-2.2	-	-
Alexander	-	-	-	-

There was a loss in the os calcis in Scott and in Worden. The rate of return in Scott was more rapid than in Worden. Irwin never really lost anything. All crewmembers returned to baseline by R+14. Scott returned to baseline somewhere between R+6 and R+14. There were no losses in the radius.

The os calcis data obtained from Scott and Worden on Apollo 15 is at variance with that obtained on Apollo 14 in which none of the three crewmembers lost bone mineral mass. The Apollo 14 data and the Apollo 15 data from Irwin in the calcaneus is in concert with results observed in bed rest situations in which no significant losses occur in the first 12 days of recumbency. However, it is interesting to note that the recovery period for Scott and Worden after Apollo 15 was approximately 12 days. In bed rest studies, the length of time it takes for bone mineral values to return to the pre-test levels is approximately equivalent to the length of time these changes take to induce. The 5 to 6 percent losses in bone mineral observed in Apollo 15 would have taken approximately 6 to 8 weeks of bed rest to induce and, in bed rest, 6 to 8 weeks to return to original levels.

The error of the method is normally established at $\pm$ 2%. Measurements made on the prime crew prior to flight were all within $\pm$ 1%. These measurements were unusually tight and their reliability is considered to be exceptionally good. Measurements made on the controls prior to flight were all within $\pm$ 1.3% and postflight within $\pm$ 2.4%.

It is emphasized that the data is preliminary. The effect of soft tissue absorption has not yet been fully accounted for. In the 15 crew, there were changes in soft tissue in terms of the calf circumference measurements. If these changes occurred only with respect to water or lean body mass, there would not be any effect expected upon the gamma ray attenuation. If the differences in calf circumference were due to changes in fat, there would be differences in gamma ray attenuation. Further examination of the Apollo 15 bone scans data will enable corrections to be made for the effects of this tissue absorption. In the worst case, the reported data could be altered by 2 to 3%.

If we compare the data obtained on Apollo 15 with all previous flights in which bone density measurements have been made, the results are not unusual. If the losses in Apollo 15 were allowed to continue unabated for a prolonged period of time, the consequences might be severe since the losses observed are probably not confined to the os calcis.

Paul Rambaut

Paul C. Rambaut, Sc.D.

CONCURRENCE:

W. W. Kemmerer, Jr., M.D.
Chief, Preventive Medicine Division

cc:
DD/Willard R. Hawkins, M.D.
John M. Vogel, M.D.
USPHS Hospital
15th Avenue and Lake Street
San Francisco, CA 94118

DC71/PCRambaut:mb:8/25/71:5056

Apollo 15 - Light Flash Test

TLC TEST Results

July 30, 1971

The first session of the light flash test involving the Apollo 15 crew was conducted during 51:37 - 52:33 G.E.T.

The crew reported by down-link voice each time a light flash was perceived. This provided data on the frequency of occurrence of events only. Crew comments on the description and characteristics of these events were recorded on DSC tape for transmission to MCC at a later time. Unfortunately, when transmission was made all the data were lost. Accordingly, no additional information on the TLC test is available.

Light flash events reported:

CDR	24
CMP	23
LMP	13
Unidentified	1
Total	61

The first light flash was reported 9 - 10 minutes following onset of the test. About half way through the test period, there was a period of about six minutes during which no light flashes were reported.

Following conclusion of the test period, the crew stated that most of the light flashes were bright point-sources of light similar to a camera flashbulb seen across an ice skating rink (during the Ice Capades). A few streaks of light were observed. All flashes were bright, easily visualized, and readily associated with the right or left eye concerned.

The CM was darkened and the eye shields were worn during the test which covered a period of 56 minutes.

R. E. Benson

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ROUTING SLIP

MAIL CODE	NAME		
	Dr. Dietlein	Action	
		Approval	
		Call Me	
		Concurrence	
		File	
		Information	
		Investigate and Advise	
		Note and Forward	
		Note and Return	
		Per Request	
		Per Telephone Conversation	
		Recommendation	
		See Me	
		Signature	
		Circulate and Destroy	

Thought you might be interested in this

RDR

NAME	TEL. NO. *(or code)* & EXT.
CODE *(or other designation)*	DATE

GPO : 1969 OF—348-365

NASA FORM 26 APR 69 PREVIOUS EDITIONS MAY BE USED

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

AUG 20 1971

REPLY TO ATTN OF: DC71/M-91/71 (RH)

RECEIVED AUG 20 12 49 PM '71 M.S.C. - D.C.

MEMORANDUM

TO: DC/Chief, Preventive Medicine Division

FROM: DC71/Radiological Health Team

SUBJECT: Total Body Gamma Spectrometry - Apollo 15

The Apollo 15 astronauts (Scott, Irwin, and Worden) were examined by total body gamma spectrometry, postflight, on August 9, 1971, approximately 48 hours following splash-down.

Radioisotopes were administered to the crew (pre- and postflight) to facilitate evaluation of various physiologic changes. The resulting radioactivity present in the crewmembers precluded evaluation of normal potassium levels (K^{40}) and cosmic ray induced radioactivity. Based on a cosmic radiation dose of less than 0.5 rad indicated by the crew radiation dosimeters, any induced radioactivity present would be well below detectable limits.

The gamma spectrum data were analyzed for total body retention of potassium^{42}, which was administered to the crew and three control subjects. The data indicate the mean K^{42} retention by the crew was not statistically different from the mean of the controls. However, individual K^{42} retention values for Scott and Irwin were slightly higher than the mean of the controls (3 percent and 2 percent, respectively), and the value for Worden was lower than the mean of the controls (approximately 6 percent). The results are based on the assumption that each crewmember and control subject received equivalent aliquots of K^{42}, although given at different times. The data were corrected for radioactive decay of K^{42} to the time of total body gamma spectrometry examinations.

Richard E. Benson
Richard E. Benson, D.V.M., M.S.

cc:
DA/C. A. Berry, M.D.
DD/W. R. Hawkins, M.D.
DD4/C. A. Jernigan, M.D.
DC7/W. C. Alexander, Ph. D.

DC71:REBenson:djm:8/18/71:4251

CLINICAL LABORATORIES

APOLLO XV PRELIMINARY REPORT

This report describes significant changes based on the pre and post flight medical evaluation of the Apollo XV crew in the general areas of:

1) Fluid and Electrolyte Balance and Endocrine Homeostasis
2) Cellular Analysis
   a) Immunology
   b) Special Hematology

Although the laboratory workup was extensive (reference Medical Requirement Document J-Type Lunar Surface Mission Section 4.4) only those parameters will be reported here which either:

1) Have direct bearing on the adaptation hypothesis and its validation or
2) Have changed significantly over the flight interval in areas not specifically related to the hypothesis.

At the time of submission of this preliminary report, approximately 85% of the data analysis and reduction are complete. The principal analyses yet to be completed are the postflight Extracellular Fluid Volumes; Antidiuretic Hormore (ADH); Parathormone (PTH); and Calcitonin (CTN). These values will be available by September 10, 1971.

FLUID AND ELECTROLYTE BALANCE

ENDOCRINE HOMEOSTASIS

The changes observed over the flight interval are consistent with the adaptation hypothesis and are characteristic of previous Apollo mission experiences.

We are confident that the initial redistribution of the total circulatory blood volume upon exposure to the null gravity environment, acting through atrial receptors and hypothalamic reflex loops, results in a diminished proximal tubular reabsorption of Na^+ and K^+ thereby leading to a salt and water diuresis. The loss of salt and water initially depletes the plasma volume which is subsequently replenished by a compensatory secondary hyperaldosteronism. This is in accord with measured increases in angiotensin and aldosterone. Even in the face of a significant decrease in RCM, the total circulating blood volume is repleted by a greater increase in plasma volume than decrease in RCM. For this compensatory stabilization of the TCBV to occur, several events ensue which tend to deplete total body stores of K^+. These events are consistent with the schematic presented in Figure 1. The greater K^+ loss in the lunar surface crew compared to the CMP suggests that the adaptive process depletes the total body K^+ by approximately 10% whereas work load, epinephrine secretion by the adrenal medulla, and possible negative electrolyte replenishment, were contributory to the additional 5% decrease in exchangeable K^+ in the LMP and CDR. The validity of the hypothesis is further supported by the insignificant change in ACTH which suggests that the adrenal cortex was functioning adequately and efficiently to control glucocorticoid and mineralocorticoid production in concert with the renin-angiotensin system for regulation of the aldosteronism.

The measured decrease in hydrocortisone immediately postflight is consistent with either 1) a preferential enzymatic shunting in the adrenal cortex tending to favor mineralocorticoid production, or 2) a circadic phenomenon attributable to phasic changes in the normal excretion of this compound. We tend to favor the preferential shunting postulate, but we cannot dismiss the possibility that circadic variability is a contributory factor. The increased levels of urinary catecholamines (epinephrine and norepinephrine) are suggestive of adrenal medullary activity which is principally under the control of the sympathetic nervous system, but this significance is more attributable to the overall stress of the environment rather than to the adaptive process. The effectivity of increased catecholamines is questionable in light of the diminished hydrocortisone levels in the plasma immediately postflight.

Figure 2 is the overall hypothesis which describes the adaptation sequence in the reestablishment of fluid and electrolyte/endocrine homeostasis upon transition to and from the null gravity environment. Those parameters which were measured and found to be significantly altered, or supportive of this schematic are identified.

In summary, we have no new information forthcoming from this mission to change our concepts of the status of the adapted crewman. We believe we have in fact confirmed a major portion of the hypothesis by repetitive measurements, and new measurements characteristic of this laboratory examination. We view the adapted space crewman as in a state of mild compensated metabolic alkalosis with a frank hypokalemia. We are confident that this adaptation is a natural event and is commensurate with the demands of the new environment. We are as yet unable to define the magnitude of the cost of this adaptation nor are we presently able to predict the status of functional reserves of the crewman. However, it is without question that the physiological cost must now be viewed principally as the potassium deficit since the compensatory mechanisms themselves are adequate to reestablish a physiological set of values in null gravity. It is only that the majority of these mechanisms result in potassium loss. Exercise or other activities (epinephrine) obviously enhance this loss but the extent of the ensuing depletion is not possible to predict.

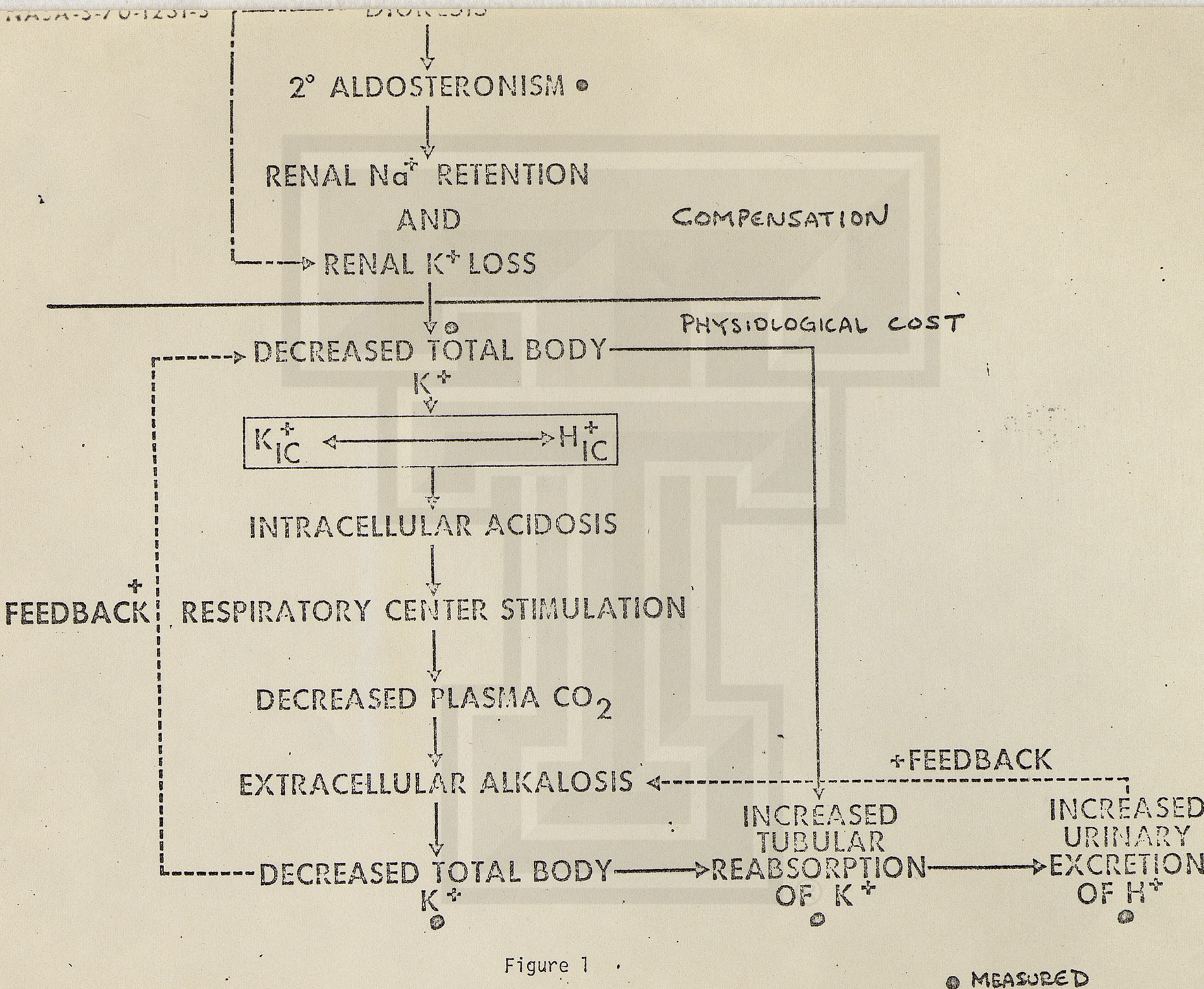
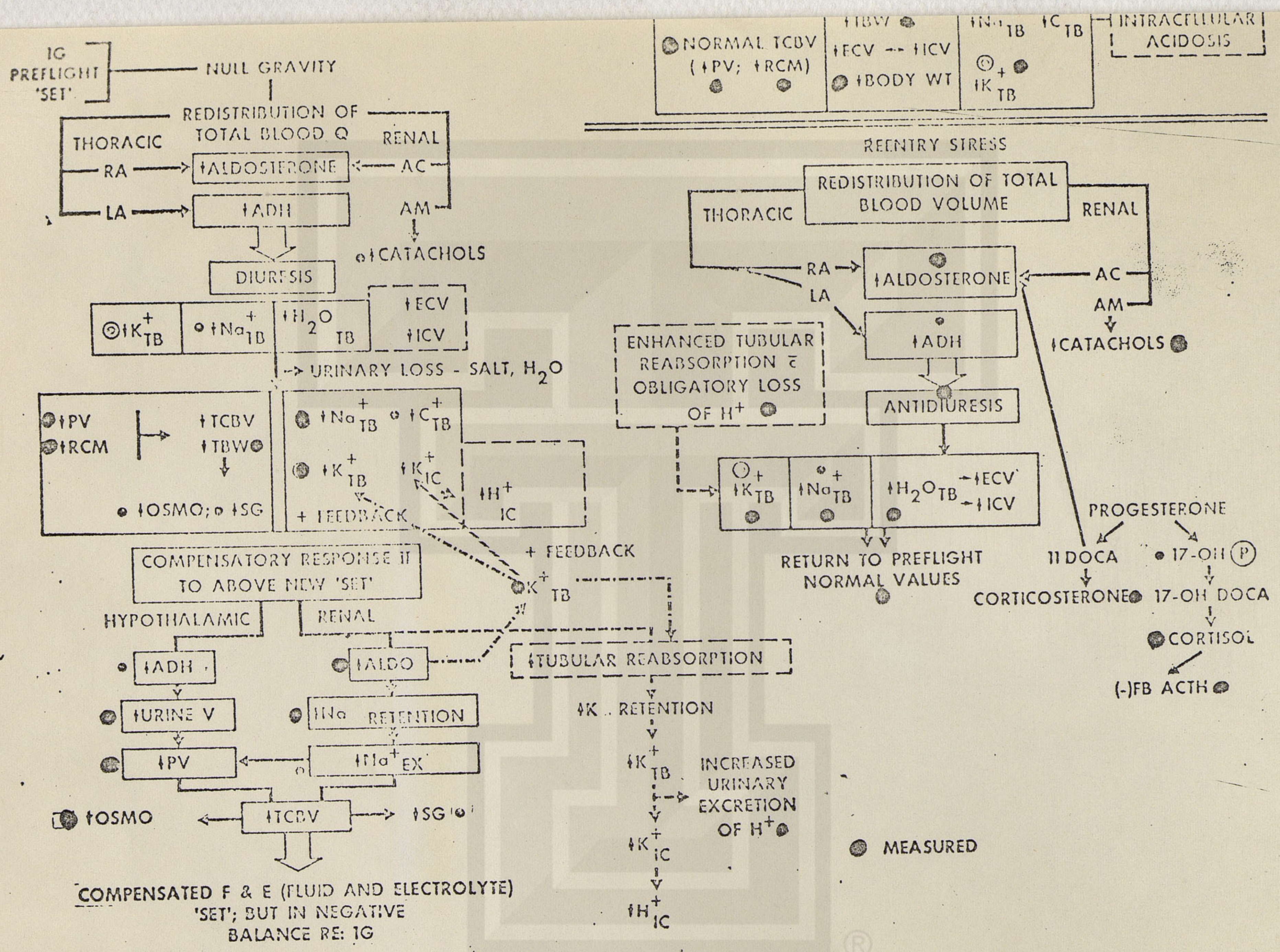

NASA-S-70-1231-S
DIURESIS
2° ALDOSTERONISM
RENAL Na+ RETENTION
AND
RENAL K+ LOSS
COMPENSATION
PHYSIOLOGICAL COST
DECREASED TOTAL BODY K+
K+IC
H+IC
INTRACELLULAR ACIDOSIS
+ FEEDBACK
RESPIRATORY CENTER STIMULATION
DECREASED PLASMA CO2
+FEEDBACK
EXTRACELLULAR ALKALOSIS
DECREASED TOTAL BODY K+
INCREASED TUBULAR REABSORPTION OF K+
INCREASED URINARY EXCRETION OF H+
MEASURED

Figure 1



1G PREFLIGHT 'SET'
NULL GRAVITY
REDISTRIBUTION OF TOTAL BLOOD Q
THORACIC
RENAL
RA
LA
AC
AM
ALDOSTERONE
ADH
CATACHOLS
DIURESIS
ECV
ICV
URINARY LOSS - SALT, H2O
PV
RCM
TCBV
TBW
OSMO; SG
+ FEEDBACK
COMPENSATORY RESPONSE II TO ABOVE NEW 'SET'
HYPOTHALAMIC
RENAL
ADH
ALDO
URINE V
Na RETENTION
PV
OSMO
TCBV
SG
COMPENSATED F & E (FLUID AND ELECTROLYTE) 'SET'; BUT IN NEGATIVE BALANCE RE: 1G
TUBULAR REABSORPTION
K.. RETENTION
INCREASED URINARY EXCRETION OF H+
NORMAL TCBV (PV; RCM)
BODY WT
INTRACELLULAR ACIDOSIS
REENTRY STRESS
REDISTRIBUTION OF TOTAL BLOOD VOLUME
ENHANCED TUBULAR REABSORPTION c OBLIGATORY LOSS OF H+
ANTIDIURESIS
RETURN TO PREFLIGHT NORMAL VALUES
PROGESTERONE
11 DOCA
17-OH (P)
CORTICOSTERONE
17-OH DOCA
CORTISOL
(-)FB ACTH
MEASURED

Figure 2

SPECIAL HEMATOLOGY/IMMUNOLOGY

Erythrocytes were examined individually by x-ray spectrometry for cellular K^+ content. The population distribution of K did not change postflight. It should be emphasized that red cell K measurements are not the best indicators of changes in the K concentration of other tissues and organs (heart, muscle, etc). This response is different from that observed on Apollo 13 and 14 in which there was a shift in the red cell Na/K ratios postflight reflecting higher Na values and/or reduced K.

Cytophotometric evaluation of hemoglobin distribution in individual red cells is still in progress.

Red cell 2,3-diphosphoglycerate (DPG) and adenosine triphosphate (ATP) levels were measured and showed no change postflight. Recent investigations have demonstrated the relationship between metabolism and function in the red cell especially with respect to the maintenance of adequate oxygen delivery (Science, Vol. 171, pp. 1205-1211, 1971). The stability of DPG/ATP in the cells is indicative of normal metabolism and Hb-O_2 affinity.

Lymphocytes were analyzed for antigenic responsiveness by quantitating the rates of synthesis (isotope uptake _in vitro_) and cellular content (cytophotometry) of RNA and DWA, with and without phytohemagglutinin (PHA) stimulation. There was no postflight change in the responsiveness of the Lymphocytes as measured by these techniques.

Serum protein values for Apollo 7-13 are summarized in Figures 1-4. Characteristic changes in Haptoglobin, Ceruloplasmin and α_1-Antitrypsin were observed in the Apollo 15 crew. These data are consistent with a humoral response to a mild inflammatory process (Fig 6),but whether or not this is related to the postulated loss in total body muscle mass is unclear.

Humoral and Cellular Immunity

Apollo Missions No. 7-13

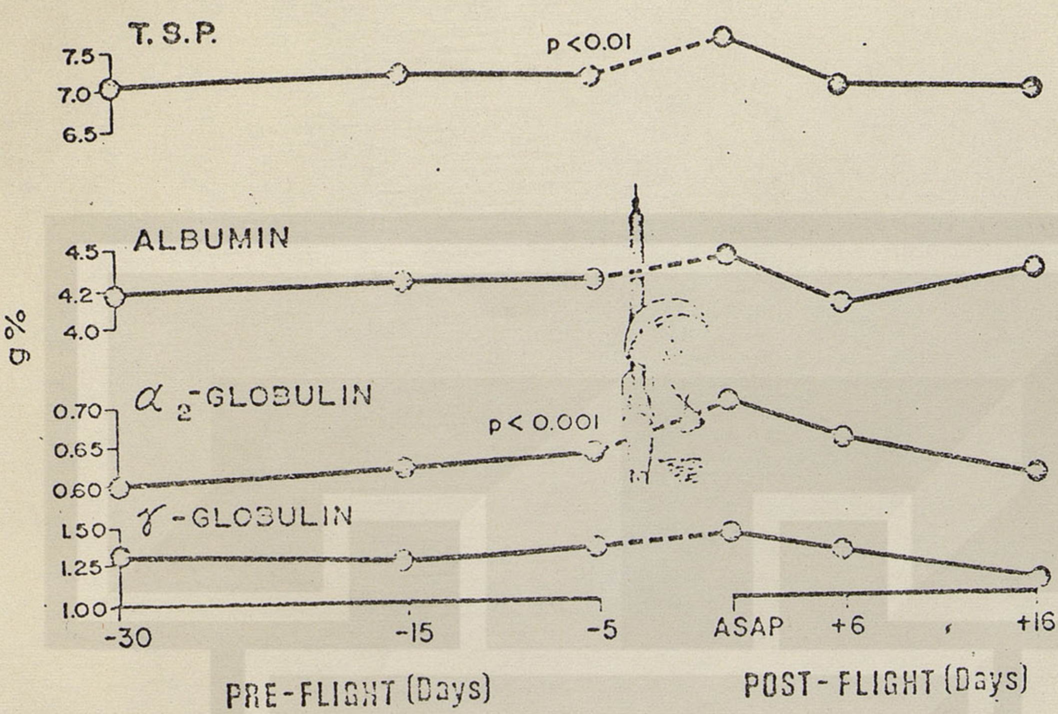


Figure 1

Humoral and Cellular Immunity

Apollo Missions No. 7-13

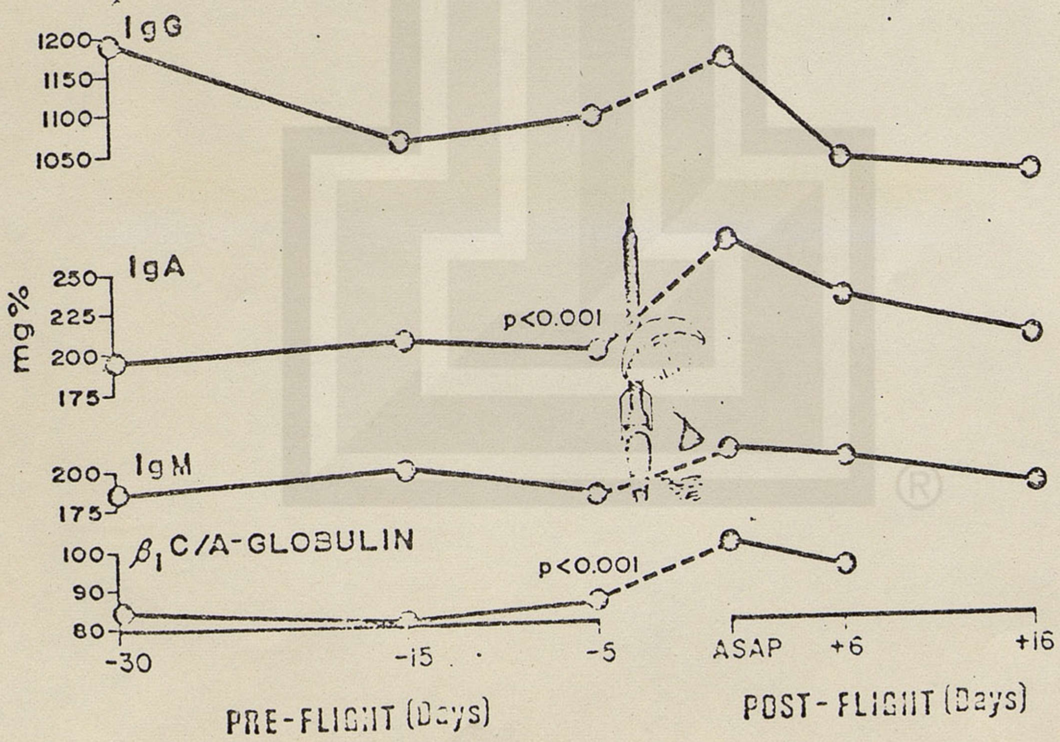


Figure 2

Figure 2

Apollo Missions No. 7-13

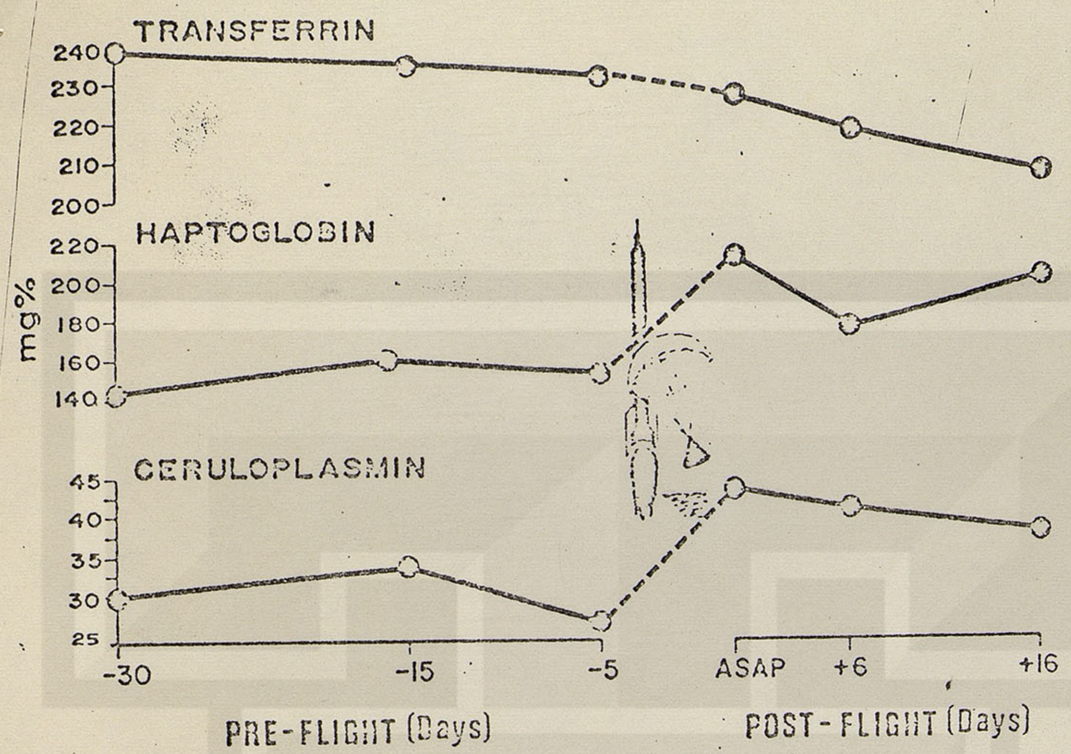


Figure 3

Humoral and Cellular Immunity

Apollo Missions No. 7-13

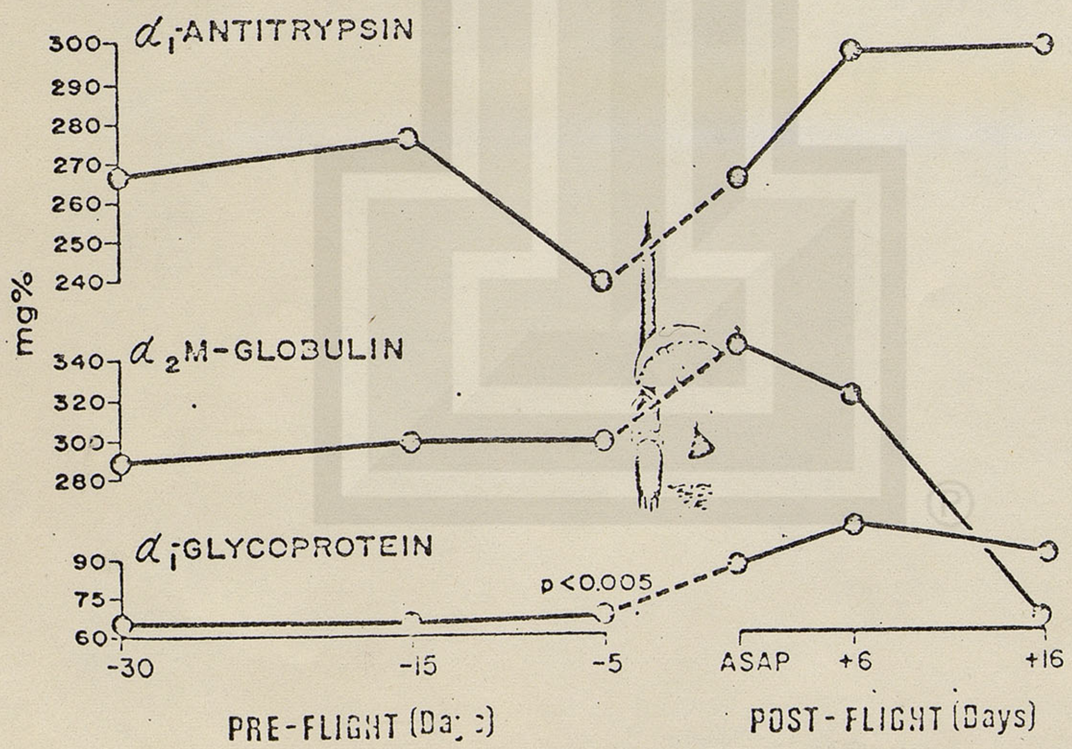


Figure 4

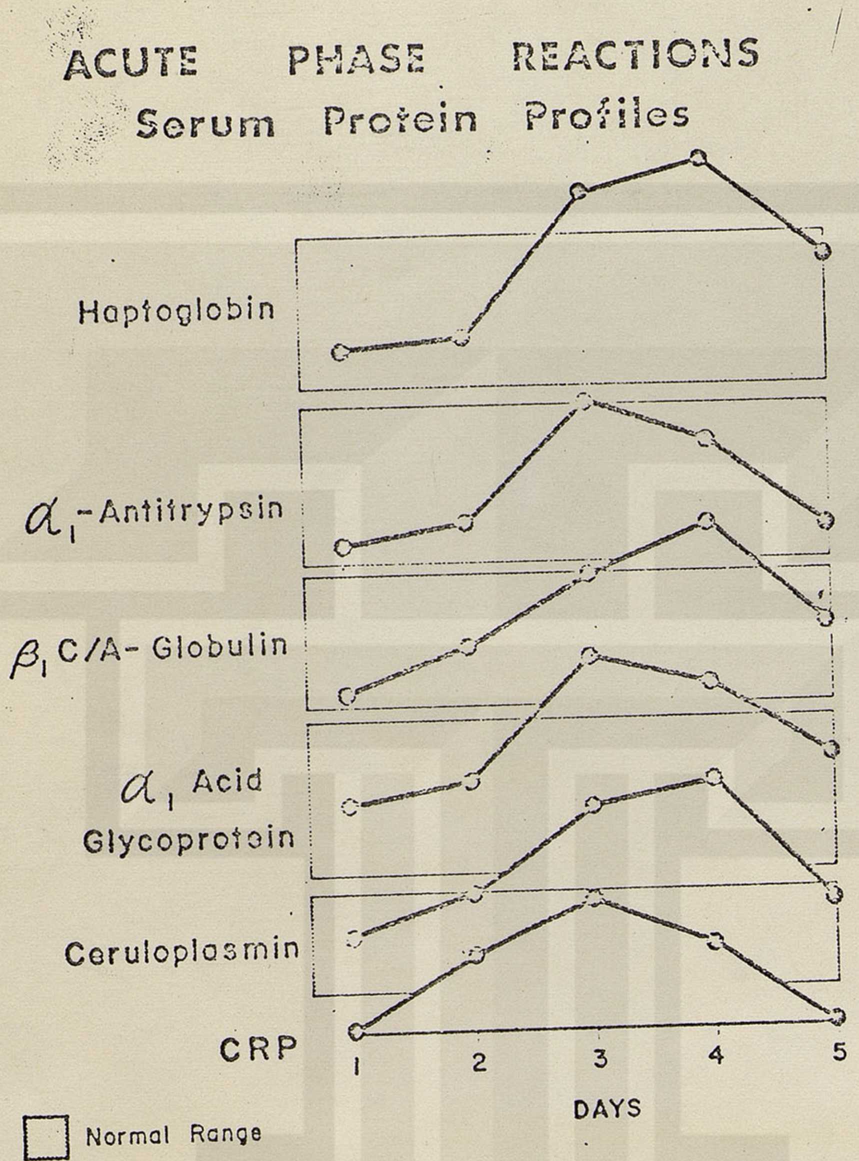

ACUTE PHASE REACTIONS
Serum Protein Profiles
Haptoglobin
α_1-Antitrypsin
β_1 C/A- Globulin
α_1 Acid Glycoprotein
Ceruloplasmin
CRP
1
2
3
4
5
DAYS
Normal Range

Figure 6

Apollo 15 - Light Flash Test

TLC TEST Results

July 30, 1971

The first session of the light flash test involving the Apollo 15 crew was conducted during 51:37 - 52:33 G.E.T.

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The CM was darkened and the eye shields were worn during the test which covered a period of 56 minutes.

R. E. Benson

MINERAL CONTENT CHANGES

APOLLO 15

Per cent change from mean baseline

Right Radius

	Scott	Worden	Irwin	Jernigan	LaPinta	Vogel	Alexander
F-27	-0.3	+0.4	-0.6	+0.7	+2.3	+1.4	+2.1
F-13	+0.7	+0.7	+0.3	-2.2	-3.2	+0.8	+1.1
F-5	-0.4	-1.1	+0.3	+1.5	+0.8	-2.2	-3.2
R-2	--	--	--	+0.6	-2.8	-2.0	+2.7
R+0	+0.1	-3.1	-0.4	--	--	--	--
R+1	-1.5	+0.2	-0.3	-0.6	+1.0	-1.3	-1.1
R+5	+1.3	-1.3	+1.7	-0.6	-1.2	-2.1	+3.8
R+14	+0.4	-0.3	--	--	+0.4	-2.1	+0.1

MINERAL CONTENT CHANGES

APOLLO 15

Per cent change from mean baseline

Left Os Calcis

	Scott	Worden	Irwin	Jernigan	LaPinta	Vogel	Alexander
F-27	-0.5	-0.5	+0.1	-0.6	-1.7	0.0	0.0
F-13	+o.4	+0.8	-0.2	+0.6	+2.1	+0.3	+o.2
F-5	+0.1	-0.3	+0.1	0.0	-0.5	-0.3	-0.3
R-2	--	--	---	-3.4	-0.6	-1.2	-2.6
R+0	-6.1	-7.0	-0.5	--	--	--	--
R+1	-2.5	-5.3	-0.9	-0.1	-2.3	-2.8	-5.3
R+5	-2.3	-3.2	-1.5	-1.1	-1.1	-2.5	-4.7
R+14	-0.9	-1.3	---	--	+1.5	0.0	+1.2

MINERAL CONTENT CHANGES

APOLLO 15

Per cent change from mean baseline

Right Radius

	Scott	Worden	Irwin	Jernigan	LaPinta	Vogel	Alexander
F-27	-0.3	+0.4	-0.6	+0.7	+2.3	+1.4	+2.1
F-13	+0.7	+0.7	+0.3	-2.2	-3.2	+0.8	+1.1
F-5	-0.4	-1.1	+0.3	+1.5	+0.8	-2.2	-3.2
R-2	--	--	--	+0.6	-2.8	-2.0	+2.7
R+0	+0.1	-3.1	-0.4	--	--	--	--
R+1	-1.5	+0.2	-0.3	-0.6	+1.0	-1.3	-1.1
R+5	+1.3	-1.3	+1.7	-0.6	+1.2	-2.1	+3.8
R+14	+0.4	-0.3	--	--	+0.4	-2.1	+0.1

MINERAL CONTENT CHANGES

APOLLO 15

Per cent change from mean baseline

Left Os Calcis

	Scott	Worden	Irwin	Jernigan	LaPinta	Vogel	Alexander
F-27	-0.5	-0.5	+0.1	-0.6	-1.7	0.0	0.0
F-13	+o.4	+0.8	-0.2	+0.6	+2.1	+0.3	+o.2
F-5	+0.1	-0.3	+0.1	0.0	-0.5	-0.3	-0.3
R-2	---	---	---	-3.4	-0.6	-1.2	-2.6
R+0	-6.1	-7.0	-0.5	---	---	---	---
R+1	-2.5	-5.3	-0.9	-0.1	-2.3	-2.8	-5.3
R+5	-2.3	-3.2	-1.5	-1.1	-1.1	-2.5	-4.7
R+14	-0.9	-1.3	---	---	+1.5	0.0	+1.2