CR-151354

JSC/METHODIST HOSPITAL 28-DAY BEDREST STUDY

(NASA-CR-151354) REPORT OF 28-DAY BEDREST SIMULATION OF SKYLAB, VOLUME 2 (Methodist Hospital) 732 p

N77-79601

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VOLUME II

FINAL REPORT

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

JANUARY 31, 1977

REPORT OF 28-DAY BEDREST SIMULATION OF SKYLAB

VOLUME II

COMPILED BY:

PHILIP C. JOHNSON, M.D.

AND

CHERYL MITCHELL, M.A.

CONTRACTOR:

THE METHODIST HOSPITAL

HOUSTON, TEXAS

NASA CONTRACT NO. NAS 9-14578

TECHNICAL MONITOR: HERBERT GREIDER

TABLE OF CONTENTS

Introduction----------1

Diet and Menu Planning----------C. Stadler----------A.1

Biochemical Studies----C. S. Leach & M. T. Troell----------B.1

Metabolic Balances----H. O. Wheeler & E. B. Smith----------C.1

Hematology and Immunology

Hematology Summary---S. L. Kimzey----------D.1

Hemoglobin and Plasma Volume---S. L. Kimzey, et al.-------D.11

Red Cell Shape Classification---S. L. Kimzey, et al.------D.25

Serum Erythropoietin-----C. D.R. Dunn et al.----------D.60

Lymphocyte Response-----B. S. Criswell & S. L. Kimzey-----D.83

Radionuclide Studies--------P. C. Johnson & T. Driscoll-------E.1

Lower Body Negative Pressure-------G. W. Hoffler et al.------F.1

Exercise Stress Testing------C.F. Sawin et al.----------G.1

Isometric Stress Testing-----Earl V. LaFevers et al.----------H.1

Vestibular System Evaluation-----Jerry L. Homick----------I.1

Sleep Characteristics-------James D. Frost----------J.1

Monitoring Inbed Spontaneous Activity-------Dan Rinks---------K.1

Biosterometric Analysis of Body--------R. E. Herron----------L.1

Summary and Conclusions ---C. Mitchell & P. C. Johnson--------M.1

INTRODUCTION

The 28 day bedrest study reported in this document was the second phase of a two part study; the first phase, a two week bedrest study, was completed in 1975, and the results were reported previously. This study began as a simulation of Skylab II, the 28 day flight, and was later modified to focus on certain scientific questions and to test the efficacy of a counter measure, saline ingestion during four hours of -30 mm Hg LBNP, which had received favorable preliminary reports from the west coast (i.e. Hyatt). As indicated by the title, the study was a cooperative effort by JSC and The Methodist Hospital, the latter being contracted to organize and administrate the project, supplying subjects, support personnel such as nurses and food technicians, and bedrest and housing facilities (Contract #NAS-9-14578). The scientific research was supported by other contracts or funds held by the various primary investigators.

In broad terms the project consisted of three phases: a three week diet controlled period, when baseline physiological data were obtained; a four week bedrest period; and a two week recovery period. A complete description of the project and its purpose including specific protocols and methods can be found in Volume I of this document. For convenience the schedule of testing and an outline of the counter measure study performed at days 13, 14 and 15 of bedrest is duplicated in the Appendix of this volume.

The paid volunteer subjects who participated in the project were between 26 and 37 years old; most were students; all were in good physical condition as determined by a routine history and physical

CBC, urinalysis, SMAC, and stress EKG. Although none was an athlete per se, all were physically active. Informed consent was obtained.

In the following pages the various primary investigators report the results of the medical testing. The reports were not edited by the contractor, but were assembled as received with minor changes. Methods are generally abbreviated, since they exist in complete form in Volume I. In addition to the reports, much of the raw data is included so that it will be available in the future to other investigators for analysis. Concluding the report is a summary prepared by Philip C. Johnson and Cheryl Mitchell of The Methodist Hospital. The conclusions reached are the opinions of these individuals and not a consensus of the primary investigators whose reports follow and are quoted in the document.

PHASE II BEDREST
1976

ACTIVITY PLANNING GUIDE

Revised 7/1/76
Page 1 of 4

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				APRIL 1	2	3
4	5	6	7	8	9	10
11	12	13	14 ←	15 Applicant	16 Testing →	17 →
18 →	19 →	20	21	22 Final Subject Selection Meeting of PI's	23	24
25	26 ←	27	28 1 Trial Diet	29 →	30 1BR-41 1 Blood 1 Radionuclide	MAY 1 1BR-40 1 Blood →

MSC Form 626 (Rev Mar 64) Previous Editions may be used.

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1976

Revised 7/1/76
Page 2 of 4

ACTIVITY PLANNING GUIDE

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
MAY 2 1 BR-39	3 1 BR-38 2 IST	4 1 BR-37 1 IST	5 1 BR-36 2 Trial Diet	6 1 BR-35 2 BR-40	7 1 BR-34 2 BR-39 2 Blood 2 Radionuclide	8 1 BR-33 2 BR-38 2 Blood
9 1 BR-32 2 BR-37	10 1 BR-31 2 BR-36	11 1 BR-30 2 BR-35	12 1 BR-29 2 BR-34	13 1 BR-28 2 BR-33	14 1 BR-27 2 BR-32	15 1 BR-25 2 BR-31
16 1 BR-25 2 BR-30	17 1 BR-24 2 BR-29 1 Ex 1 Vest 1 Blood 1 LBNP	18 1 BR-23 2 BR-28	19 1 BR-22 2 BR-27 1 IST	20 1 BR-21 2 BR-26 1 Start Diet 2 Blood 2 LBNP 2 Ex 2 Vest	21 1 BR-20 2 BR-25 1 Ex 1 Vest 1 LBNP	22 1 BR-19 2 BR-24
23 1 BR-18 2 BR-23	24 1 BR-17 2 BR-22	25 1 BR-16 2 BR-21 2 Start Diet 2 IST	26 1 BR-15 2 BR-20 2 LBNP 2 Vest	27 1 BR-14 2 BR-19 1 LBNP 1 Ex 1 Vest 1 Blood	28 1 BR-13 2 BR-18	29 1 BR-12 2 BR-17
30 1 BR-11 2 BR-16	31 1 BR-10 2 BR-15	JUNE 1 1 BR-9 2 BR-14 1 EEG 2 LBNP 2 Ex 2 Vest 2 Blood	2 1 BR-8 2 BR-13 1 IST 1 EEG	3 1 BR-7 2 BR-12 1 LBNP 1 Ex 1 Vest 1 EEG	4 1 BR-6 2 BR-11 2 IST 1 RBF	5 1 BR-5 2 BR-10

PHASE II BEDREST
1976

Revised 7/1/76

ACTIVITY PLANNING GUIDE

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JUNE 6 1 BR-4 2 BR-9	7 1 BR-3 2 BR-8 1 RBF	8 1 BR-2 2 BR-7 2 LBNP 2 Ex 2 Vest	9 1 BR-1 2 BR-6 1 X-Ray, LBNP 1 Ex, Vest 1 Stereo 2 RBF	10 1 BR+0 2 BR-5 1 Start Bedrest 1 Blood 1 Radionuclide 1 IST 1 EEG	11 1 BR+1 2 BR-4 1 EEG 2 RBF 2 Ex	12 1 BR+2 2 BR-3 1 EEG
13 1 BR+3 2 BR-2	14 1 BR+4 2 BR-1 1 IST, EEG 2 LBNP, Vest 2 Stereo 2 X-Ray	15 1 BR+5 2 BR+0 2 Start Bedrest 2 Blood, IST 2 Radionuclide	16 1 BR+6 2 BR+1	17 1 BR+7 2 BR+2	18 1 BR+8 2 BR+3 1 Blood	19 1 BR+9 2 BR+4
20 1 BR+10 2 BR+5	21 1 BR+11 2 BR+6 1 EEG 1 LBNP 1 Ex	22 1 BR+12 2 BR+7 1 IST 1 RBF 2 PV, Blood 2 LBNP, Ex	23 1 BR+13 2 BR+8 See Table 1 1 PV 1 RCM	24 1 BR+14 2 BR+9 See Table 1	25 1 BR+15 2 BR+10 See Table 1 1 EEG	26 1 BR+16 2 BR+11 2 RBF
27 1 BR+17 2 BR+12 1 EEG	28 1 BR+18 2 BR+13 See Table 2 2 PV 2 RCM	29 1 BR+19 2 BR+14 See Table 2	30 1 BR+20 2 BR+15 See Table 2 1 EEG	JULY 1 1 BR+21 2 BR+16 1 Ex 1 Blood 1 PV 2 IST	2 1 BR+22 2 BR+17 1 LBNP 1 IST	3 1 BR+23 2 BR+18 1 RBF 1 EEG
4 1 BR+24 2 BR+19	5 1 BR+25 2 BR+20 HOLIDAY 1 EEG.	6 1 BR+26 2 BR+21 1 EEG 1 IST 2 Blood, LBNP 2 Ex 2 PV	7 1 BR+27 2 BR+22 1 Ex 1 EEG, LBNP 1 Blood 1 Radionuclide	8 1 R+0 2 BR+23 See Table 3 1 EEG	9 1 R+1 2 BR+24 1 Blood, LBNP 1 Ex, EEG 1 Stereo 1 Vest	10 1 R+2 2 BR+25 1 LBNP 1 Ex, EEG 1 Vest

ACTIVITY PLANNING GUIDE

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JULY 11 1 R+3 2 BR+26 1 IST	12 1 R+4 2 BR+27 1 EEG, IST 2 Blood 2 Radionuclide 2 LBNP 2 IST	13 1 R+5 2 R+0 2 See Table 3 1 EEG	14 1 R+6 2 R+1 1 EEG, Blood 2 Blood, LBNP 2 Ex, Stereo 2 Vest	15 1 R+7 2 R+2 2 LBNP 2 Ex 2 Vest	16 1 R+8 2 R+3 1 LBNP 1 Ex, Vest 2 IST	17 1 R+9 3 R+4
18 1 R+10 2 R+5	19 1 R+11 2 R+6 1 IST 2 Blood	20 1 R+12 2 R+7 2 LBNP 2 Ex 2 Vest	21 1 R+13 2 R+8 1 Radionuclide 1 Blood	22 1 R+14 2 R+9 1 End Diet	23 2 R+10 2 IST	24 2 R+11
25 2 R+12	26 2 R+13 2 Radionuclide 2 Blood	27 2 R+14 2 End Diet 1 Ex	2 R+15	2 R+16	2 R+17 2 Ex	

CROSSOVER STUDY

	DAY 13 (June 23)			DAY 14 (June 24)			DAY 15 (June 25)		
TIME / SUBJECT	1 (HL)	2 (JH)	3 (RT)	1 (HL)	2 (JH)	3 (RT)	1 (HL)	2 (JH)	3 (RT)
6:00	PV	PV	PV	PV	PV	PV	PV	PV	PV
6:15									
6:30	T	Eat	Eat	T	Eat	Eat	T	Eat	Eat
6:45	LBNP			LBNP			LBNP		
7:00									
7:15		T			T			T	
7:30									
7:45	Ex	LBNP		Ex	LBNP		Ex	LBNP	
8:00									
8:15	T		T	T		T	T		T
8:30	Eat			Eat			Eat		
8:45		Ex	LBNP		Ex	LBNP		Ex	LBNP
9:00	Start Rx			Start Rx			Start Rx		
9:15		T			T			T	
9:30		Eat			Eat			Eat	
9:45			Ex			Ex			Ex
10:00		Start Rx			Start Rx			Start Rx	
10:15			T			T			T
10:30			Eat			Eat			Eat
10:45	Saline								
11:00	+		Start Rx	Saline		Start Rx	Nothing		Start Rx
11:15	LBNP								
11:30								Saline	
11:45								+	
12:00		Saline			Nothing			LBNP	
12:15									
12:30	PV			PV			PV		
12:45			Nothing	T		Saline	T		Saline
1:00	T			LBNP		+	LBNP		
1:15	LBNP					LBNP			
1:30		PV			PV			PV	
1:45		T			T				
2:00				Ex	LBNP		Ex	T	
2:15	Ex	LBNP						LBNP	
2:30			PV	T		PV	T		PV
2:45	T		T						T
3:00				Eat	Ex	T	Eat		
3:15	Eat	Ex	LBNP			LBNP		Ex	LBNP
3:30					T				
3:45		T						T	
4:00					Eat				
4:15		Eat	Ex			Ex		Eat	Ex
4:30									
4:45			T			T			T
5:00									
5:15			Eat			Eat			Eat

T = TRANSFER BY STRETCHER

CROSSOVER STUDY

	DAY 13 (June 28)			DAY 14 (June 29)			DAY 15 (June 30)		
TIME / SUBJECT	4 (JM)	5 (MA)	6 (JH)	4 (JM)	5(MA)	6 (JH)	4 (JM)	5 (MA)	6 (JH)
6:00	PV	PV	PV	PV	PV	PV	PV	PV	PV
6:15									
6:30	T	Eat	Eat	T	Eat	Eat	T	Eat	Eat
6:45	LBNP			LBNP			LBNP		
7:00									
7:15		T			T			T	
7:30									
7:45	Ex	LBNP		Ex	LBNP		Ex	LBNP	
8:00									
8:15	T		T	T		T	T		T
8:30	Eat			Eat			Eat		
8:45		Ex	LBNP		Ex	LBNP		Ex	LBNP
9:00	Start Rx			Start Rx			Start Rx		
9:15		T			T			T	
9:30		Eat			Eat			Eat	
9:45			Ex			Ex			Ex
10:00		Start Rx			Start Rx			Start Rx	
10:15			T			T			T
10:30			Eat			Eat			Eat
10:45	Saline								
11:00	+		Start Rx	Saline		Start Rx	Nothing		Start R
11:15	LBNP								
11:30								Saline	
11:45								+	
12:00		Saline			Nothing			LBNP	
12:15									
12:30	PV			PV			PV		
12:45			Nothing	T		Saline	T		Saline
1:00	T			LBNP		+	LBNP		
1:15	LBNP					LBNP			
1:30		PV			PV			PV	
1:45		T			T				
2:00				Ex	LBNP		Ex	T	
2:15	Ex	LBNP						LBNP	
2:30			PV	T		PV	T		PV
2:45	T		T						T
3:00				Eat	Ex	T	Eat		
3:15	Eat	Ex	LBNP			LBNP		Ex	LBNP
3:30					T				
3:45		T						T	
4:00					Eat				
4:15		Eat	Ex			Ex		Eat	Ex
4:30									
4:45			T			T			T
5:00									
5:15			Eat			Eat			Eat

T = TRANSFER BY STRETCHER

November 12, 1976

METHODIST HOSPITAL BEDREST STUDY - PHASE II

Food and Nutritional Support - Final Report

Connie Stadler, R.D.

Individual 6-day menu cycles were designed for each bedrest subject based upon their individual food preferences and the Skylab nutritional constraints. In order to determine food preferences, the subjects consumed an evaluation diet consisting of Skylab food for 6 days approximately 2 or 3 weeks prior to the study. The evaluation diet was designed to allow the subjects to taste each of the available food items 1 or 2 times and to rate each one on a 9-point hedonic scale (Table 1).

Evaluation diets were planned at 2800 calories per day and a variety of additional items were supplied to allow subjects to adjust their caloric intake as needed. The caloric intake of each subject during this period was used along with calculated caloric requirements based upon height, weight and age to determine the caloric level of each individual menu cycle.

The Skylab nutritional constraints are listed in Table 2. Individual menu cycles for each subject are listed in Tables 3-8.

Menu cycles for individual subjects were revised at various times during the study for a number of reasons. In some cases the supply of various food items was exhausted during the study. Because of the repetitious nature of the menus, it was desirable to use as many different food items as possible in menu planning; however, some items were available in much greater supply than others. Since previous experience revealed the inevitability of menu cycle revision during bedrest, it was decided to include items which were not available in sufficient supply to last throughout the study if specific individuals indicated a high preference for them.

In some cases different food lots were used for a given item requiring some menu modification. Each of the Skylab food items was produced in 3 different production lots and nutritional analyses were done on each lot. These 3 lots were used for astronaut evaluation, for Skylab Medical Experiments Altitude Test (SMEAT) and for flight during the Skylab missions. The nutritional profile was not necessarily the same for all test nutrients in each food lot. This was particularly true of sodium since some effort was made to reduce sodium levels in some foods in the flight lot. During the bedrest study when a supply of food in a given lot was exhausted the same item from another lot was used if available, but frequently that necessitated some additional menu adjustments in order to keep nutritional intake of all test nutrients at a constant level.

Individuals developed a dislike for certain items, particularly during the bedrest phase of the study, and it became necessary to revise menus on that account in order to maintain constant nutrient intake levels.

For most of the subjects, caloric intake decreased during bedrest (Table 9). Usually this was accomplished by eliminating high calorie foods available for supplemental snacking, but in some cases rather extensive menu revision was necessary in order to maintain the test nutrients at a constant pre-rest level.

During the period between the menu evaluation and the beginning of the control diet, subjects were instructed to eat some high calcium foods each day in an effort to maintain daily calcium intakes around 800 mg. They were also requested to keep a record of all foods eaten during that period. The primary purpose of the food records was to focus and maintain the attention of the subjects on their food intake so they would remember to include calcium containing foods in their diet. From the food records, it appeared that everyone made an

effort to include some high calcium-containing foods in their diet most of the time. Estimated daily calcium intake before the study averaged between 750 and 1200 mg, however, variation was very large, the estimated range was 200 to 2500 mg calcium. Estimated calcium-to-phosphorus intake ratios during the pre-study period varied from equal amounts of calcium and phosphorus to 1 part of calcium to 4 parts phosphorus.

During the periods of controlled dietary intake, controlled nutrients fell within Skylab constraints for both level of intake and variability (Tables 10-15). Sodium levels were adjusted to a constant level each day by the addition of appropriate levels of table salt, however, the broth caper did impact the variability of sodium intake during the rest and post-rest phases of the study.

TABLE 1

FOOD PREFERENCE RATING SCALE

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like Nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

TABLE 2

Skylab Nutritional Constraints

Calories	-	Based upon individual height, weight, and age
Protein		90 - 125g ± 10g
Calcium		750 - 850mg ± 16mg
Phosphorus		1500 - 1700 ± 120mg
Na		3000 - 6000 ± 500mg (130 - 261 ± 22 mEq)
Mg		300 - 400 ± 100mg (25 - 33 ± 8mEq)
K		>2740mg (>70 mEq)

5-6-76

TABLE 3
SUBJECT 1
BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Sliced Strawberries Scrambled Eggs Rice Krispies Cocoa Coffee	Orange Juice Sugar Coated Cornflakes Coffee	Canadian Bacon in Applesauce Scrambled Eggs Grapefruit Juice Cocoa Coffee
Lunch	Turkey Rice Soup Macaroni & Cheese Buttered Asparagus Soda Crackers Butter Diced Pineapple Lemonade Coffee	Tomato Soup Beef Hash Sliced Strawberries Apple Drink Coffee	Chili Soda Crackers Butter Peach Ambrosia Strawberry Drink Coffee
Dinner	Shrimp Cocktail Roast Beef German Potato Salad Buttered Cream Style Corn Diced Peaches Tea w/Lemon and Sugar Coffee	Diced Veal & Barbecue Buttered Cream Style Corn Buttered Asparagus Vanilla Wafers Tea w/Lemon & Sugar Coffee	Chicken w/Gravy Mashed Potatoes w/Butter Buttered Asparagus Sliced Strawberries Apple Drink Coffee
Lunch	Diced Pears Applesauce Ham & Cheese Crackers Lemonade Apple Drink Coffee X2	Survival Bar Peanut Butter Bread Cherry Drink Tea w/Lemon & Sugar Tea w/Lemon & Sugar Coffee X2	Dried Apricots Dry Roasted Peanuts Diced Pineapple Flake Bar Coffee X2

TABLE 3
SUBJECT 1

5-6-76

BEDREST MENUS - PHASE II (CONTINUED)

DAY	4	5	6
Breakfast	Diced Pears Coffee Cake Chocolate Instant Breakfast Coffee	Applesauce Sausage Chocolate Instant Breakfast Coffee	Diced Pineapple Sausage Sugar Coated Cornflakes Grapefruit Juice Coffee
Lunch	Split Pea Soup Chicken & Rice Soda Crackers Butter Diced Pineapple Apple Drink Coffee	Turkey Rice Soup Pork & Potatoes Buttered Cream Style Corn Soda Crackers Butter Peach Ambrosia w/Pecans Apple Drink Coffee	Split Pea Soup Salmon Salad Soda Crackers Butter Diced Pears Apple Drink Coffee
Dinner	Potato Soup Roast Pork w/Dressing & Gravy Creamed Peas Applesauce Tea w/Lemon & Sugar Coffee	Hot Dogs in Tomato Sauce Macaroni and Cheese Green Beans w/Mushroom Sauce Diced Peaches Tea w/Lemon & Sugar Coffee	Turkey & Gravy Mashed Potatoes w/Butter Stewed Tomatoes Vanilla Ice Cream Sliced Strawberries Strawberry Drink Coffee
Snack	Peanut Butter Bread Tea w/Lemon & Sugar Coffee X2	Vanilla Wafers Cherry Drink Tea w/Lemon & Sugar Tea w/Lemon & Sugar Coffee X2	Dinner Mints Apple Drink Lemonade Lemonade Grapefruit Juice Tea w/Lemon & Sugar Tea w/Lemon & Sugar Coffee X2

TABLE 4
SUBJECT 2

BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Sliced Strawberries Rice Krispies Chocolate Instant Breakfast Coffee	Orange Juice Diced Pears Sugar Coated Cornflakes Coffee	Canadian Bacon in Applesauce Scrambled Eggs Orange Juice Cocoa
Lunch	Chili Soda Crackers Butter Diced Pears Lemonade	Tomato Soup Spaghetti w/Meat Sauce Asparagus Diced Pineapple Lemonade	Shrimp Cocktail Turkey Rice Soup Diced Pineapple Strawberry Drink
Dinner	Roast Beef German Potato Salad Buttered Cream Style Corn Applesauce Tea w/Lemon and Sugar Coffee	Diced Veal and Barbecue German Potato Salad Creamed Peas Diced Peaches Grapefruit Juice Coffee	Chicken Chunks in Gravy Buttered Mashed Potatoes Buttered Asparagus Sliced Strawberries Vanilla Ice Cream Coffee
Snack	Peach Ambrosia Dry Roasted Peanuts Apple Drink Tea w/Lemon & Sugar X2 Coffee	Peanut Butter Bread Peach Ambrosia Sliced Strawberries Coffee Grapefruit Juice	Dry Roasted Peanuts Diced Pears Lemonade Lemonade Lemonade Coffee Coffee

TABLE 4
SUBJECT 2

BEDREST MENUS - PHASE II (CONTINUED)

DAY	4	5	6
Breakfast	Diced Peaches Coffee Cake Butter Chocolate Instant Breakfast Coffee	Diced Pears Chocolate Instant Breakfast Coffee	Orange Juice Diced Pears Sugar Coated Cornflakes Coffee
Lunch	Split Pea Soup Chicken w/Rice Soda Crackers Butter Diced Pineapple Lemonade	Turkey Rice Soup Pork & Potatoes Buttered Cream Style Corn Apple Drink	Split Pea Soup Beef Hash Soda Crackers Butter Diced Peaches Apple Drink
Dinner	Potato Soup Roast Pork w/Dressing & Gravy Buttered Asparagus Applesauce Coffee	Hot Dogs in Tomato Sauce German Potato Salad Green Beans Peach Ambrosia Strawberry Drink Coffee	Shrimp Cocktail Lobster Newburg Pork & Scalloped Potatoes Buttered Asparagus Peach Ambrosia w/Pecans Tea w/Lemon & Sugar Coffee
Snack	Peanut Butter Bread Sliced Strawberries Coffee	Dry Roasted Peanuts Tea w/Lemon & Sugar Tea w/Lemon & Sugar Coffee	Applesauce Diced Pineapple Grapefruit Juice Tea w/Lemon & Sugar X3 Coffee

6-19-76

TABLE 5

SUBJECT 3

BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Sliced Strawberries Rice Krispies Cocoa	Sliced Strawberries Sausage Sugar Coated Cornflakes Orange Juice	Canadian Bacon in Applesauce Chocolate Instant Breakfast Apple Drink
Lunch	Turkey Rice Soup Tuna Salad Spread Buttered Roll Diced Pineapple Orange Drink	Tomato Soup Spaghetti w/Meat Sauce Catsup Diced Pineapple Lemonade	Chili Buttered Roll Diced Peaches Lemonade
Dinner	Shrimp Cocktail Catsup Roast Beef Mashed Potatoes w/Butter Buttered Cream Style Corn Lemon Pudding Strawberry Drink	Diced Veal and Barbecue Catsup German Potato Salad Creamed Peas Diced Pears Lemonade	Turkey w/Gravy Buttered Mashed Potatoes Buttered Asparagus Sliced Strawberries Apple Drink
Snack	Peach Ambrosia Dry Roasted Peanuts Vanilla Wafers Orange Drink	Dried Apricots Peanut Butter Bread Grapefruit Drink Orange Drink	Diced Pears Diced Pineapple Dry Roasted Peanuts Lemon Pudding

TABLE 5

SUBJECT 3

5-11-76

BEDREST MENUS - PHASE II

DAY	4	5	6
Breakfast	Sliced Strawberries Sausage Catsup Coffee Cake Butter Chocolate Instant Breakfast	Diced Peaches Beef Hash Catsup Chocolate Instant Breakfast	Beef Hash Catsup Rice Krispies Coffee Cake Butter Strawberry Drink
Lunch	Split Pea Soup Chicken w/Rice Peach Ambrosia Sugar Cookies Lemonade	Ham Salad Spread Pork & Potatoes w/Butter Buttered Roll Peach Ambrosia w/Pecans Lemonade	Split Pea Soup Salmon Salad Soda Crackers Peach Ambrosia Strawberry Drink
Dinner	Potato Soup Roast Pork w/Dressing & Gravy Buttered Asparagus Applesauce Lemonade	Hot Dogs in Tomato Sauce Buttered Corn Green Beans Diced Pears Vanilla Wafers Tea w/Lemon and Sugar	Chicken Chunks w/Gravy Mashed Potatoes w/Butter Buttered Asparagus Sliced Strawberries Vanilla Ice Cream Strawberry Drink
Snack	Diced Pears Lemonade	Vanilla Wafers Lemonade	Diced Pears Vanilla Wafers

6-24-76

TABLE 6

SUBJECT 4

BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Sliced Strawberries Bacon Bars Scrambled Eggs Grapefruit Drink Cocoa Coffee	Orange Juice Sugar Coated Cornflakes Cocoa Coffee	Canadian Bacon in Applesauce Scrambled Eggs Orange Drink Coffee
Lunch	Split Pea Soup Soda Crackers Butter Macaroni and Cheese Stewed Tomatoes Strawberry Drink	Tomato Soup Beef Hash Sliced Strawberries Orange Drink	Chili Ham and Cheese Crackers Peach Ambrosia Orange Drink
Dinner	Roast Beef Buttered Mashed Potatoes Asparagus Peach Ambrosia Strawberry Drink Coffee	Diced Veal and Barbecue German Potato Salad Creamed Peas Diced Pineapple Strawberry Drink Coffee	Chicken Chunks in Gravy Mashed Potatoes Asparagus Buttered Roll Sliced Strawberries Vanilla Ice Cream Coffee
Snack		Peanut Butter Bread Grapefruit Juice	Dry Roasted Peanuts Coffee

TABLE 6
SUBJECT 4

BEDREST MENUS - PHASE II (CONTINUED)

DAY	4	5	6
Breakfast	Coffee Cake Butter Chocolate Instant Breakfast Coffee	Applesauce Sausage Chocolate Instant Breakfast Coffee	Diced Pineapple Sausage Rice Krispies Cocoa Coffee
Lunch	Split Pea Soup Chicken w/Rice Stewed Tomatoes Peach Ambrosia Tea w/Lemon and Sugar	Turkey Rice Soup Pork and Potatoes Asparagus Peach Ambrosia w/Pecans Orange Drink	Turkey Cubes in Gravy Mashed Potatoes Asparagus Diced Pears Strawberry Drink
Dinner	Shrimp Cocktail Potato Soup Roast Pork w/Dressing & Gravy Corn Lemon Pudding Vanilla Wafers Tea w/Lemon and Sugar Coffee	Hot Dogs in Tomato Sauce Corn Green Beans Diced Peaches Tea w/Lemon and Sugar Coffee	Lobster Newburg Stewed Tomatoes Peach Ambrosia w/Pecans Lemonade Coffee
Snack		Strawberries	Strawberry Drink

TABLE 8

SUBJECT 6

BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Diced Peaches Scrambled Eggs w/Butter Rice Krispies Grapefruit Drink Cocoa Coffee	Dried Apricots Sausage Catsup Sugar Coated Cornflakes Cocoa Orange Juice Coffee	Canadian Bacon in Applesauce Scrambled Eggs w/Butter Cocoa Coffee
Lunch	Chili Buttered Roll Peach Ambrosia Strawberry Drink Coffee	Tomato Soup Spaghetti w/Meat Sauce Buttered Asparagus Diced Pineapple Orange Drink Coffee	Turkey Rice Soup Soda Crackers Pork and Potatoes w/Butter Macaroni and Cheese Peach Ambrosia Strawberry Drink
Dinner	Shrimp Cocktail Roast Beef Catsup Buttered Mashed Sweet Potatoes Buttered Cream Style Corn Sliced Strawberries Coffee	Diced Veal and Barbecue Catsup Creamed Peas Diced Pears Strawberry Drink Coffee	Chicken Chunks in Gravy Buttered Mashed Potatoes Buttered Asparagus Sliced Strawberries Vanilla Ice Cream Lemonade Coffee
Snack	Coffee	Coffee Grapefruit Drink Tea w/Lemon and Sugar	Diced Pineapple Coffee

TABLE 7
SUBJECT 5

BEDREST MENUS - PHASE II

DAY	1	2	3
Breakfast	Sliced Strawberries Bacon Bars Scrambled Eggs Rice Krispies Orange Drink Cocoa Coffee	Sugar Coated Cornflakes Grapefruit Drink Cocoa Coffee	Canadian Bacon in Applesauce Coffee Cake Butter Chocolate Instant Breakfast Coffee
Lunch	Split Pea Soup Chicken w/Rice Stewed Tomatoes Diced Pineapple Lemonade	Tomato Soup Spaghetti w/Meat Sauce Cream Style Corn Lemonade	Chili Buttered Roll Buttered Corn Peach Ambrosia Tea w/Lemon and Sugar
Dinner	Roast Beef Mashed Sweet Potatoes Buttered Asparagus Lemon Pudding Strawberry Drink Coffee	Diced Veal and Barbecue German Potato Salad Creamed Peas Diced Peaches Strawberry Drink Coffee	Chicken w/Gravy Buttered Mashed Potatoes Buttered Asparagus Diced Peaches Tea w/Lemon and Sugar Coffee
Snack	Lemonade Coffee	Peanut Butter Bread Orange Drink Orange Juice	Applesauce Vanilla Wafers Dry Roasted Peanuts Coffee Tea w/Lemon and Sugar

TABLE 7
SUBJECT 5

BEDREST MENUS - PHASE II (CONTINUED)

DAY	4	5	6
Breakfast	Sausage Catsup Rice Krispies Orange Drink Cocoa Coffee	Applesauce Beef Hash Rice Krispies Grapefruit Juice Cocoa Coffee	Coffee Cake Butter Rice Krispies Grapefruit Juice Coffee
Lunch	Potato Soup Tuna Salad Spread Buttered Roll Diced Peaches Strawberry Drink	Turkey Rice Soup Pork & Potatoes w/Butter Buttered Asparagus Sliced Strawberries Lemonade	Split Pea Soup Salmon Salad Soda Crackers Peach Ambrosia Lemonade
Dinner	Shrimp Cocktail Catsup Roast Pork w/Dressing and Gravy Stewed Tomatoes Buttered Cream Style Corn Applesauce Vanilla Wafers Coffee	Hot Dogs in Tomato Sauce Macaroni and Cheese w/Butter Green Beans Diced Pineapple Orange Drink Coffee	Shrimp Cocktail Catsup Turkey w/Gravy Buttered Mashed Potatoes Stewed Tomatoes Sliced Strawberries Vanilla Ice Cream Lemonade Coffee
Snack	Cheese Crackers Coffee	Lemonade	Lemon Pudding Diced Pears

5-17-76

TABLE 8

SUBJECT 6

BEDREST MENUS - PHASE II

DAY	4	5	6
Breakfast	Diced Peaches Coffee Cake Butter Chocolate Instant Breakfast Orange Drink Coffee	Applesauce Beef Hash Catsup Chocolate Instant Breakfast Coffee	Diced Pineapple Sausage Catsup Rice Krispies Coffee
Lunch	Diced Turkey w/Gravy Buttered Mashed Potatoes Buttered Asparagus Diced Pineapple Lemonade Coffee	Potato Soup Ham Sandwich Spread Buttered Roll Diced Peaches Coffee	Split Pea Soup Salmon Salad Soda Crackers Butter Sliced Strawberries Strawberry Drink Coffee
Dinner	Roast Pork w/Dressing & Gravy Buttered Cream Style Corn Applesauce Lemon Pudding Tea w/Lemon and Sugar Coffee	Hot Dogs in Tomato Sauce Macaroni and Cheese Green Beans Diced Pears Tea w/Lemon and Sugar Coffee	Lobster Newburg Chicken w/Rice Stewed Tomatoes Diced Peaches Strawberry Drink Coffee
Snack	Coffee	Coffee	Applesauce Lemon Pudding Tea w/Lemon and Sugar Coffee

TABLE 9

Mean Daily Calorie Consumption

Subject	Pre	Bedrest	Post	Overall	Planned
1	3600 ± 261	2881 ± 435	2887 ± 480	3122 ± 519	2950
2	2851 ± 290	2839 ± 305	2781 ± 206	2830 ± 278	2850
3	3769 ± 237	3632 ± 226	3582 ± 311	3666 ± 258	2900
4	3122 ± 258	2717 ± 236	2775 ± 243	2865 ± 304	2550
5	3175 ± 176	3308 ± 225	3113 ± 194	3221 ± 216	2800
6	2788 ± 112	2769 ± 167	2672 ± 182	2754 ± 159	2600

TABLE 10

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 1

	Pre	Bedrest	Post	Overall	12 Day Food Record
Calories	3600 ± 261	2881 ± 435	2887 ± 480	3122 ± 519	2270 ± 860
Water (ml)	6371 ± 773	5092 ± 849	4804 ± 1110	5454 ± 1097	
Protein(g)	106 ± 4	105 ± 3	104 ± 5	105 ± 4	114 ± 50
Calcium(mg)	834 ± 12	830 ± 12	818 ± 39	829 ± 22	1340 ± 610
Phosphorus(mg)	1735 ± 80	1708 ± 83	1703 ± 73	1716 ± 80	2025 ± 615
Sodium(mEq)	279 ± 15	275 ± 51	271 ± 50	275 ± 42	175 ± 130
Magnesium(mEq)	32 ± 4	32 ± 5	32 ± 4	32 ± 4	
Potassium(mEq)	108 ± 13	102 ± 11	104 ± 12	105 ± 12	80 ± 20

TABLE 11

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 2

	Pre	Bedrest	Post	Overall
Calories	2851 ± 290	2839 ± 305	2781 ± 206	2830 ± 278
Water(ml)	2494 ± 424	2271 ± 439	2271 ± 464	2345 ± 445
Protein(g)	96 ± 2	97 ± 3	97 ± 3	96 ± 3
Calcium(mg)	791 ± 10	791 ± 14	789 ± 9	790 ± 12
Phosphorus(mg)	1513 ± 84	1517 ± 92	1515 ± 91	1515 ± 87
Sodium(mEq)	230 ± 19	242 ± 50	238 ± 55	237 ± 43
Magnesium(mEq)	30 ± 4	30 ± 5	30 ± 4	30 ± 4
Potassium(mEq)	88 ± 7	88 ± 6	90 ± 5	89 ± 6

TABLE 12

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 3

	Pre	Bedrest	Post	Overall
Calories	3769 ± 237	3632 ± 226	3582 ± 311	3666 ± 258
Water(ml)	3321 ± 697	2972 ± 463	3378 ± 728	3179 ± 629
Protein(g)	107 ± 5	106 ± 11	107 ± 4	107 ± 11
Calcium(mg)	784 ± 25	778 ± 9	779 ± 12	780 ± 17
Phosphorus(mg)	1747 ± 49	1728 ± 81	1729 ± 67	1734 ± 68
Sodium(mEq)	268 ± 18	282 ± 45	278 ± 56	276 ± 41
Magnesium(mEq)	32 ± 2	30 ± 4	30 ± 4	31 ± 3
Potassium(mEq)	104 ± 14	101 ± 11	101 ± 8	102 ± 12

TABLE 13

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 4

	Pre	Bedrest	Post	Overall
Calories	3122 ± 258	2717 ± 236	2775 ± 243	2865 ± 304
Water(ml)	3147 ± 512	2874 ± 471	3290 ± 560	3058 ± 526
Protein(g)	101 ± 4	100 ± 3	99 ± 2	100 ± 3
Calcium(mg)	820 ± 17	821 ± 12	826 ± 9	821 ± 14
Phosphorus(mg)	1699 ± 99	1677 ± 85	1694 ± 76	1688 ± 87
Sodium(mEq)	258 ± 19	267 ± 41	270 ± 40	265 ± 35
Magnesium(mEq)	29 ± 3	29 ± 3	29 ± 3	29 ± 3
Potassium(mEq)	102 ± 9	102 ± 9	102 ± 9	104 ± 9

TABLE 14

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 5

	Pre[a]	Bedrest	Post	Overall
Calories	3175 ± 176	3308 ± 225	3113 ± 194	3221 ± 216
Water(ml)	3235 ± 270	3733 ± 719	3728 ± 642	3571 ± 628
Protein(g)	105 ± 5	105 ± 5	104 ± 4	105 ± 5
Calcium(mg)	814 ± 20	813 ± 22	811 ± 9	813 ± 19
Phosphorus(mg)	1775 ± 77	1757 ± 84	1742 ± 83	1759 ± 81
Sodium(mEq)	277 ± 16	300 ± 55	290 ± 51	290 ± 45
Magnesium(mEq)	28 ± 2	30 ± 4	30 ± 5	29 ± 4
Potassium(mEq)	111 ± 9	113 ± 0	110 ± 8	112 ± 9

[a]Food Intake record not received for the last day of the preflight phase for this subject.

TABLE 15

Mean Nutrient Intake-Bedrest Study-Phase II
Subject 6

	Pre	Bedrest	Post	Overall	15 Day Food Record
Calories	2788 ± 112	2769 ± 167	2672 ± 182	2754 ± 159	1540 ± 400
Water(ml)	2936 ± 418	3167 ± 403	3237 ± 493	3105 ± 440	
Protein(g)	97 ± 3	98 ± 3	97 ± 3	97 ± 3	68 ± 20
Calcium(mg)	799 ± 5	804 ± 8	800 ± 15	801 ± 10	845 ± 282
Phosphorus(mg)	1671 ± 37	1662 ± 38	1651 ± 47	1662 ± 40	1063 ± 258
Sodium(mEq)	262 ± 16	271 ± 49	263 ± 49	266 ± 40	70 ± 30
Magnesium(mEq)	27 ± 3	29 ± 3	28 ± 3	28 ± 3	
Potassium(mEq)	106 ± 16	103 ± 11	102 ± 11	104 ± 13	65 ± 13

BAYLOR BEDREST PHASE II

Biochemical Results

Carolyn S. Leach and Martha T. Troell

The utilization of bedrest as a comparison to weightlessness in spaceflight has been frequent in the past. This 28 day bedrest study was to compare observed electrolyte and hormonal changes to those seen in 28 days of spaceflight.[1]

Experimental Protocol and Methods

Each of the six subjects established his baseline data during the twenty-one day prebedrest period. Twenty-four hour urine collections began at this time and continued throughout bedrest and for 14 days after arising. Bedrest days 13, 14 and 15 were termed crossover days. Each subject was treated with a regime of either saline, saline during by lower body negative pressure (LBNP) or no treatment on each of the three days. Urine data charts, Tables II and III, reflect the order of these treatments for each subject. The purpose of such a protocol was to ascertain the effect of saline and LBNP or saline alone on a subject's ability to with stand an orthostatic stress (LBNP) during and after bedrest. Saline was administered in the form of bouillon cubes dissolved in water. Free amino acid and electrolyte analysis of the bouillon were conducted. Routine biochemical parameters were measured by methods normally used in a clinical laboratory. Other methods required for further testing included radioimmunoassay and spectrofluorometry. Urinary biochemical parameters are as follows: volume, specific gravity, osmolality, sodium, potassium, chloride, calcium,

magnesium, inorganic phosphate, uric acid, creatinine, cortisol, aldosterone and antidiuretic hormone (ADH).

A fasting blood sample was drawn on each subject at 7am at 25 and 14 days prior to bedrest, and on the day that bedrest began. Sampling during the bedrest period was on day 8, 13, 14, 15, 21 and 27. Ionized calcium was determined at R+0; all blood testing was carried out on Recovery days 1, 6, and 13. Tests performed on plasma were angiotensin I, aldosterone, cortisol, insulin, growth hormone (HGH), triiodothyronine (T3) and thyroxine (T4). Serum was assayed for glucose, cholesterol, SGOT, SGPT, BUN, uric acid, alkaline phosphatase, calcium, magnesium, inorganic phosphate, total bilirubin, creatinine, CPK, LDH, osmolality, sodium, potassium, chloride, triglycerides, and ionized calcium.

Feces was collected throughout the study, weighed, lyophilized and delivered for analysis.

A daily diet of spaceflight food was given to the subjects who were instructed to consume it all. Thereby, it was known the exact intake of food constituents for each subject. This record was kept along with fluid intake and daily body weights.

Results

Table I gives the free amino acid and electrolyte analysis of the bouillon supplement. Tables II and III show daily urinary endocrine and biochemical results with the mean for each period of the study. Percent change from the baseline to the mean of bedrest and to recovery

was calculated. Urinary cortisol, aldosterone, and ADH were elevated during bedrest; the recovery data show a continued elevation of ADH in all subjects, increased cortisol in 4 of 6 whereas aldosterone was increased in 3 subjects and decreased in 3. Osmolality decreases were observed in bed, while recovery data is variable. Increases were detected in the urinary assays of sodium, potassium, chloride, calcium, phosphorus, magnesium, uric acid, creatinine and volume measurement. Those differences significant at the 0.05 level or less are indicated on Table IV.

Table Va lists the mean values for each treatment near the crossover period. Table Vb summarized the effect of the crossover protocol on several urinary parameters. These data were analyzed for all 5 subjects in the same treatment sequence. Generally, significant changes ($p \leq .05$) were seen between the 6 day precrossover mean and the saline, LBNP treatment and between the precrossover mean and saline protocol.

Plasma and serum results are listed in Table VI and VII. Statistically significant differences ($p \leq .05$) between prebedrest means and some bedrest draws and between prebedrest and recovery data are indicated on Table VIII.

To summarize the results of percent change calculations, decreases during bedrest include glucose, SGOT, calcium, magnesium, CPK, LDH, osmolality, sodium, potassium, chloride and ionized calcium. Cholesterol, SGPT, BUN, and phosphate are elevated, while uric acid, alkaline phosphatase, bilirubin, and creatinine results were variable. The recovery

phase showed elevated glucose, uric acid, alkaline phosphatase, phosphate and triglycerides, cholesterol was up at R+1 and variable thereafter. Decreases were observed for calcium, magnesium, osmolality, sodium, potassium, chloride and ionized calcium. BUN was still down at R+1 and variable thereafter. Data are variable after bedrest for SGOT, SGPT, bilirubin, creatinine, CPK and LDH.

There were no significant changes in the subjects' bodyweight during bedrest or recovery.

DISCUSSION

Several bedrest studies of one month duration have been conducted. However, biochemical and endocrine studies have not been given emphasis except in the calcium area. It remains to study these changes in a protocol more realistic to actual space flight mission activities. This study was conducted to simulate a 28 day space flight without significant exercise. The biochemical findings are discussed in relation to Skylab 2 findings.[1]

This study extends the calcium metabolism investigations of previous studies by the addition of ionized calcium measurement. These subjects all showed decreased ionized calcium 3-7% during bedrest. These findings occur at the same time that total serum calcium decreased and phosphorus increased. All six subjects increased the urinary excretion of calcium and phosphorus during bedrest. Because of the difficulty in measuring ionized calcium it has not often been considered. Heath and colleagues in 1972 reported abnormal elevations of serum ionized calcium during bedrest in all four subjects while serum total calcium remained normal;

however, this study was for 12 days.[2] The bedrest period in our study was twice the duration of Heath's study, we believe that this accounts for the decreases we observed. Schneider has found decreases in total serum calcium and increases in serum phosphorus in bedrest of durations longer than 1 month.[3] The pathogenesis of these changes remains obscure however the finding of decreased total and ionized calcium in the bedrest concomitant with increased phosphorus level and urinary loss of Ca suggests a more renal-parathyroid involvement in the calcium loss than previously considered.

It has been demonstrated that exposure to weightlessness results in a redistribution of the volume of blood within the vascular system. This redistribution is interpreted as an increase in blood volume by stretch receptors in the left atrium, thus causing a compensatory loss in water, sodium and potassium from the renal tubules. This loss in water has been manifested after every space flight as a loss in body weight, most of which is rapidly regained on the first post-bedrest day. It should be pointed out, however, that some of this body weight loss is not regained and is thought to be comprised of both fat and proteinaceous material. The decreased adiposity has been attributable to a hypocaloric food intake, while the loss in the elemental constituents of the musculoskeletal system appears to be a more direct consequence of reduced compressional and tensile forces.

Skylab 2 crewmen showed mean weight losses of 12.5 pounds. Body weight changes are not characteristic of bedrest, in fact, care must

be taken to prevent weight gain during the bedrest phase. The subjects in this study did not lose weight. A comparison of urine volume and sodium excretion in the Skylab II crewmen and the 6 subjects of this bedrest shows sodium excretion elevated in both groups about the same from control values. The differences in the magnitude of the sodium changes appear in days 2-7 in Skylab. This is the same period when the intake was generally decreased in those crewmen. Twenty-four hour urine volumes are elevated the first two days of bedrest, but not in space flight. With the exception of this initial period, subsequent 24 hour urine volumes were not significantly different from those obtained pre- and post-bedrest.

Urinary ADH showed an overall elevation on 4 out of the first 5 days in bedrest. It was decreased on day 3.

The concentration of serum sodium was not altered with four weeks of bedrest in spite of the additional regimes of saline therapy. The bedrest subjects showed slight decreases from prebedrest means and post-bedrest. Serum potassium was slightly decreased in all 6 subjects. The magnitude of the potassium decrease was about the same as observed in the Skylab II crewmen. Urinary potassium was elevated in bedrest. Again, these results compare favorably in direction if not in magnitude to the Skylab results. The rigid adherence to the control diet during all phases of the study adds to the significance of the loss in both sodium and potassium.

The negative sodium and potassium balances have been accompanied by increased aldosterone excretion in space flight crewmen. An overall

increase in aldosterone was observed during this bedrest study which we have reported previously when it was shown to be elevated in bedrest subjects on controlled diet and no medication for 2 weeks.[4] The magnitude of this increase, however, is not as great as that (84%) shown during the first two weeks on the Skylab flights. This finding of a slight increase in 6 subjects confirms our previous 2 week bedrest study results.

Plasma aldosterone and renin activity were variable as with space flight but were generally decreased early then increased.

Blood urea nitrogen has been decreased following space flight. It was very slightly increased until the end of the bedrest period. Urinary creatinine was not altered during or post-bedrest and plasma creatinine was not effected by the bedrest. These results are comparable to other bedrest findings.

Uric acid excretion was generally increased in all subjects during this bedrest. This is unlike space flight where the excretion of uric acid was decreased. Plasma levels were not significantly changed with bedrest. Following space flight serum uric acid has generally been found to be decreased.

Adrenal cortical hormones have been of significant concern since early space flight. The findings during and following bedrest have been variable. This study showed overall increases in urinary cortisol with slight decreases post-bedrest in plasma cortisol.

To examine the reported decreases of plasma glucose with bedrest, insulin, growth hormone and glucose were measured before and following

bedrest.[5] Glucose was decreased in 4 of the 6 subjects during bedrest and insulin was slightly elevated. Human growth hormone was more variable but generally decreases from pre-values were observed.

Cholesterol was also variable but were generally increased. This study did not show the decreased cholesterol which has been observed following space flight for as long as 3 weeks. However, 5 of the subjects did show slight increases in thyroxine and triiodothyronine during bedrest. Skylab results also showed increased thyroxine after space flight.

Alkaline phosphatase was increased in 5 out of 6 subjects after 2 weeks of bedrest. This enzyme has shown variable results after bedrest and has not been changed due to space flight. The role of alkaline phosphatase in calcium metabolism would support the elevation of this enzyme in light of the increased calcium and phosphorus excretion. Following Apollo flights alkaline phosphatase was slightly increased; however, it was slightly though not significantly decreased following Skylab.[6][7]

Creatinine phospokinase (CPK) and lactic dehydrogenase (LDH) were decreased during this bedrest study. After Skylab, CPK was generally increased during the recovery phase. The finding of this study were more variable. Both the CPK and LDH results are intepreted to be related to decreased muscle activity during bedrest and an increase during the post phase.

Significant biochemical changes have occurred during and after 4 weeks of absolute bedrest. Most of these changes are similar in direction if not magnitude of those observed during and post flight on the Skylab crewmen after one month in space.

The cross over part of the study was undertaken to define more clearly fluid and electrolyte dynamics in bedrest subjects exposed to LBNP (lower body negative pressure) and saline ingestion as a possible countermeasure to the orthostatic intolerance caused by supine bedrest. Five of the subjects were studied after 13 days of absolute bedrest. They consumed a metabolic balance diet which included 260 $\pm$ 27 mEq per day sodium. Complete 24 hour urine collections were accomplished. When the results of the pre countermeasure bedrest days are compared to the days when the subjects were given an additional liter of saline (182 mEq/l), significant increases ($p \leq .001$) were observed in 24 hour urine volume and in the excretion of sodium and chloride. Urinary excretion of aldosterone was decreased ($p \leq .05$). When these same subjects were given a liter of saline (182 mEq/l) during 4 hours of -30 mm Hg LBNP, significant increases ($p \leq .001$) were observed in urine volume and the urinary excretion of sodium, chloride, aldosterone and cortisol. It is believed that the shifting of fluid and electrolytes from the vascular space with LBNP resulted in a decreased effective blood volume which was detected via the kidney and aldosterone was stimulated. Aldosterone together with cortisol initiated renal mechanisms to conserve salt and water, thereby increasing effective

blood volume. This type of protocol could counteract orthostatic changes caused by bedrest or space flight as well as provide basic information regarding fluid and electrolyte changes in the space environment.

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TABLE I

BOUILLON FREE AMINO ACID ANALYSIS

mg/liter

Acidic and Neutral Amino Acids	$\bar{x}$ of 3 Samples	± SD
phosphoserine	7.82	0.26
phosphoethanolamine	12.63	1.01
taurine	20.27	1.84
urea	88.02	7.24
hydroxyproline	8.34	0.52
aspartic acid	34.39	4.21
threonine	21.20	2.88
serine	79.40	4.25
asparagine/glutamine	12.70	0.76
sarcosine	12.77	2.43
proline	35.23	2.90
glutamic acid	202.84	7.24
glycine	15.97	1.34
alanine	26.45	1.91
valine/cystine	20.74	1.12
cystathinonine	2.58	0.06
methionine	4.53	0.66
isoleucine	13.57	0.29
leucine	26.16	0.63
tyrosine	9.46	0.43
phenylalanine	19.08	1.23
β-aminoisobutyric acid	0.85	0.12
mg	625.00	23.91

Basic Amino Acids	$\bar{x}$ of 3 Samples	± SD
γ-aminobutyric acid	0.65	0.26
ornithine	0.37	0.13
ammonia	1.93	0.32
lysine	24.68	0.04
histidine	7.71	0.45
creatinine	10.70	0.19
arginine	47.18	2.14
mg	93.23	1.9[illegible]

Total AA 718.22±23.86mg/l

Electrolyte Analysis Results

	mEq/l
Sodium	181.5±0
Potassium	1.4±0
Chloride	179.0±2
Calcium	1.2±0
Magnesium	0.7±0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 1

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-20-76	3960	51.5	14.3	8.7
5-21-76	3660	91.5	15.9	14.6
5-22-76	2930	73.3	23.1	7.0
5-23-76	1920	52.8	42.7	6.4
5-24-76	5500	79.8	45.2	2.7
5-25-76	4740	52.1	21.4	4.0
5-26-76	4770	85.9	19.9	5.0
5-27-76	2375	61.8	18.5	9.8
5-28-76	3650	38.3	18.7	4.6
5-29-76	2890	65.0	27.7	7.5
5-30-76	3860	38.6	31.7	9.5
5-31-76	5200	39.0	31.5	2.8
6-1-76	4910	46.7	9.5	3.3
6-2-76	4660	69.9	16.5	10.6
6-3-76	3260	66.8	13.8	15.0
6-4-76	3760	77.1	12.5	17.6
6-5-76	4460	89.2	19.6	7.1
6-6-76	4440	91.0	21.9	26.6
6-7-76	5600	109.2	25.6	28.3
6-8-76	3640	101.9	17.5	19.4
6-9-76	2200	77.0	14.6	7.9
MEAN±SD		69.4±27.0	22.0±9.0	10.4±7.0

SUBJECT 1

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-10-76	4100	131.5	22.2	13.3
6-11-76	3050	183.0	19.1	13.4
6-12-76	3630	130.7	26.5	29.0
6-13-76	3060	122.4	32.6	31.0
6-14-76	2840	89.5	31.2	28.7
6-15-76	3040	159.6	55.8	23.5
6-16-76	4400	149.6	29.9	13.2
6-17-76	3680	127.0	26.1	31.4
6-18-76	3860	86.9	32.6	19.5
6-19-76	2840	80.9	22.7	19.7
6-20-76	4760	76.2	26.4	13.0
6-21-76	3580	164.7	25.0	7.2
6-22-76	3825	86.1	17.5	5.6
6-23-76 ***	4790	153.3	38.3	8.6
6-24-76 **	4540	154.4	33.1	10.9
6-25-76 *	2940	119.1	24.8	7.6
6-26-76	4190	71.2	28.9	10.3
6-27-76	5080	58.4	24.4	6.4
6-28-76	3560	103.2	29.3	18.5
6-29-76	2640	72.6	22.0	19.0
6-30-76	3040	94.2	26.3	19.9
7-1-76	2390	108.8	28.8	21.3

*Nothing
**Saline
***Saline+LBNP

SUBJECT 1

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-2-76	2980	120.7	41.0	23.9
7-3-76	3300	80.0	15.9	22.9
7-4-76	2600	44.2	18.6	21.1
7-5-76	3160	47.4	23.3	29.5
7-6-76	5550	61.1	16.1	12.6
7-7-76	5110	69.0	24.5	13.6
MEAN±SD		105.2±38.0	27.2±8.0	17.7±8.0
7-8-76	2900	26.1	44.0	30.1
7-9-76	2680	45.6	31.9	16.8
7-10-76	3220	74.1	20.8	17.6
7-11-76	2400	114.0	16.4	13.4
7-12-76	3030	63.6	13.7	10.7
7-13-76	4470	109.5	22.8	20.9
7-14-76	2025	91.1	20.8	36.5
7-15-76	2450	118.8	29.1	44.0
7-16-76	2020	91.9	23.7	22.1
7-17-76	2050	158.9	26.1	27.4
7-18-76	3040	141.4	37.7	34.5
7-19-76	2900	108.8	24.6	3.9
7-20-76	3050	86.9	23.0	25.2
7-21-76	1340	95.7	20.1	28.3
MEAN±SD		94.7±35.0	25.3±8.0	23.7±11.0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 2

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-20-76	300	9.2	3.4	4.0
5-21-76	1100	25.9	8.8	18.3
5-22-76	530	20.4	5.4	10.2
5-23-76	670	31.2	6.8	8.5
5-24-76	840	47.5	7.3	13.8
5-25-76	1040	38.5	9.3	18.8
5-26-76	1020	35.2	8.2	12.5
5-27-76	1240	47.7	10.2	12.1
5-28-76	595	33.9	10.2	8.4
5-29-76	730	31.0	8.4	15.7
5-30-76	500	19.8	10.5	9.9
5-31-76	920	33.6	9.4	15.4
6-1-76	860	45.2	6.6	9.5
6-2-76	900	44.1	8.8	7.7
6-3-76	560	30.8	6.9	34.0
6-4-76	450	38.3	5.5	14.1
6-5-76	500	42.5	8.6	7.6
6-6-76	590	33.6	5.6	15.6
6-7-76	440	29.7	3.1	27.3
6-8-76	730	74.8	8.8	10.3
6-9-76	720	50.4	7.4	22.6
MEAN±SD		36.3±13.0	7.6±2.0	14.1±7.0
6-10-76	1030	51.5	6.5	18.6

SUBJECT 2

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-11-76	1150	79.9	6.6	27.0
6-12-76	1120	44.8	5.0	33.8
6-13-76	910	30.5	11.0	27.5
6-14-76	885	48.7	9.1	21.2
6-15-76	1060	39.2	10.5	32.0
6-16-76	710	40.8	6.7	11.0
6-17-76	1190	58.9	8.2	20.5
6-18-76	1230	51.7	9.5	24.6
6-19-76	1220	39.0	9.0	27.5
6-20-76	1880	64.9	9.9	26.9
6-21-76	1020	57.6	8.6	17.7
6-22-76	1860	72.5	8.3	27.3
6-23-76**	1580	76.6	7.5	32.8
6-24-76*	2140	107.0	11.6	23.7
6-25-76***	1320	62.7	11.4	25.5
6-26-76	1640	70.5	6.4	22.9
6-27-76	1310	57.6	7.8	28.7
6-28-76	915	29.3	5.2	39.0

*Nothing
**Saline
***Saline+LBNP

SUBJECT 2

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-29-76	1140	34.2	7.7	66.9
6-30-76	1230	40.6	8.8	55.8
7-1-76	11-5	54.2	8.6	26.5
7-2-76	1200	54.6	11.1	35.2
7-3-76	820	31.2	6.3	20.9
7-4-76	1150	47.7	9.3	32.3
7-5-76	1140	27.9	9.5	38.8
7-6-76	1500	48.0	8.1	34.0
7-7-76	1000	32.0	7.9	28.1
MEAN±SD		51.9±18.0	8.4±2.0	29.5±6.0
7-8-76	900	42.3	10.4	31.2
7-9-76	940	28.2	5.3	35.3
7-10-76	620	22.9	3.9	30.3
7-11-76	550	38.5	3.2	14.8
7-12-76	560	16.8	4.8	12.6
7-13-76	560	38.1	13.0	17.4
7-14-76	510	31.1	6.7	9.9
7-15-76	1040	25.5	4.6	23.5
7-16-76	550	27.5	6.9	19.9
7-17-76	640	70.4	5.9	16.3
7-18-76	460	32.2	8.5	10.2
7-19-76	730	38.3	6.7	17.2

SUBJECT 2

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-20-76	700	37.5	3.2	14.6
7-21-76	820	44.1	5.9	23.7
MEAN±SD		35.2±13.0	6.4±3.0	19.8±8.0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 3

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-20-76	1020	24.0	11.3	24.5
5-21-76	1200	54.0	15.5	20.8
5-22-76	1080	37.3	10.5	18.0
5-23-76	830	63.9	16.2	9.6
5-24-76	960	48.0	15.8	21.6
5-25-76	1060	58.8	15.5	15.9
5-26-76	895	60.4	13.1	21.6
5-27-76	1060	42.9	9.8	13.9
5-28-76	1520	45.6	13.1	14.9
5-29-76	1900	51.3	14.0	16.8
5-30-76	1430	40.8	14.8	20.0
5-31-76	1390	22.9	14.7	14.1
6-1-76	1880	74.3	12.9	21.5
6-2-76	1480	66.6	9.3	14.7
6-3-76	680	47.6	6.3	18.0
6-4-76	1380	79.6	24.2	31.3
6-5-76	1030	59.2	16.3	18.6
6-6-76	500	62.5	12.6	7.1
6-7-76	650	34.1	11.2	10.3
6-8-76	830	45.2	7.8	30.3
6-9-76	790	31.6	5.0	20.1
MEAN±SD		50.0±15.0	12.9±4.0	18.3±6.0
6-10-76	2120	130.4	8.0	32.4

SUBJECT 3

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-11-76	1860	67.0	8.1	31.0
6-12-76	1760	42.4	12.0	41.0
6-13-76	2150	84.9	21.3	55.8
6-14-76	1560	56.2	24.6	35.4
6-15-76	1755	48.3	28.6	41.0
6-16-76	1440	93.6	12.0	22.0
6-17-76	1520	70.7	13.5	44.4
6-18-76	1190	41.7	13.5	21.3
6-19-76	1340	60.3	12.2	23.1
6-20-76	1980	41.6	16.2	26.4
6-21-76	1500	60.8	12.4	21.0
6-22-76	1860	27.0	8.8	21.3
6-23-76 *	2100	66.7	20.3	17.5
6-24-76 ***	2980	79.0	20.0	21.1
6-25-76 **	2380	27.4	9.5	18.8
6-26-76	3100	77.5	18.8	26.5
6-27-76	1400	39.9	11.8	13.4
6-28-76	1700	21.3	15.2	33.9

*Nothing
**Saline
***Saline+LBNP

SUBJECT 3

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-29-76	2095	33.5	20.0	35.7
6-30-76	2210	34.3	12.7	17.6
7-1-76	3100	54.3	27.8	39.3
7-2-76	1640	36.9	17.0	27.3
7-3-76	2550	51.0	20.4	34.0
7-4-76	1380	18.6	6.4	20.2
7-5-76	2700	55.4	25.8	41.4
7-6-76	2000	34.0	7.2	19.7
7-7-76	2460	46.7	5.6	31.5
MEAN±SD		53.6±25.0	15.3±7.0	29.1±10.0
7-8-76	1810	32.6	16.7	21.8
7-9-76	1140	13.7	5.6	12.5
7-10-76	1360	25.8	10.4	19.1
7-11-76	1200	27.0	9.9	18.4
7-12-76	760	29.3	5.9	12.8
7-13-76	760	31.9	19.2	23.5
7-14-76	505	42.2	16.4	9.9
7-15-76	880	73.5	13.3	13.6
7-16-76	1060	39.2	5.5	24.1
7-17-76	660	46.2	5.9	14.7
7-18-76	690	35.2	6.8	12.9

SUBJECT 3

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-19-76	560	33.6	6.7	17.4
7-20-76	780	35.6	6.0	24.4
7-21-76	800	33.2	4.5	33.3
MEAN±SD		35.6±13.0	9.5±5.0	18.5±6.0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 4

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-25-76	1200	46.2	5.7	12.2
5-26-76	1700	36.6	7.3	19.9
5-27-76	1940	44.6	7.1	12.5
5-28-76	1230	44.3	7.1	19.0
5-29-76	1150	34.5	7.1	13.6
5-30-76	1210	32.7	7.8	7.7
5-31-76	1890	55.8	8.5	10.8
6-1-76	2560	28.2	12.3	14.5
6-2-76	2120	47.1	9.1	16.4
6-3-76	1450	58.0	8.7	14.4
6-4-76	2160	48.6	10.3	11.8
6-5-76	1580	30.8	9.8	12.4
6-6-76	1700	40.8	10.8	15.8
6-7-76	2235	73.8	14.0	10.6
6-8-76	1940	41.7	10.0	32.3
6-9-76	1500	45.0	6.4	24.0
6-10-76	1380	51.1	8.6	21.2
6-11-76	1500	45.8	7.8	32.0
6-12-76	960	49.0	9.5	14.1
6-13-76	690	20.7	5.7	11.5
6-14-76	1600	74.4	7.6	22.5
MEAN±SD		45.2±13.0	8.6±2.0	16.6±7.0
6-15-76	1940	28.1	5.8	16.3

SUBJECT 4

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-16-76	1600	58.4	8.9	14.6
6-17-76	2320	34.8	11.1	34.1
6-18-76	1660	28.2	9.5	20.4
6-19-76	1840	39.6	9.4	21.2
6-20-76	2160	36.7	8.9	22.5
6-21-76	1980	30.7	11.5	19.5
6-22-76	2100	71.4	11.2	24.1
6-23-76	1750	70.9	13.2	21.5
6-24-76	2180	69.8	15.4	21.2
6-25-76	2150	59.1	12.7	13.7
6-26-76	2030	58.9	11.5	18.1
6-27-76	1420	61.8	10.6	17.1
6-28-76 ***	2660	81.1	15.2	33.6
6-29-76**	2750	33.0	1.2	23.6
6-30-76*	2560	35.8	2.6	25.0
7-1-76	2145	23.6	6.7	21.7
7-2-76	1810	41.6	9.8	15.5
7-3-76	1390	29.9	5.9	19.5
7-4-76	3120	57.7	6.4	22.5

*Nothing
**Saline
***Saline+LBNP

SUBJECT 4

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-5-76	1800	45.0	15.0	24.0
7-6-76	2070	30.0	14.5	24.0
7-7-76	1870	51.0	13.7	21.5
7-8-76	1720	29.2	7.5	23.0
7-9-76	1320	54.1	8.4	29.0
7-10-76	1730	51.0	6.0	19.6
7-11-76	1880	65.8	6.1	20.0
7-12-76	2280	28.5	6.3	39.5
MEAN±SD		46.6±17.0	9.5±4.0	22.4±6.0
7-13-76	2310	28.9	8.9	28.0
7-14-76	2750	86.6	9.4	23.1
7-15-76	1720	77.4	4.9	24.2
7-16-76	1600	53.6	6.1	13.5
7-17-76	1040	41.1	8.0	9.5
7-18-76	840	44.1	9.2	6.0
7-19-76	1160	60.9	8.0	20.8
7-20-76	3700	159.1	11.4	76.6
7-21-76	790	114.6	6.9	23.9
7-22-76	780	46.8	7.2	8.5
7-23-76	2295	59.7	7.1	32.1

SUBJECT 4

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-24-76	1130	52.6	8.3	24.8
7-25-76	2100	77.7	7.0	35.0
7-26-76	1910	68.8	9.9	55.9
MEAN±SD		69.4±34.0	8.0±2.0	27.3±19.0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 5

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-25-76	1440	19.4	8.9	6.6
5-26-76	2390	102.8	12.8	11.0
5-27-76	2600	33.8	11.7	11.1
5-28-76	1830	35.7	9.9	10.5
5-29-76	1440	10.8	8.7	7.8
5-30-76	2150	36.6	17.4	11.3
5-31-76	2710	73.2	12.7	13.6
6-1-76	2110	20.1	7.9	8.7
6-2-76	1520	19.0	6.0	6.6
6-3-76	1720	30.1	7.9	16.6
6-4-76	2175	26.1	7.5	17.7
6-5-76	2630	40.8	8.6	14.4
6-6-76	2120	21.2	6.5	10.7
6-7-76	2725	58.9	11.1	12.0
6-8-76	2390	66.9	11.6	23.2
6-9-76	2025	30.4	7.7	20.5
6-10-76	2890	50.6	10.9	34.0
6-11-76	3100	96.1	6.9	47.6
6-12-76	3120	43.7	12.5	34.1
6-13-76	2000	60.0	9.1	29.3
6-14-76	2920	67.2	12.7	12.9
MEAN±SD		44.9±25.0	10.0±3.0	17.2±11.0
6-15-76	2420	47.2	8.5	11.8
6-16-76	1840	57.0	11.3	17.2

SUBJECT 5

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-17-76	1750	28.0	9.5	26.6
6-18-76	2800	43.4	14.0	37.4
6-19-76	2040	42.8	11.6	26.7
6-20-76	2700	68.9	13.5	28.1
6-21-76	2420	44.8	13.3	26.4
6-22-76	2995	43.4	17.4	29.2
6-23-76	2700	58.1	13.8	19.4
6-24-76	2600	31.2	14.6	19.0
6-25-76	2825	41.0	13.4	19.6
6-26-76	3040	73.0	8.8	17.1
6-27-76	2060	58.7	15.1	13.4
6-28-76 **	4030	62.5	10.0	36.3
6-29-76*	3495	54.2	6.7	24.7
6-30-76***	4540	102.1	12.7	27.6
7-1-76 **	4780	22.7	34.7	20.7
7-2-76	4260	57.5	6.2	11.6
7-3-76	2150	25.8	7.8	27.5
7-4-76	2940	26.5	9.2	24.7
7-5-76	3140	48.7	11.5	28.0
7-6-76	2940	39.7	12.9	25.1
7-7-76	4250	44.0	9.2	26.6

*Nothing
**Saline
***Saline+LBNP

SUBJECT 5

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-8-76	3900	44.9	7.6	28.6
7-9-76	2700	31.1	11.1	17.6
7-10-76	3240	43.7	11.8	24.6
7-11-76	2220	53.0	11.4	23.5
7-12-76	3020	66.4	8.1	23.3
MEAN±SD		48.6±17.0	12.0±5.0	23.7±6.0
7-13-76	2920	78.8	10.4	34.3
7-14-76	4000	84.4	10.8	27.8
7-15-76	2230	59.1	7.7	17.9
7-16-76	2880	77.8	10.4	17.3
7-17-76	1660	55.6	9.2	21.1
7-18-76	2390	69.3	8.9	33.4
7-19-76	780	66.4	7.1	38.1
7-20-76	2000	63.0	16.0	26.6
7-21-76	1000	22.5	5.6	28.1
7-22-76	2295	57.4	5.9	37.2
7-23-76	2445	62.4	6.6	31.6
7-24-76	1185	37.3	13.9	37.9
7-25-76	1010	22.7	12.5	33.5
7-26-76	1320	44.2	6.3	35.2
MEAN±SD		57.2±19.0	9.4±3.0	30.0±7.0

TABLE II

URINARY ENDOCRINE RESULTS

SUBJECT 6

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
5-25-76	2090	42.9	13.7	7.0
5-26-76	2610	49.6	7.9	15.0
5-27-76	1900	31.4	12.2	7.9
5-28-76	1740	28.7	7.0	7.4
5-29-76	1740	31.3	8.9	6.6
5-30-76	1360	19.7	8.8	5.9
5-31-76	2320	25.5	12.2	10.9
6-1-76	2020	66.7	9.4	83.7
6-2-76	1920	67.2	8.5	21.2
6-3-76	1720	9.5	7.6	13.1
6-4-76	1685	24.4	3.7	8.1
6-5-76	1680	18.5	9.5	12.5
6-6-76	1845	49.8	11.9	9.6
6-7-76	1715	42.0	8.9	6.5
6-8-76	2020	90.9	11.8	28.4
6-9-76	1810	63.4	11.2	27.8
6-10-76	1500	13.5	5.6	18.0
6-11-76	2020	23.2	4.6	23.8
6-12-76	2580	23.2	8.5	27.2
6-13-76	NS	-	-	-
6-14-76	2380	50.0	11.6	9.1
MEAN±SD		38.6±21.0	9.2±3.0	17.5±17.0
6-15-76	2270	72.6	8.2	8.5

SUBJECT 6

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
6-16-76	3020	61.9	7.5	8.8
6-17-76	2550	52.3	9.1	29.6
6-18-76	2380	30.9	14.0	11.9
6-19-76	2500	36.3	11.4	15.0
6-20-76	2340	44.4	15.9	20.3
6-21-76	2180	43.6	9.4	13.1
6-22-76	2440	46.4	15.0	19.6
6-23-76	2240	51.5	11.9	11.6
6-24-76	3180	109.7	21.3	16.1
6-25-76	2080	18.7	12.4	13.1
6-26-76	2830	53.8	15.6	7.9
*6-27-76	1940	41.7	8.0	6.3
6-28-76 *	2750	53.6	11.8	28.9
6-29-76***	2640	68.6	19.8	26.4
6-30-76**	3200	43.2	2.1	21.3
7-1-76	3720	57.7	4.9	11.7
7-2-76	1930	15.4	6.7	8.8
7-3-76	3060	99.5	11.0	34.7

*Nothing
**Saline
***Saline+LBNP
*Less Than 24 Hours

SUBJECT 6

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-4-76	2800	35.0	6.8	17.6
7-5-76	1560	37.4	18.6	15.2
7-6-76	2590	63.5	23.4	22.1
7-7-76	3080	50.8	9.6	20.1
7-8-76	2100	20.0	10.5	16.8
7-9-76	2270	60.2	12.4	19.3
7-10-76	2620	52.4	11.9	10.7
7-11-76	2220	104.3	8.7	11.8
7-12-76	2260	81.4	11.4	16.9
MEAN±SD		53.8±24.0	11.8±5.0	16.6±7.0
7-13-76	1910	61.1	12.5	10.7
7-14-76	2895	111.5	11.1	30.1
7-15-76	3640	89.2	8.5	20.4
7-16-76	890	33.3	5.2	6.8
7-17-76	1760	158.9	7.0	19.2
7-18-76	1560	141.4	12.5	15.6
7-19-76	1680	108.8	14.3	8.7
7-20-76	2580	86.9	16.0	22.4
7-21-76	1960	95.7	17.6	24.1
7-22-76	1510	46.8	9.7	23.2
7-23-76	1900	51.3	15.9	18.3

SUBJECT 6

DATE	VOLUME	CORTISOL ug/TV	ALDO ug/TV	ADH mU/TV
7-24-76	2020	46.5	11.3	21.9
7-25-76	1120	33.4	8.8	13.1
7-26-76	1840	41.4	19.8	19.2
MEAN±SD		79.0±41.0	12.2±4.0	18.1±6.0

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 1

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-20-76	3960	1.006	246	178	63	147	17.1	15.3	1108	871	1980
5-21-76	3660	1.007	272	212	59	154	16.2	19.2	1610	1098	2196
5-22-76	2930	1.007	270	147	67	123	13.5	18.3	1113	762	2110
5-23-76	1920	1.009	294	54	48	42	9.6	9.4	998	653	1882
5-24-76	5500	1.005	184	138	111	117	14.4	15.4	1430	990	2640
5-25-76	4740	1.005	201	209	95	190	13.7	14.6	1043	948	2275
5-26-76	4770	1.005	204	224	72	186	14.5	13.9	1240	859	2194
5-27-76	2375	1.009	329	157	48	102	11.6	13.4	1330	998	2138
5-28-76	3650	1.006	261	201	73	161	13.1	11.9	1095	803	2044
5-29-76	2890	1.006	213	84	38	49	22.7	10.2	1214	867	1965
5-30-76	3860	1.005	236	151	62	120	16.5	15.3	1004	1004	2393
5-31-76	5200	1.005	207	239	88	198	16.0	13.8	1352	936	2184
6-1-76	4910	1.005	184	196	83	157	15.4	12.9	1108	786	2062
6-2-76	4660	1.007	182	191	61	135	15.0	13.8	1398	932	2144
6-3-76	3260	1.006	242	163	88	130	11.2	11.7	913	717	2086
6-4-76	3760	1.005	218	169	71	132	11.6	11.0	1053	827	2106
6-5-76	4460	1.006	165	143	62	94	13.1	11.4	1160	803	2141

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-6-76	4440	1.004	204	142	75	107	16.0	11.7	1154	978	2398
6-7-76	5600	1.004	183	218	101	202	21.0	14.0	1120	784	2240
6-8-76	3640	1.005	245	167	87	146	13.7	8.4	1019	874	2111
6-9-76	2200	1.007	311	143	44	90	10.6	10.3	924	704	1848
MEAN±SD	3923± 1061	1.006± .001	231± 46	168± 45	71± 19	132± 44	14.6± 3	13.1± 3	1165± 177	866± 114	2149± 179
6-10-76	4100	1.008	223	256	70	196	16.1	11.8	864	806	2202
6-11-76	3050	1.008	375	284	85	253	15.1	9.2	976	854	2318
6-12-76	3630	1.006	285	218	80	211	15.1	14.3	1089	871	2395
6-13-76	3060	1.007	346	220	95	193	15.1	9.1	918	857	2203
6-14-76	2840	1.007	331	182	65	151	14.6	11.1	1079	852	1988
6-15-76	3040	1.008	337	188	97	143	19.2	10.3	1216	912	2250
6-16-76	4400	1.005	213	158	97	123	15.2	11.7	1144	880	2200
6-17-76	3680	1.006	293	217	88	173	16.9	10.8	1178	883	2208
6-18-76	3860	1.006	287	212	85	185	18.7	15.6	1312	926	2470
6-19-76	2840	1.008	365	207	77	182	19.6	12.7	1022	852	2102
6-20-76	4760	1.004	207	205	71	162	19.1	11.0	1047	857	2094
6-21-76	3580	1.007	332	279	82	233	24.9	12.1	1217	931	2220
6-22-76	3825	1.006	261	218	73	172	15.7	10.2	1071	842	1989
6-23-76 ***	4790	1.005	275	331	86	311	24.4	15.5	1150	958	2299
6-24-76 **	4540	1.006	306	395	91	368	25.9	15.9	1271	908	2270
6-25-76 **	2940	1.008	369	247	71	212	23.1	14.0	1117	823	2117

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-26-76	4190	1.006	294	230	101	210	25.0	15.0	1257	922	2263
6-27-76	5080	1.005	209	178	86	147	25.2	15.6	1321	813	2134
6-28-76	3560	1.007	294	178	85	157	20.9	14.6	1210	854	2136
6-29-76	2640	1.010	432	201	90	180	21.3	12.7	1426	950	2218
6-30-76	3040	1.009	392	219	91	188	26.0	15.5	1581	973	2310
7-1-76	2390	1.010	399	141	76	120	18.4	15.4	1481	813	1960
7-2-76	2980	1.010	416	188	51	128	27.3	18.7	1788	1013	2622
7-3-76	3300	1.008	357	231	106	221	23.8	14.6	1320	726	1980
7-4-76	2600	1.009	431	213	68	205	23.3	17.2	1300	780	2028
7-5-76	3160	1.007	330	193	79	155	19.8	12.7	1390	758	2086
7-6-76	5550	1.004	227	244	89	205	27.3	14.3	1776	888	2331
7-7-76	5110	1.004	206	204	77	158	28.0	17.5	1533	818	1942
MEAN±SD	3658± 860	1.007± .002	314± 70	223± 52	83± 12	191± 54	20.9± 4	13.5± 3	1252± 231	869± 66	2191± 160
7-8-76	2900	1.008	334	131	67	131	18.8	9.9	1218	928	2146
7-9-76	2680	1.010	419	214	105	180	33.1	18.5	1662	965	2305
7-10-76	3220	1.007	332	235	77	188	46.2	16.7	1481	837	2125
7-11-76	2400	1.011	467	240	89	218	19.7	16.1	1248	912	2256
7-12-76	3030	1.007	292	182	67	145	18.0	17.6	1454	1091	2000
7-13-76	4470	1.005	210	148	45	107	21.8	18.9	1609	1073	2235
7-14-76	2025	1.013	533	188	73	158	18.0	15.4	1296	932	2106
7-15-76	2450	1.011	456	169	74	135	20.4	18.4	1323	833	2156
7-16-76	2020	1.011	421	121	40	103	17.3	16.9	1131	768	2020

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-17-76	2080	1.012	480	187	87	156	17.2	15.8	1248	957	2246
7-18-76	3040	1.006	241	106	46	76	17.8	11.3	790	912	2189
7-19-76	2900	1.006	242	139	46	84	16.6	11.2	986	754	1914
7-20-76	3050	1.006	260	159	64	128	13.4	8.5	976	732	1891
7-21-76	1840	1.010	358	110	55	66	13.2	12.8	994	662	1987
MEAN±SD	2722± 680	1.009± .003	360± 103	166± 44	67± 19	134± 44	20.8± 9	14.9± 3	1244± 254	883± 125	2113± 132

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 2

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-20-76	300	1.026	1031	61	34	66	2.9	2.6	294	336	750
5-21-76	1100	1.025	931	219	101	202	12.8	5.9	1232	1034	2420
5-22-76	530	1.027	1007	112	54	94	4.3	5.5	901	477	1558
5-23-76	670	1.029	1083	135	80	130	6.7	8.9	992	683	2228
5-24-76	840	1.026	1030	183	77	165	6.4	5.0	857	773	2066
5-25-76	1040	1.024	953	224	76	208	10.2	6.5	811	790	1997
5-26-76	1020	1.022	900	196	74	202	11.9	11.7	918	694	1938
5-27-76	1240	1.019	692	175	68	166	8.8	9.2	942	868	2009
5-28-76	595	1.027	1033	127	62	114	5.4	6.3	643	643	1773
5-29-76	730	1.027	1073	166	75	158	6.5	7.5	774	701	2044
5-30-76	500	1.023	842	67	52	71	2.7	3.8	680	420	1400
5-31-76	920	1.022	854	154	59	122	8.0	9.5	846	699	2006
6-1-76	860	1.019	887	175	84	184	7.3	5.0	568	585	1359
6-2-76	900	1.021	867	148	57	125	5.9	8.5	990	774	1944
6-3-76	560	1.023	959	116	55	111	4.3	3.6	448	482	1198
6-4-76	450	1.032	1160	73	34	46	2.4	7.1	1294	657	1755
6-5-76	500	1.027	1030	80	43	71	3.8	7.5	680	580	1488

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-6-76	590	1.024	1014	120	48	114	5.1	6.7	755	507	1180
6-7-76	440	1.019	931	96	52	109	4.0	1.6	238	282	475
6-8-76	730	1.024	964	115	48	112	6.6	9.4	964	569	1708
6-9-76	720	1.025	1022	148	59	142	8.2	7.6	734	648	762
MEAN±SD	725± 248	1.024± .003	965± 103	138± 48	62± 17	129± 47	6.4± 3	6.6± 3	789± 263	629± 177	1622± 520
6-10-76	1030	1.021	901	212	56	199	11.2	6.2	762	680	1812
6-11-76	1150	1.019	853	248	62	231	11.8	3.7	644	690	1863
6-12-76	1120	1.021	885	213	58	184	11.5	9.5	986	806	1971
6-13-76	910	1.024	1009	169	69	171	9.5	9.8	983	728	2002
6-14-76	885	1.021	906	150	54	146	8.8	8.5	885	655	1628
6-15-76	1060	1.024	968	195	73	181	12.5	10.5	1145	763	2268
6-16-76	710	1.026	1072	142	65	136	8.0	7.6	951	540	1775
6-17-76	1190	1.021	917	243	81	232	13.2	7.9	1047	762	2142
6-18-76	1230	1.019	813	207	76	188	13.9	9.5	1107	812	1919
6-19-76	1220	1.019	845	217	81	198	16.4	8.2	1000	756	1928
6-20-76	1880	1.011	505	190	68	184	17.2	11.3	902	752	1842
6-21-76	1020	1.024	805	169	69	173	13.9	8.6	734	653	1428
6-22-76	1860	1.015	631	218	80	169	19.6	10.6	1488	818	2604
6-23-76 **	1580	1.017	779	321	101	313	18.4	5.9	1011	822	2022
6-24-76 *	2140	1.013	587	304	86	278	26.4	9.1	1241	856	2097
6-25-76 ***	1320	1.019	855	230	66	247	24.8	13.4	1030	739	2006

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-26-76	1640	1.014	621	241	64	217	23.8	9.1	1017	820	1968
6-27-76	1310	1.020	870	265	75	249	23.6	9.9	1231	786	2070
6-28-76	915	1.017	751	130	52	130	15.9	8.3	769	476	1427
6-29-76	1140	1.019	820	200	74	181	19.9	10.1	980	730	1938
6-30-76	1230	1.019	819	212	73	187	23.1	8.9	1033	787	1845
7-1-76	1165	1.020	861	190	63	181	23.0	12.7	1118	792	1911
7-2-76	1200	1.017	744	173	53	152	23.0	11.5	1152	912	1896
7-3-76	820	1.020	843	142	43	117	16.7	9.5	1050	590	1492
7-4-76	1150	1.018	765	168	68	153	18.0	10.8	1127	690	2001
7-5-76	1140	1.018	775	194	70	176	20.0	9.3	1140	684	2006
7-6-76	1500	1.015	690	243	81	219	19.8	10.7	1050	690	1800
7-7-76	1000	1.019	812	158	71	151	17.7	10.2	1000	580	1700
MEAN±SD	1233± 333	1.019± .003	811± 124	205± 47	69± 12	191± 45	17.2± 5	9.3± 2	1021± 171	727± 99	1906± 243
7-8-76	900	1.022	928	146	62	151	18.8	10.5	1044	738	1692
7-9-76	940	1.016	689	135	61	122	16.8	5.1	827	508	1410
7-10-76	620	1.017	726	109	35	99	14.9	6.1	508	384	918
7-11-76	550	1.021	848	103	36	97	9.9	9.1	561	396	1353
7-12-76	560	1.022	871	103	35	76	9.1	6.7	739	470	1176
7-13-76	560	1.026	953	74	59	67	7.3	8.3	728	493	1400
7-14-76	510	1.024	944	73	42	65	7.7	7.9	714	571	1255
7-15-76	1040	1.013	551	121	67	104	8.8	6.1	686	478	1061
7-16-76	550	1.015	629	69	43	75	6.4	4.6	396	308	748

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-17-76	640	1.021	879	138	43	118	10.0	8.2	653	499	1267
7-18-76	460	1.023	882	179	108	159	6.5	1.7	478	405	1242
7-19-76	730	1.022	911	170	76	177	13.1	11.5	686	672	1650
7-20-76	700	1.020	836	189	54	167	10.8	7.4	560	616	1260
7-21-76	820	1.022	871	178	56	123	10.4	7.3	1066	705	1374
MEAN±SD	684± 178	1.020 .004	823± 124	128± 41	56± 20	114± 38	10.8± 4	7.2± 2	689± 194	517± 128	1286± 264

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 3

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-20-76	1020	1.020	803	141	58	114	15.2	14.0	1244	836	1979
5-21-76	1200	1.016	670	150	72	133	11.5	10.0	1104	720	1896
5-22-76	1080	1.021	882	202	73	184	14.2	11.3	1102	756	2333
5-23-76	830	1.025	1054	141	79	160	13.1	13.2	1162	747	2457
5-24-76	960	1.024	1006	170	65	174	16.0	14.0	941	883	2477
5-25-76	1060	1.022	905	184	72	191	12.1	12.4	1166	912	2332
5-26-76	895	1.024	988	174	64	171	15.4	12.0	1217	806	2238
5-27-76	1060	1.016	730	181	63	172	11.5	7.0	594	551	1505
5-28-76	1520	1.020	833	255	87	243	20.4	18.2	1611	1064	2918
5-29-76	1900	1.012	501	162	67	152	24.0	13.0	1140	836	2204
5-30-76	1430	1.015	631	170	72	169	16.7	14.0	1087	887	2259
5-31-76	1390	1.015	654	192	54	190	17.5	12.6	1112	834	2224
6-1-76	1880	1.015	646	271	81	265	24.0	15.9	1429	940	2820
6-2-76	1480	1.014	609	207	58	178	16.1	9.8	1095	740	2013
6-3-76	680	1.019	846	133	44	144	9.0	5.5	381	408	1183
6-4-76	1380	1.022	875	134	60	124	20.9	16.6	1656	1104	3229
6-5-76	1030	1.020	780	110	74	116	15.5	12.6	968	886	2225

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-6-76	500	1.026	933	54	25	60	11.0	7.0	380	570	1600
6-7-76	650	1.027	1040	99	40	109	15.3	9.8	949	767	2015
6-8-76	830	1.016	750	155	67	159	8.7	3.4	664	498	1328
6-9-76	790	1.017	765	160	50	157	9.8	6.7	600	427	1153
MEAN±SD	1122± 381	1.019± .004	805± 153	164± 49	63± 15	160± 45	15.1± 4	11.4± 4	1029± 347	770± 189	2114± 545
6-10-76	2120	1.012	561	327	89	282	18.9	8.2	1230	806	2247
6-11-76	1860	1.013	596	281	71	246	20.0	9.3	1042	707	2120
6-12-76	1760	1.011	483	180	56	178	15.6	11.3	915	634	197[illegible]
6-13-76	2150	1.011	521	245	92	232	23.5	11.2	989	774	2408
6-14-76	1560	1.014	582	175	66	158	18.1	10.2	655	655	2090
6-15-76	1755	1.013	555	193	76	170	21.0	11.5	1017	667	2211
6-16-76	1440	1.016	651	166	79	147	19.2	10.1	1008	720	2304
6-17-76	1520	1.017	770	290	90	246	21.1	4.9	851	790	2280
6-18-76	1190	1.019	832	218	67	224	22.1	11.9	1118	714	2261
6-19-76	1340	1.015	634	192	59	180	20.3	8.2	938	643	1849
6-20-76	1980	1.011	489	200	73	172	23.0	9.1	1188	792	2138
6-21-76	1500	1.013	579	200	72	189	20.1	6.8	840	630	1860
6-22-76	1860	1.013	556	227	91	190	22.1	10.4	1190	781	2418
6-23-76*	2100	1.014	605	265	90	246	26.4	14.8	1302	966	2982
6-24-76***	2980	1.011	436	358	95	364	27.3	12.2	1192	894	2444
6-25-76**	2380	1.009	426	324	67	281	25.2	7.5	904	619	1856

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-26-76	3100	1.009	452	372	102	372	33.7	11.5	1364	992	2666
6-27-76	1400	1.011	470	134	41	115	19.6	8.7	952	588	1708
6-28-76	1700	1.013	546	192	78	163	23.4	9.6	952	714	2210
6-29-76	2095	1.014	586	260	94	245	30.8	17.0	1341	922	2933
6-30-76	2210	1.007	341	188	71	177	18.9	7.3	707	663	1547
7-1-76	3100	1.010	418	282	87	248	34.5	18.6	1860	930	3162
7-2-76	1640	1.014	564	180	72	153	24.6	12.1	1214	853	2165
7-3-76	2550	1.010	431	235	89	222	28.4	12.9	1377	867	2652
7-4-76	1380	1.007	352	101	46	88	12.5	4.9	442	386	994
7-5-76	2700	1.010	456	248	105	221	28.9	15.8	1674	918	3132
7-6-76	2000	1.009	432	214	72	182	18.2	8.2	1000	720	1600
7-7-76	2460	1.010	450	224	84	197	26.7	16.4	1870	886	2952
MEAN±SD	1994± 538	1.012± .003	528± 112	231± 65	78± 16	210± 64	23.0± 5	10.7± 3	1112± 327	758± 137	2256± 507
7-8-76	1810	1.012	525	205	96	203	19.6	9.2	1267	833	2172
7-9-76	1140	1.006	332	98	35	97	7.6	2.5	296	251	707
7-10-76	1360	1.013	546	137	48	132	14.3	9.6	1034	653	1659
7-11-76	1200	1.014	572	122	66	107	13.1	7.8	984	720	1608
7-12-76	760	1.011	496	81	49	84	5.9	2.9	426	441	836
7-13-76	760	1.023	887	100	55	97	14.2	9.9	1277	836	2341
7-14-76	505	1.025	989	70	34	66	9.8	7.4	636	636	1545
7-15-76	880	1.023	855	114	43	104	14.4	9.4	1214	880	2341
7-16-76	1060	1.011	721	138	56	122	9.8	3.3	509	488	1018

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-17-76	660	1.018	806	121	55	121	7.3	4.7	673	449	1069
7-18-76	690	1.021	843	157	71	173	12.5	8.8	938	511	1628
7-19-76	560	1.017	768	157	78	216	8.0	4.7	381	370	1120
7-20-76	780	1.010	437	98	47	107	6.7	2.9	234	374	952
7-21-76	800	1.016	667	159	59	135	7.4	5.7	752	544	1328
MEAN±SD	926± 355	1.016 .006	675± 194	126± 36	57± 17	126± 44	10.8± 4	6.3± 3	759± 364	570± 195	1452± 544

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 4

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-25-76	1200	1.017	775	226	66	209	10.5	6.4	898	792	1704
5-26-76	1700	1.013	557	202	78	211	9.9	6.1	996	748	1870
5-27-76	1940	1.012	558	252	87	256	12.0	6.2	970	815	1746
5-28-76	1230	1.020	883	231	82	224	12.2	8.4	1107	861	1870
5-29-76	1150	1.017	751	181	63	171	10.0	7.5	966	828	1725
5-30-76	1210	1.017	754	191	70	208	10.0	7.6	799	823	1839
5-31-76	1890	1.012	525	221	83	214	10.8	15.1	1021	869	1852
6-1-76	2560	1.009	399	223	92	223	11.1	6.9	1075	870	1741
6-2-76	2120	1.010	475	216	100	208	10.8	8.0	1060	848	1866
6-3-76	1450	1.016	698	223	88	197	10.3	9.3	1102	870	1885
6-4-76	2160	1.010	459	203	86	194	15.3	10.2	994	950	1814
6-5-76	1580	1.014	575	180	77	161	8.2	10.5	980	980	1928

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-6-76	1580	1.013	558	188	77	166	12.3	7.5	885	790	1675
6-7-76	2235	1.009	385	127	51	96	10.3	9.0	1341	760	2235
6-8-76	1940	1.012	522	235	97	239	12.7	7.4	814	892	1746
6-9-76	1500	1.016	653	218	95	182	9.6	7.3	1110	840	1800
6-10-76	1380	1.017	722	224	91	215	12.0	8.5	911	911	1794
6-11-76	1500	1.014	604	183	90	158	10.5	7.6	690	780	1800
6-12-76	960	1.022	881	163	88	153	6.9	5.8	1075	845	1824
6-13-76	690	1.024	927	119	65	110	7.1	5.0	621	635	1435
6-14-76	1600	1.018	784	278	114	270	11.5	8.8	1216	1120	2112
MEAN±SD	1599± 459	1.015± .004	640± 160	204± 38	83± 14	194± 43	10.7± 2	8.1± 2	981± 167	849± 96	1822± 157
6-15-76	1940	1.014	607	320	83	277	14.6	5.1	892	737	1785
6-16-76	1600	1.013	574	208	82	192	10.9	7.1	768	736	1632
6-17-76	2320	1.010	461	244	86	234	17.7	9.4	696	789	1810
6-18-76	1660	1.013	542	186	78	173	12.4	8.3	863	730	1726
6-19-76	1840	1.012	520	182	94	171	12.7	6.9	1104	773	1766
6-20-76	2160	1.010	466	248	95	220	13.1	4.2	864	821	1555
6-21-76	1980	1.013	543	228	93	208	17.3	8.9	950	832	2020
6-22-76	2100	1.011	492	235	103	223	15.0	6.9	714	798	1764
6-23-76	1750	1.013	543	186	84	163	19.4	5.5	805	770	1855
6-24-76	2180	1.011	507	231	105	203	19.3	6.6	1177	872	1874
6-25-76	2150	1.011	508	230	101	213	18.7	7.2	989	817	1720
6-26-76	2030	1.011	462	162	89	154	17.0	7.6	1583	853	1868

DATE	VOLUME ml	SP. GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-27-76	1420	1.016	684	192	74	173	19.4	8.6	1136	824	1789
6-28-76***	2660	1.010	482	335	96	330	28.1	7.6	745	745	1808
6-29-76**	2750	1.009	453	380	72	355	25.3	6.5	770	770	1650
6-30-76*	2560	1.009	419	253	69	230	24.6	7.0	1024	819	1792
7-1-76	2145	1.012	524	262	92	236	17.7	8.7	1201	815	1759
7-2-76	1810	1012	507	163	76	148	14.3	8.0	1320	796	1701
7-3-76	1390	1.015	618	174	70	145	16.0	7.6	1001	695	1529
7-4-76	3120	1.009	408	324	106	256	20.3	6.9	1123	811	1810
7-5-76	1800	1.014	579	180	95	176	19.2	10.9	1188	828	1980
7-6-76	2070	1.012	514	205	91	186	19.8	9.4	1325	869	1822
7-7-76	1870	1.010	465	200	65	153	15.4	7.2	1010	598	1459
7-8-76	1720	1.014	579	205	84	187	18.7	7.6	1101	791	1686
7-9-76	1320	1.018	804	235	81	231	19.3	8.2	1188	792	1795
7-10-76	1730	1.012	603	232	80	213	36.7	7.0	1073	796	1765
7-11-76	1880	1.013	590	256	87	227	20.7	7.1	940	790	1767
7-12-76	2280	1.010	447	207	75	196	21.4	9.2	1277	775	1687
MEAN±SD	2008± 415	1.012± .002	532± 84	231± 54	86± 11	210± 50	18.8± 5	7.5± 1	1030± 215	787± 56	1756± 121
7-13-76	2310	1.010	466	224	90	208	18.4	7.8	1155	832	1802
7-14-76	2750	1.010	441	294	99	259	18.3	6.9	1320	880	1815
7-15-76	1720	1.014	626	258	76	232	18.5	7.9	1032	791	1754

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-16-76	1600	1.013	543	178	66	165	13.3	7.2	960	704	1600
7-17-76	1040	1.021	855	181	81	167	17.9	7.5	957	832	1893
7-18-76	840	1.024	915	146	73	138	13.6	11.8	1193	1042	1848
7-19-76	1160	1.021	878	188	76	158	12.7	9.4	1124	1090	1879
7-20-76	3700	1.009	426	113	35	98	18.4	11.7	1480	1332	1870
7-21-76	790	1.024	950	184	74	189	11.7	7.5	790	790	1817
7-22-76	780	1.024	951	191	76	168	8.8	4.7	702	749	1685
7-23-76	2295	1.010	446	109	32	98	15.3	8.5	964	734	1607
7-24-76	1130	1.016	638	137	48	130	9.6	4.8	702	338	1924
7-25-76	2100	1.011	501	118	45	110	10.2	5.1	1008	840	1764
7-26-76	1910	1.011	478	111	49	93	7.9	5.5	1031	840	1719
MEAN±SD	1723± 855	1.016 .006	651± 211	174± 57	66± 21	158± 51	13.9± 4	7.6± 2	1030± 219	842± 222	1784± 102

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 5

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-25-76	1440	1.015	611	148	78	138	9.3	14.1	1267	893	1930
5-26-76	2390	1.010	439	227	91	222	15.4	18.4	1434	956	2390
5-27-76	2600	1.009	426	286	88	273	16.0	13.5	1300	884	2020
5-28-76	1830	1.014	620	273	97	265	13.3	14.0	1135	805	2123
5-29-76	1440	1.013	531	134	60	125	9.0	11.2	1210	691	1757
5-30-76	2150	1.013	528	224	97	217	15.2	15.0	1204	946	2322
5-31-76	2710	1.009	385	225	76	206	15.7	15.5	976	813	2168
6-1-76	2110	1.011	470	213	80	205	12.9	13.2	1097	760	1899
6-2-76	1520	1.009	370	116	44	97	8.2	8.1	730	578	2158
6-3-76	1720	1.013	581	245	92	225	11.7	13.5	929	757	1926
6-4-76	2175	1.011	474	226	74	198	13.7	16.7	1262	914	2219
6-5-76	2630	1.010	430	247	95	226	13.2	13.8	1262	947	2367

DATE	VOLUME ml	SP. GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-6-76	2630	1.011	452	249	105	216	19.8	17.6	1315	1105	2735
6-7-76	2725	1.010	418	253	112	234	15.1	13.6	1090	872	2289
6-8-76	2390	1.008	366	179	76	153	15.6	13.8	860	813	1912
6-9-76	2025	1.012	496	235	97	198	11.7	14.2	972	770	2056
6-10-76	2890	1.008	353	225	95	211	18.7	15.3	983	867	2139
6-11-76	3100	1.008	363	295	93	242	13.6	15.7	992	868	2234
6-12-76	3120	1.009	374	287	97	256	18.3	15.0	936	998	2371
6-13-76	2000	1.011	453	204	86	184	12.6	11.8	840	760	1920
6-14-76	2920	1.008	329	187	91	169	12.6	14.0	934	876	2044
MEAN±SD	2310± 529	1.011± .002	451± 85	223± 49	87± 15	203± 46	13.9± 3	14.2± 2	1082± 187	851± 114	2143± 226
6-15-76	2420	1.011	456	281	92	247	14.3	16.3	1065	823	2275
6-16-76	1840	1.012	488	213	68	197	13.6	16.4	1141	810	1967
6-17-76	1750	1.015	620	247	79	247	20.5	16.5	1015	980	2415
6-18-76	2800	1.009	384	238	95	235	20.6	14.4	1120	896	2408
6-19-76	2040	1.013	554	249	47	114	16.9	10.7	1224	938	2285
6-20-76	2700	1.009	402	235	89	208	16.4	15.9	1188	972	2160
6-21-76	2420	1.011	484	264	99	244	19.0	14.8	1016	823	2129
6-22-76	2995	1.009	368	240	87	213	18.0	15.6	1078	898	2156
6-23-76	2700	1.010	420	265	108	235	16.7	12.3	1080	918	2214
6-24-76	2600	1.009	394	208	99	182	19.8	14.0	1144	832	2340
6-25-76	2825	1.010	419	274	113	246	19.5	15.3	1187	848	2204
6-26-76	3040	1.008	347	225	103	195	21.9	16.2	1216	912	2128

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-27-76	2060	1.012	520	229	95	212	19.5	15.4	865	865	2142
6-28-76 **	4030	1.006	296	290	77	282	24.3	16.0	806	806	2176
6-29-76 *	3495	1.008	360	343	87	332	27.7	13.8	979	979	2586
6-30-76 ***	4540	1.007	320	386	104	368	39.5	13.5	999	908	2361
7-1-76 **	4780	1.007	328	478	115	416	26.0	17.2	1434	956	2581
7-2-76	4260	1.006	304	349	102	298	22.0	17.1	1278	767	2130
7-3-76	2160	1.012	493	226	99	215	20.0	17.5	1118	860	2150
7-4-76	2940	1.009	356	229	82	191	18.4	17.9	1235	882	2058
7-5-76	3140	1.008	350	261	97	214	18.8	15.7	1193	754	1947
7-6-76	2940	1.008	359	232	100	221	20.0	15.1	1176	823	2176
7-7-76	4250	1.008	355	357	149	306	26.7	20.2	1530	1020	2550
7-8-76	3900	1.006	289	269	101	215	23.0	18.0	1482	936	2106
7-9-76	2700	1.010	413	227	103	221	17.8	17.4	1080	702	1890
7-10-76	3240	1.007	307	194	100	175	24.7	16.5	1231	778	2074
7-11-76	3210	1.008	345	247	100	193	20.1	16.7	1091	835	2119
7-12-76	3020	1.007	330	230	79	202	32.4	13.1	1027	725	1993
MEAN±SD	3028±806	1.009±.002	395±83	267±63	95±18	237±62	21.4±5	15.7±2	1143±162	866±81	2205±182
7-13-76	2920	1.008	357	219	93	210	15.2	10.7	993	759	2044
7-14-76	4000	1.006	308	340	104	296	16.3	14.2	1120	800	2080
7-15-76	2230	1.011	497	285	78	239	14.6	15.1	937	758	1962
7-16-76	2880	1.008	350	228	84	193	17.5	15.3	1094	864	2131

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-17-76	1660	1.012	489	164	76	143	12.0	13.1	1195	830	2092
7-18-76	2390	1.009	375	86	40	71	15.4	14.4	1052	956	2247
7-19-76	1680	1.014	548	115	56	99	12.8	14.4	1075	974	2386
7-20-76	2000	1.011	440	100	38	83	13.2	15.1	920	880	2120
7-21-76	1000	1.021	803	183	66	156	9.6	10.2	640	880	1940
7-22-76	2295	1.009	362	89	27	67	11.2	14.3	872	872	1974
7-23-76	2445	1.009	374	95	31	83	13.7	15.5	880	831	2054
7-24-76	1185	1.016	609	119	67	121	8.5	10.9	687	877	2204
7-25-76	1010	1.021	781	138	84	114	8.4	12.8	1091	929	2202
7-26-76	1320	1.014	540	113	44	86	8.1	11.9	1082	739	1637
MEAN±SD	2073± 849	1.012± .002	488± 157	162± 79	63± 24	140± 70	12.6± 3	13.4± 2	974± 163	854± 72	2077± 175

TABLE III

URINARY BIOCHEMISTRY RESULTS

SUBJECT 6

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
5-25-76	2090	1.010	458	205	115	190	10.0	8.8	1129	711	1756
5-26-76	2610	1.008	348	230	78	201	8.9	7.4	1096	626	1566
5-27-76	1900	1.012	482	194	82	191	10.6	6.8	1140	646	1786
5-28-76	1740	1.010	443	174	54	143	8.0	6.8	1114	557	1601
5-29-76	1740	1.010	438	153	56	130	8.3	6.8	1114	626	1810
5-30-76	1360	1.008	335	80	34	65	6.6	5.5	653	408	1170
5-31-76	2320	1.010	441	255	88	209	11.3	9.4	1067	742	1856
6-1-76	2020	1.010	420	198	75	190	8.5	8.7	929	525	1737
6-2-76	1920	1.010	452	196	81	196	8.8	7.7	1075	614	1690
6-3-76	1730	1.011	507	218	74	194	8.1	6.7	1066	654	1686
6-4-76	1685	1.007	333	138	56	131	4.9	4.0	573	404	1011
6-5-76	1680	1.007	320	101	55	97	5.6	5.0	672	470	1176
6-6-76	1845	1.012	514	201	87	172	11.1	10.1	1328	775	2140
6-7-76	1715	1.009	384	151	67	129	9.7	6.8	858	480	1372
6-8-76	2070	1.009	387	190	87	184	22.4	8.4	662	538	1408
6-9-76	1810	1.012	517	210	83	190	12.4	7.6	1014	724	1846
6-10-76	1500	1.009	382	132	53	89	7.4	3.6	720	480	1200
6-11-76	2020	1.009	385	176	67	141	10.5	5.0	808	606	1454
6-12-76	2580	1.007	301	181	88	163	11.8	6.5	774	619	1445

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
6-14-76	2380	1.010	423	205	119	193	11.4	8.6	1000	714	1761
MEAN±SD	1935± 334	1.010± .002	414± 66	179± 43	75± 21	160± 42	9.8± 4	7.0± 2	940± 210	596± 110	1574± 288
6-15-76	2270	1.010	438	245	70	216	11.0	9.5	726	636	1861
6-16-76	3020	1.006	296	217	76	205	16.0	6.9	785	544	1872
6-17-76	2550	1.009	395	250	82	224	17.0	8.1	765	663	1909
6-18-76	2380	1.009	411	226	83	200	16.0	9.2	952	714	1999
6-19-76	2500	1.008	362	210	80	190	16.6	9.1	950	650	1750
6-20-76	2340	1.009	400	187	91	180	13.9	9.4	1030	702	1872
6-21-76	2180	1.010	452	231	81	201	17.3	9.2	1003	654	1738
6-22-76	2440	1.009	358	193	98	183	14.7	7.8	927	683	2050
6-23-76	2240	1.008	365	186	83	168	14.1	6.2	717	582	1523
6-24-76	3180	1.008	351	254	111	232	19.0	9.7	954	763	2226
6-25-76	3180	1.008	372	254	114	229	25.0	12.5	1081	890	2417
6-26-76	2830	1.009	403	241	108	226	19.5	11.2	1302	849	2321
6-27-76	1940	1.008	384	188	76	173	10.4	5.3	698	466	1319
6-28-76 *	2750	1.009	408	228	96	215	26.6	9.5	1210	825	2420
6-29-76 ***	2640	1.010	430	232	108	232	21.6	9.6	1003	686	2165
6-30-76 **	3200	1.008	403	378	102	358	23.9	8.3	832	704	1728
7-1-76	3720	1.013	407	443	108	413	21.8	12.7	1265	818	2232
7-2-76	1930	1.010	429	176	66	160	16.6	8.8	1042	618	1505
7-3-76	3060	1.010	460	303	119	275	26.9	13.2	1591	918	2387

*Nothing
**Saline
***Saline+LBNP

DATE	VOLUME ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-4-76	2800	1.006	290	168	87	154	13.4	6.9	1008	560	1512
7-5-76	1560	1.012	495	119	78	100	8.6	7.4	1061	624	1654
7-6-76	2590	1.011	458	228	106	212	17.7	12.5	1243	777	2435
7-7-76	3080	1.008	381	283	105	262	17.0	11.8	1109	678	1910
7-8-76	2100	1.010	428	197	74	166	14.8	10.3	1218	672	1722
7-9-76	2270	1.010	441	218	73	207	15.3	9.3	1180	636	1771
7-10-76	2620	1.007	316	176	76	162	13.0	5.7	996	576	1572
7-11-76	2220	1.007	342	155	87	135	10.8	6.2	844	533	1332
7-12-76	2260	1.010	424	192	79	165	17.2	11.0	1040	588	1808
MEAN±SD	2566±477	1.009±.002	396 50	228±65	90±15	209±63	17.0±5	9.2±2	1019±204	679±111	1898±331
7-13-76	1910	1.006	277	90	53	84	12.1	5.7	611	382	1108
7-14-76	2895	1.009	414	255	110	243	16.6	9.3	1274	8-1	2258
7-15-76	3640	1.007	316	280	84	226	16.7	10.6	1310	655	2038
7-16-76	890	1.009	370	59	28	55	4.1	3.7	392	249	712
7-17-76	1760	1.012	483	185	60	155	11.5	10.1	1056	739	1936
7-18-76	1560	1.012	464	126	73	109	11.1	9.4	749	780	1716
7-19-76	780	1.014	550	59	68	59	6.0	4.5	515	468	952
7-20-76	2580	1.009	360	165	103	150	13.4	11.1	1032	826	1858
7-21-76	1960	1.009	368	125	82	116	9.8	9.6	941	588	1607
7-22-76	1510	1.011	456	113	88	115	8.8	9.3	906	604	1842
7-23-76	1900	1.011	475	165	99	144	9.2	9.0	988	760	1862

DATE	VOLUME Ml	SP GR	OSMO mOsmo	Na mEq/TV	K mEq/TV	Cl mEq/TV	CA mEq/TV	MG mEq/TV	IPO4 mg/TV	URIC ACID mg/TV	CREAT mg/TV
7-24-76	2020	1.010	425	182	67	162	9.7	11.0	889	606	1656
7-25-76	1120	1.007	328	73	55	76	4.2	3.6	403	314	739
7-26-76	1840	1.012	481	142	85	114	12.0	12.5	1325	773	2318
MEAN±SD	1883± 768	1.010± .002	412± 78	144± 67	75± 22	129± 56	10.4± 4	8.5± 3	885± 316	611± 191	1614± 530

TABLE IV
URINARY PARAMETERS
SIGNIFICANT DIFFERENCES

	BEDREST	RECOVERY
Volume	$p < .05$	
Cortisol		
Aldosterone	$p < .05$	
ADH		
Specific Gravity		
Osmolality		
Sodium	$p < .001$	$p < .02$
Potassium	$p < .01$	
Chloride	$p < .01$	$p < .05$
Calcium	$p < .001$	
Magnesium		
Inorganic Phosphate	$p < .02$	
Uric Acid		
Creatinine		

TABLE Va

$\bar{x}$ BEDREST 6 DAYS VS

SUBJECT	N	VOLUME	NA	CORTISOL	ALDO	ADH
1	$\bar{x}$ 6 Days Pre	3758	223	103.6	25.1	16.1
	Saline + LBNP	4790	331	153.3	38.3	8.6
	Saline	4540	395	154.4	33.1	10.9
	Nothing	2940	247	119.1	24.8	7.6
	$\bar{x}$ 6 Days Post	3483	191	84.7	26.6	15.9
2	$\bar{x}$ 6 Days Pre	1400	223	57.4	8.9	24.1
	Saline	1580	321	76.6	7.5	32.8
	Nothing	2140	304	107.0	11.6	23.7
	Saline + LBNP	1320	230	62.7	11.4	25.5
	$\bar{x}$ 6 Days Post	1233	191	47.7	7.4	40.0
3	$\bar{x}$ 6 Days Pre	1565	221	50.4	12.8	26.3
	Nothing	2100	265	66.7	20.3	17.5
	Saline + LBNP	2980	358	79.0	20.0	21.1
	Saline	2380	324	27.4	9.5	18.8
	$\bar{x}$ 6 Days Post	2268	238	43.5	17.7	27.7
4	$\bar{x}$ 6 Days Pre	1938	206	65.3	12.4	19.3
	Saline + LBNP	2660	335	81.1	15.2	33.6
	Saline	2750	380	33.0	1.2	23.6
	Nothing	2560	253	35.8	2.6	25.0
	$\bar{x}$ 6 Days Post	2056	218	38.0	9.7	21.2
5	$\bar{x}$ 6 Days Pre	2703	254	50.9	13.9	13.9
	Saline	4030	290	62.5	10.0	36.3
	Nothing	3495	343	54.2	6.7	24.7
	Saline + LBNP	4540	386	102.1	17.7	27.6
	Saline	4780	478	27.7	34.2	20.7
	$\bar{x}$ 6 Days Post	3280	276	40.4	9.5	9.5

TABLE Va (Con't)

SUBJECT	N	VOLUME	NA	CORTISOL	ALDO	ADH
6	$\bar{x}$ 6 Days Pre	2635	219	53.6	14.0	12.4
	Nothing	2750	228	53.6	11.8	28.9
	Saline + LBNP	2640	232	68.6	19.8	26.4
	Saline	3200	378	43.2	2.1	21.3
	$\bar{x}$ 6 Days Post	2610	240	51.4	11.9	18.4

TABLE Vb

BAYLOR BEDREST II

Analysis of Variance

p Values

	PRE TO SALINE,LBNP	PRE TO SALINE	PRE TO NO TREATMENT	PRE TO POST
Volume	$p < .001$	$p < .001$	-	-
Osmolality	-	-	-	-
Sodium	$p < .001$	$p < .001$	-	-
Chloride	$p < .001$	$p < .001$	$p < .025$	-
Aldosterone	$p < .001$	$p < .05$	-	-
Cortisol	$p < .005$	-	-	$p < .025$

Pre - Bedrest $\bar{x}$ 6 Days Pre Crossover

Post - Bedrest $\bar{x}$ 6 Days Post Crossover

TABLE VI

PLASMA ENDOCRINE RESULTS

SUBJECT 1

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-17-76	0.05	11.3	89	5	1.2	133	5.5
F-14	5-27-76	0.28	7.2	89	4	1.5	145	5.5
F-0	6-10-76	0.13	8.0	149	7	0.7	120	5.5
BR+8	6-18-76	0.69	-	225	-	-	-	-
BR+13AM ***	6-23-76	QNS	-	191	-	-	-	-
BR+13PM ***	6-23-76	0.62	-	-	-	-	-	-
BR+14PM **	6-24-76	0.06	-	63	-	-	-	-
BR+15PM *	6-25-76	QNS	-	100	-	-	-	-
BR+21	7-1-76	1.32	21.8	183	-	-	-	-
BR+27	7-7-76	0.39	7.4	172	7	0.7	120	5.8
R+1 PM	7-9-76	0.23	3.0	110	7	0.7	120	5.3
R+6	7-14-76	0.23	3.7	106	4	5.4	99	5.7
R+13	7-21-76	0.06	9.0	157	9	1.6	110	5.7
PRE $\bar{x}$		.15±.12	8.8±2.0	109±35	5±2	1.1±0.4	133±13	5.5±0

*Nothing
**Saline
***Saline+LBNP

PLASMA ENDOCRINE RESULTS

SUBJECT 2

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-17-76	0.85	8.9	154	5	1.5	160	6.8
F-14	5-27-76	0.43	13.2	145	4	1.2	145	5.5
F-0	6-10-76	0.30	11.0	154	4	1.0	120	5.8
BR+8	6-18-76	0.96		113	-	-		-
BR+13AM**	6-23-76	QNS	-	164	-	-		-
BR+13PM**	6-23-76	0.16	-	74	-	-		-
BR+14PM*	6-24-76	0.12	-	72	-	-		-
BR+15PM***	6-25-76	0.73	-	74	-	-		-
BR+21	7-1-76	1.10	19.0	110	-	-		-
BR+27	7-7-76	0.44	14.0	129	5	1.0	145	6.1
R+1 PM	7-9-76	0.23	7.6	31	13	1.3	110	6.1
R+6	7-14-76	1.36	7.9	172	19	1.3	160	7.3
R+13	7-21-76	0.56	7.6	105	10	1.6	120	6.2
PRE $\bar{x}$		0.53±.29	11.0±2.0	151±5	4±1	1.2±0.3	142±20	6.0±1.0

*Nothing
**Saline
***Saline+LBNP

PLASMA ENDOCRINE RESULTS

SUBJECT 3

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-17-76	0.33	7.9	111	11	1.2	145	7.2
F-14	5-27-76	0.18	12.5	99	6	1.5	145	6.1
F-0	6-10-76	0.08	7.9	127	3	0.6	120	6.8
BR+8	6-18-76	1.10		183	-	-	-	-
BR+13AM *	6-23-76	QNS		147	-	-	-	-
BR+13PM *	6-23-76	0.22		44	-	-	-	-
BR+14PM ***	6-24-76	0.38		74	-	-	-	-
BR+15PM **	6-25-76	0.07		44	-	-	-	-
BR+21	7-1-76	0.77	14.1	155	-	-	-	-
BR+27	7-7-76	0.29	19.0	172	6	0.8	133	6.7
R+1 PM	7-9-76	0.33	5.6	106	11	0.8	160	6.7
R+6	7-14-76	0.35	6.1	102	15	0.8	175	6.5
R+13	7-21-76	0.28	11.5	138	6	0.8	190	7.3
PRE $\bar{x}$		0.20±.13	9.4±3.0	112±14	7±4	1.1±0.5	137±14	6.7±1.0

*Nothing
**Saline
***Saline+LBNP

PLASMA ENDOCRINE RESULTS

SUBJECT 4

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-20-76	0.12	10.2	59	4	0.9	120	6.8
F-14	6-1-76	0.46	11.6	104	5	0.9	120	6.1
F-0	6-15-76	0.13	14.0	149	3	0.7	99	5.5
BR+8	6-22-76	1.12	-	141	-	-	-	-
BR+13AM ***	6-28-76	QNS	-	141	-	-	-	-
BR+13PM ***	6-28-76	0.56	-	73	-	-	-	-
BR+14PM **	6-29-76	0.10	-	112	-	-	-	-
BR+15PM *	6-30-76	QNS	-	84	-	-	-	-
BR+21	7-6-76	1.22	15.7	141	-	-	-	-
BR+27	7-12-76	0.81	13.5	125	4	0.6	160	6.4
R+1 PM	7-14-76	0.23	8.4	105	5	1.0	133	6.1
R+6	7-19-76	0.65	11.5	85	9	0.7	145	6.9
R+13	7-26-76	0.32	11.3	189	4	0.6	145	6.9
PRE $\bar{x}$		0.24±.19	11.9±2.0	104±45	4±1	0.8±0.1	113±12	6.1±1.0

*Nothing
**Saline
***Saline+LBNP

PLASMA ENDOCRINE RESULTS

SUBJECT 5

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-20-76	0.75	9.7	98	7	1.2	145	8.1
F-14	6-1-76	0.69	12.5	185	7	0.9	145	7.2
F-0	6-15-76	0.71	11.7	104	7	0.8	145	7.5
BR+8	6-22-76	0.43	-	127	-	-	-	-
BR+13AM**	6-28-76	1.18	-	QNS	-	-	-	-
BR+13PM**	6-28-76	0.47	-	90	-	-	-	-
BR+14PM*	6-29-76	0.33	-	67	-	-	-	-
BR+15PM***	6-30-76	1.13	-	74	-	-	-	-
BR+21	7-6-76	1.22	12.3	99	-	-	-	-
BR+27	7-12-76	0.89	10.0	167	29	1.0	175	8.0
R+1 PM	7-14-76	0.41	9.7	106	13	0.6	133	6.4
R+6	7-19-76	0.92	7.7	120	9	0.7	145	7.3
R+13	7-26-76	0.55	10.0	111	23	0.4	133	6.5
PRE $\bar{x}$		0.72±.03	11.3±1.0	129±49	7±0	1.0±0.2	145±0	7.6±0.5

*Nothing
**Saline
***Saline+LBNP

PLASMA ENDOCRINE RESULTS

SUBJECT 6

		ANGIO I ng/ml/hour	CORTISOL ug/dl	ALDO pg/ml	INSULIN μU/ml	HGH ng/ml	T_3 ng/dl	T_4 ug/dl
F-25	5-20-76	0.55	13.1	164	5	0.9	120	6.4
F-14	6-1-76	0.28	13.8	101	10	1.2	99	6.1
F-0	6-15-76	0.27	12.0	113	3	0.6	99	5.8
BR+8	6-22-76	0.87		113	-	-	-	-
BR+13AM *	6-28-76	0.56		QNS	-	-	-	-
BR+13PM *	6-28-76	0.65		64	-	-	-	-
BR+14PM ***	6-29-76	1.29		87	-	-	-	-
BR+15PM **	6-30-76	0.05		73	-	-	-	-
BR+21	7-6-76	1.06	17.7	141	-	-	-	-
BR+27	7-12-76	0.83	9.0	157	14	0.7	145	6.4
R+1 PM	7-14-76	0.45	7.9	108	25	0.7	133	5.8
R+6	7-19-76	0.45	9.5	118	7	0.6	120	6.2
R+13	7-26-76	0.44	9.7	196	2	1.1	120	5.7
PRE $\bar{x}$		0.37±.16	13.0±1.0	126±33	6±4	0.9±.3	106±12	6.1±.3

*Nothing
**Saline
***Saline+LBNP

TABLE VII

SERUM BIOCHEMISTRY RESULTS

SUBJECT 1

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MU/ML	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PCT
F-25	93	150	22	22	15.5	4.8	45	8.9	1.9	3.0	0.4	ND
F-14	97	141	19	20	11.0	5.9	50	8.9	2.0	3.1	1.3	0.1
F-0	87	182	19	21	11.0	6.0	55	10.3	2.3	2.9	0.9	ND
MEAN±SD	92±5	158±22	20±2	21±1	12.5±3	5.6±1	50±5	9.4±1	2.1±.2	3.0±.1	0.9±.5	
BR8	89	196	ND	ND	13.1	ND	ND	9.7	2.1	ND	ND	ND
BR13AM ***	79	ND	ND	ND	12.8	ND	ND	ND	ND	ND	ND	ND
BR13PM ***	ND	ND	ND	ND	ND	ND	ND	8.7	1.8	ND	ND	ND
BR14PM **								8.5	1.6			
BR15PM *								8.5	1.5			
BR21	77	ND	ND	ND	16.3	ND	ND	ND	ND	ND	ND	ND
BR27	90	191	16	26	14.2	5.3	51	8.6	1.8	4.1	0.9	ND
R+0 R+1 PM	96	151	35	16	11.1	5.3	58	8.7	1.8	3.9	0.8	ND
R+6	88	198	42	23	12.6	7.2	59	8.7	1.8	4.1	1.1	ND
R+13	85	143	28	31	11.0	6.8	53	8.4	2.0	3.9	0.7	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
1.3	116	164	283	142.0	4.5	106	48.6	Normal	1.93
0.8	112	163	293	142.0	3.9	109	76.0	Normal	1.91
1.4	104	146	295	142.0	4.2	105	75.0	Normal	2.04
1.2±.3	111±6	158±10	290±6	142.0±0	4.2±.3	107±2	66.5±16		1.96±.07
ND	ND	ND	292	143.5	4.0	104	90.0	Normal	
ND	ND	ND	283	140.0	3.9	103	90.0	Normal	1.97
ND	ND	ND	293	142.0	4.5	103	ND	Normal	
ND	ND	ND	293	141.5	4.1	106		Normal	
			288	139.0	3.9	100		Normal	
ND	ND	ND	285	139.0	3.9	102	93.0	Normal	1.98
1.1	30	95	286	139.0	3.9	102	92.0	Normal	1.80
1.1	469	106	291	141.0	3.9	106	55.0	Normal	2.03 1.98
1.3	1543	192	292	140.0	4.3	104	53.0	Normal	1.89
1.3	264	183	289	142.0	3.9	103	58.0	Normal	1.82

SUBJECT 2

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MU/ML	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PC
F-25	81	128	18	12	15.4	5.6	80	9.5	2.0	3.5	0.5	ND
F-14	92	110	19	15	16.4	5.7	79	9.3	2.0	3.9	0.7	ND
F-0	85	150	21	17	20.1	5.3	90	9.4	2.0	4.3	0.5	ND
MEAN±SD	86±6	129±20	19±2	15±3	17.3±2	5.5±.2	83±6	9.4±.1	2.0±0	3.9±.4	0.6±.1	
BR8	81	154	ND	ND	15.7	ND	ND	10.0	2.0	ND	ND	ND
BR13AM**	84	ND	ND	ND	17.3	ND	ND	ND	ND	ND	ND	ND
BR13PM**								9.1	1.6			
BR14PM*								9.5	1.5			
BR15PM***								9.3	1.4			
BR21	80	ND	ND	ND	19.2	ND	ND			ND	ND	ND
BR27	87	153	15	16	16.3	5.4	76	9.0	1.8	3.9	0.7	ND
R+0												
R+1 PM	88	131	13	8	13.6	5.5	80	9.2	1.6	3.4	0.7	ND
R+6	90	177	23	16	18.0	6.5	89	9.6	1.9	3.6	0.7	ND
R+13	87	129	14	15	14.5	5.5	93	ND	ND	3.0	0.6	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
0.9	345	162	288	147.5	4.1	103	58.7	Normal	2.07
0.8	273	167	297	142.0	4.2	105	71.5	Normal	2.02
1.3	377	162	298	141.0	4.1	105	56.0	Normal	2.01
.0±.3	332±53	164±3	294±6	143.5±4	4.1±.1	104±1	62.1±8		2.03±.03
ND	ND	ND	292	143.5	4.3	104	69.0	Normal	
ND	ND	ND	284	140.0	4.2	102	82.0	Normal	2.06
			291	144.0	4.1	104		Normal	
			292	139.0	3.9	102		Normal	
			289	139.0	4.0	102		Normal	
ND	ND	ND	285	138.5	4.0	102	133.0	Normal	1.92
0.9	79	118	288	139.0	4.0	99	82.0	Normal	1.92
									2.06
1.0	111	72	292	141.0	4.2	101	77.0	Normal	2.08
1.2	313	153	294	140.0	4.3	103	47.0	Normal	1.98
0.7	115	134	291	142.0	4.0	102	64.0	Normal	1.93

SUBJECT 3

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MG/PCT	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PCT
F-25	96	118	18	13	9.6	4.9	54	9.4	2.2	2.3	0.7	ND
F-14	95	94	17	13	11.2	4.6	48	8.9	2.1	3.0	0.5	ND
F-0	94	131	18	21	9.9	5.4	53	9.4	2.2	3.1	0.6	ND
MEAN±SD	95±1	114±19	18±1	16±5	10.2±.9	5.0±.4	52±3	9.2±.3	2.2±.1	2.8±.4	0.6±.1	
BR8	90	136	ND	ND	9.8	ND	ND	9.8	2.2	ND	ND	ND
BR13 AM*	90	ND	ND	ND	12.5	ND	ND	ND	ND	ND	ND	ND
BR13PM *								8.9	1.7			
BR14PM ***								8.5	1.5			
BR15PM **								7.9	1.3			
BR21	89	ND	ND	ND	10.8	ND	ND			ND	ND	ND
BR27	87	157	14	17	10.7	5.6	51	8.7	1.9	3.7	0.6	ND
R+0												
R+1 PM	95	138	17	14	7.5	5.1	58	9.0	1.7	4.0	0.7	ND
R+6	101	145	18	16	10.5	6.5	65	8.8	1.9	3.2	0.5	ND
R+13	96	115	14	16	9.8	5.5	67	8.7	2.1	3.4	0.3	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
0.9	203	170	288	147.0	4.3	103	70.6	Normal	1.97
0.8	163	153	296	144.0	4.1	107	35.9	Normal	1.97
1.4	163	139	296	142.0	4.3	106	46.0	Normal	1.95
1.0±.3	176±23	154±16	293±5	144.3±3	4.2±.1	105±2	50.8±18		1.96±.01
ND	ND	ND	291	142.0	4.2	105	ND	Normal	
ND	ND	ND	286	139.5	4.2	103	116.0	Normal	1.99
			292	139.0	3.6	102		Normal	
			287	138.5	4.0	103		Normal	
			286	139.5	3.5	102		Normal	
ND	ND	ND	283	139.5	3.8	101	99.0	Normal	1.89
1.2	77	99	286	140.0	3.6	100	76.0	Normal	1.86
1.0	177	128	290	141.0	3.7	104	108.0	Normal	1.95 2.06
1.3	137	143	291	140.5	3.8	103	67.0	Normal	1.90
1.3	141	164	290	142.0	3.7	101	97.0	Normal	1.90

SUBJECT 4

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MU/ML	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PCT
F-25	83	132	19	22	16.0	5.4	80	9.4	2.2	3.7	0.8	ND
F-14	85	181	13	16	15.2	6.2	85	9.7	2.2	4.0	0.6	ND
F-0	90	184	13	15	14.1	6.4	79	9.5	2.3	4.1	0.3	ND
MEAN±SD	86±4	166±29	15±3	18±4	15.1±1	6.0±.5	82±3	9.5±.2	2.2±.1	3.9±.2	0.6±.3	
BR7	88	211	12	14	15.0	6.1	100	9.8	2.2	4.5	0.2	ND
BR13 AM***								9.2	1.7			
BR13PM ***								8.7	1.8			
BR14PM **								7.9	1.5			
BR15PM *								8.4	1.7			
BR21	88	188	12	14	18.2	6.6	72	9.2	2.2	ND	0.2	ND
BR27	78	259	10	17	14.0	6.1	78	8.7	1.7	5.0	0.4	ND
R+0												
R+1 PM	81	232	17	19	13.3	6.4	76	9.3	2.0	4.3	0.5	ND
R+6	88	171	14	16	15.9	8.7	75	9.1	2.3	4.7	0.4	ND
R+13	89	172	12	14	11.1	6.7	96	8.3	2.1	4.1	0.3	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
1.0	236	154	291	143.5	4.2	107	47.0	Normal	1.97
1.1	72	141	293	142.0	4.7	106	80.1	Normal	2.05
1.4	88	140	294	143.0	4.7	104	101.0	Normal	2.03
1.2±.2	132±90	145±8	293±2	146.2±6	4.5±.3	106±2	76.0±27		2.02±.04
1.2	50	140	285	138.0	4.6	101	129.0	Normal	
			295	141.0	4.4	106		Normal	2.00
			294	139.5	4.3	106		Normal	
			291	140	4.1	103		Normal	
			289	139.5	4.2	102		Normal	
1.2	37	102	286	138.0	4.4	101	128.0	Normal	1.86
1.1	45	120	293	139.5	4.1	103	77.0	Normal	1.84
									1.98
1.3	174	118	291	139.0	4.4	103	109.0	Normal	2.02
1.3	174	155	289	141.0	4.4	104	74.0	Normal	1.93
1.1	127	149	287	139.0	4.5	106	65.0	Normal	1.98

SUBJECT 5

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MU/ML	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PC
F-25	85	164	17	17	13.5	6.1	51	8.9	1.9	3.8	0.4	ND
F-14	85	141	15	16	16.5	6.0	52	9.4	1.9	3.3	0.3	ND
F-0	80	134	17	12	11.5	6.0	58	9.3	2.0	3.9	0.3	ND
MEAN±SD	83±3	146±16	16±1	15±3	13.8±3	6.0±.1	54±4	9.2±.3	1.9±.1	3.7±.3	0.3±.1	
BR8	79	181	14	12	15.8	6.0	70	9.1	1.9	4.3	0.3	ND
BR13 AM**								8.9	1.4			
BR13PM **								7.9	1.4			
BR14PM *								7.7	1.2			
BR15PM ***								8.2	1.4			
BR21	98	164	21	20	14.0	5.8	48	8.8	1.8	ND	0.2	ND
BR27	74	201	14	18	11.9	5.7	60	8.4	1.4	4.3	0.2	ND
R+0 R+1 PM	85	179	24	19	11.5	6.2	59	8.6	1.8	4.0	0.4	ND
R+6	82	145	17	16	10.7	6.2	56	8.7	1.7	3.6	0.3	ND
R+13	85	139	16	14	15.9	6.9	66	7.8	1.8	4.4	0.3	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
1.2	87	158	289	140.5	4.1	105	120.0	Normal	1.91
1.1	69	152	292	141.0	4.8	105	127.4	Normal	2.10
1.3	98	139	290	140.0	4.1	105	147.0	Normal	1.95
1.2±.1	85±15	150±10	290±2	140.5±.5	4.3±.4	105±0	131.5±14		1.99±.10
1.2	81	153	288	138.0	4.5	100	149.0	Normal	
			287	138.5	4.1	105		Normal	1.96
			289	138.0	4.0	105		Normal	
			287	138.5	3.6	102		Normal	
			285	138.5	3.9	103		Normal	
1.1	60	199	282	137.0	4.7	101	149.0	Normal	1.74
1.1	50	121	292	141.0	4.0	102	122.0	Normal	1.78
									1.88
1.3	242	196	288	138.5	4.0	103	169.0	Normal	1.90
1.3	77	163	284	140.0	3.7	103	173.0	Normal	1.91
1.2	247	179	290	140.0	4.1	107	131.0	Normal	1.93

SUBJECT 6

DATE	GLU MG/PCT	CHOL MG/PCT	SGOT MU/ML	SGPT MU/ML	BUN MG/PCT	URIC ACID MG/PCT	ALK PHOS IU	CA MG/PCT	MG MG/PCT	PO4 MG/PCT	BILI T MG/PCT	BILI D MG/PCT
F-25	85	134	33	22	18.3	6.4	40	9.5	1.9	3.3	0.7	ND
F-14	90	158	18	22	12.9	5.4	48	9.4	2.0	2.3	0.5	ND
F-0	89	217	14	18	13.7	6.1	28	10.0	2.1	3.8	0.5	ND
MEAN±SD	88±3	170±43	22±10	21±2	15.0±3	6.0±.5	39±10	9.6±.3	2.0±.1	3.1±.8	0.6±.1	
BR7	94	147	22	25	16.4	5.8	58	9.9	1.9	3.9	0.2	ND
BR13AM*								9.5	1.5			
BR13PM*								8.4	1.3			
BR14PM***								8.3	1.4			
BR15PM**								7.9	1.5			
BR21	95	176	29	66	16.0	6.0	41	9.0	1.8	3.6	0.1	ND
BR27	95	215	25	62	14.1	6.0	52	8.7	1.5	4.0	0.3	ND
R+0 R+1 PM	90	178	32	66	15.7	6.3	47	9.0	1.8	4.1	0.3	ND
R+6	96	150	21	47	14.8	7.9	48	8.7	1.8	3.2	0.6	ND
R+13	94	149	15	37	14.9	6.4	53	8.5	1.8	4.3	0.4	ND

*Nothing
**Saline
***Saline+LBNP

CREAT MG/PCT	CPK MU/ML	LDH MU/ML	OSMO MOSM	NA MEQ/L	K MEQ/L	CL MEQ/L	TRIGLY MG/PCT	TURB	IONIZED CA MEQ/L
1.1	596	154	286	142.5	4.1	100	61.0	Normal	1.93
1.1	115	128	298	144.5	4.5	106	96.6	Normal	2.13
1.2	64	109	299	145.0	4.5	106	97.0	Normal	2.03
1.1±.1	258±294	130±23	294±7	144.0±1	4.4±.2	104±3	84.9±21		2.03±.10
1.2	65	104	287	140.0	4.7	100	88.0	Normal	
			292	140.5	4.2	102		Normal	2.03
			290	139.5	3.9	102		Normal	
			288	140.0	4.0	100		Normal	
			291	142.0	4.3	106		Normal	
1.3	40	100	286	140.0	4.2	101	97.0	Normal	1.85
1.3	45	100	297	141.5	4.1	102	146.0	Normal	1.81
1.1	214	214	294	140.0	4.4	104	149.0	Normal	1.89 1.94
1.1	94	149	288	140.0	3.9	103	96.0	Normal	1.84
1.3	84	122	291	141.0	4.2	104	131.0	Normal	1.96

TABLE VIII

PLASMA/SERUM PARAMETERS

Significance Differences

	BR8	BR21	BR27	R+0	R+1	R+6	R+13
Angiotensin I	p< .001	<.001	<.05	*		<.01	
Cortisol	*	<.001		*	<.005	<.025	
Aldosterone				*			
Insulin	*	*		*	<.05		
HGH	*	*		*			
T3	*	*		*			
T4	*	*		*		<.05	
Glucose				*			
Cholesterol	<.025	*	<.001	*	<.05		
SGOT	*	*		*	<.05	<.05	
SGPT	*	*		*			
BUN		<.05		*	<.025		
Uric Acid	*	*		*		<.001	
Alkaline Phosphate	*	*		*			<.001
Calcium	<.025	*	<.001	*	<.005	<.001	<.001
Magnesium		*	<.001	*	<.001	<.001	<.05
Inorganic Phosphate	*	*	<.001	*	<.01		<.025
Total Bilirubin	*	*		*			<.0025
Creatinine	*	*		*		<.005	
CPK	*	*		*			
LDH	*	*	<.01	*			
Osmolality	<.025	<.001		*			
Sodium				*			
Potassium			<.01	*			
Chloride	<.001	<.001	<.001	*		<.025	
Triglycerides	<.025	<.001	<.05	*	<.005		
Ionized Calcium	*	<.001	<.001			<.005	<.025

*Comparison Not Done, Incomplete or No Data Available

METABOLIC BALANCE

BAYLOR BEDREST - PHASE II

H.O. Wheeler[1] and E.B. Smith[2]

[1]Life Sciences Directorate, NASA-JSC, Houston, Texas

[2]Life Sciences Directorate, Technology Incorporated, Houston, Texas

RESULTS

The Metabolic Balance portion of the Baylor Bedrest-Phase II was originally designed to measure and report the body weight, fecal weight, water, nitrogen, phosphorus, sodium, potassium, magnesium, chloride, and calcium balances. Due to personnel cut-backs the original goals were not obtained in this study.

The study accomplished the following: a) fecal samples were obtained, and stabilized, for the entire experimental period of 59 days, b) the metabolic balance (water, phosphorus, sodium, potassium, magnesium, and calcium) were only completed, following Skylab protocols, for the "pre-bed" phase. The collected and stabilized fecal samples for the "in-bed" and "post-bed" phase were forwarded to the USPHS Hospital, San Francisco, Laboratories for analyses (Ca, P, and N). The data received from San Francisco may have possible errors built into the answers due to laboratory to laboratory variability in procedures, analysis, and sample preparation. The data included in this report is for subject #1 through #6. The 21 day "pre" period is allocated as follows: a) pre 1-5 days, b) pre 6-11 days, c) pre 12-17 days, and d) total pre 1-17 days. The time periods were chosen to coincide with the Skylab data points. The tables demonstrate, for each quantity of metabolite, as to a) intake, b) fecal, c) urine, and d) delta (intake-output (fecal+urine)=delta). The second group of data in-bed and post-bed are the results obtained from the USPHS, San Francisco. All stabilized biological samples that this laboratory was responsible for have been shipped to USPHS Hospital, San Francisco, CA.

DISCUSSION

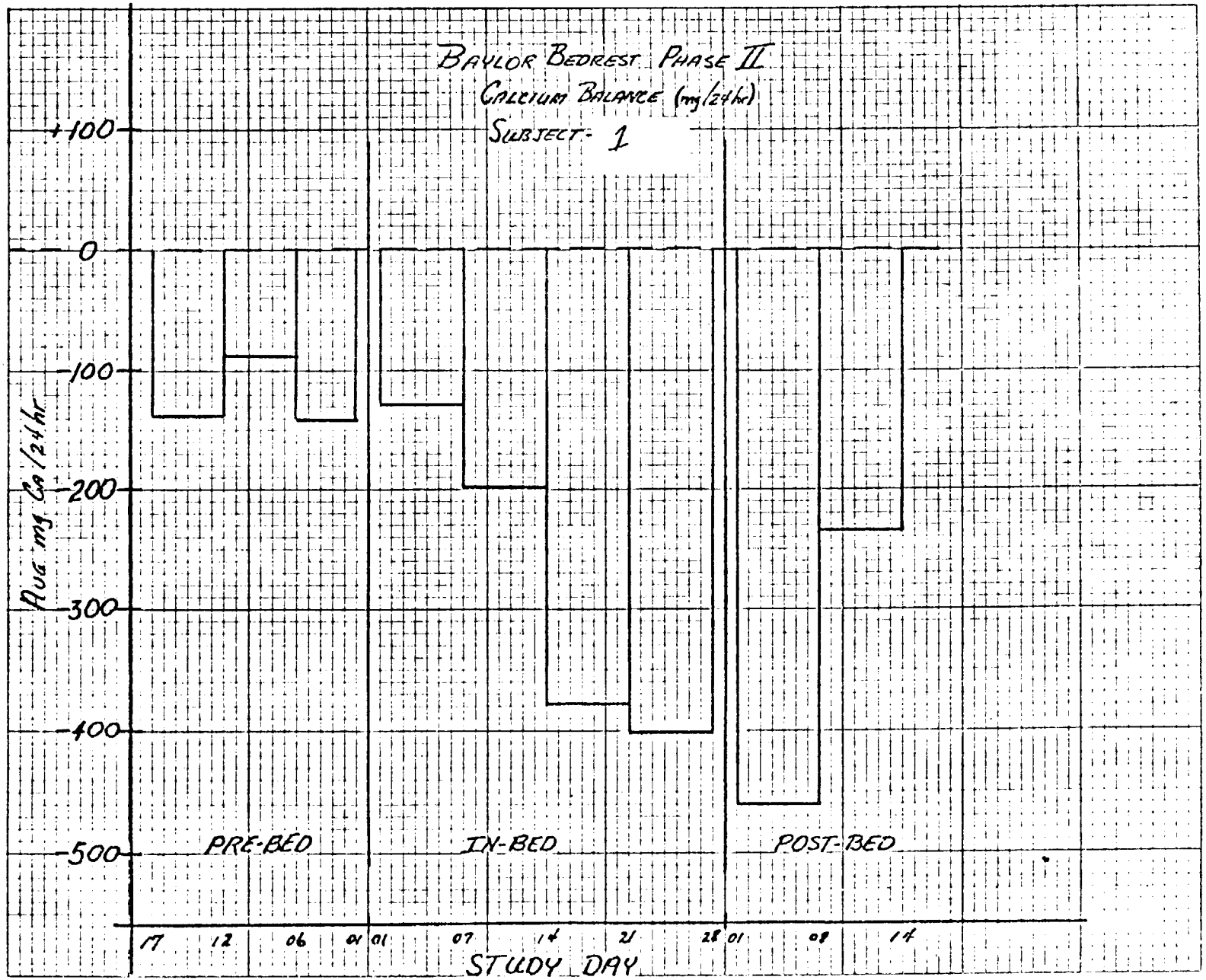
The only metabolite balance to be considered abnormal during the "pre-bed" experimental period is the calcium. It is clearly demonstrated that the "normal" calcium metabolic profile, under the conditions of this study, is termed a negative calcium balance. Negative balance being that a greater amount of dietary calcium is being eliminated through the feces and urine that is being injected by the subject.

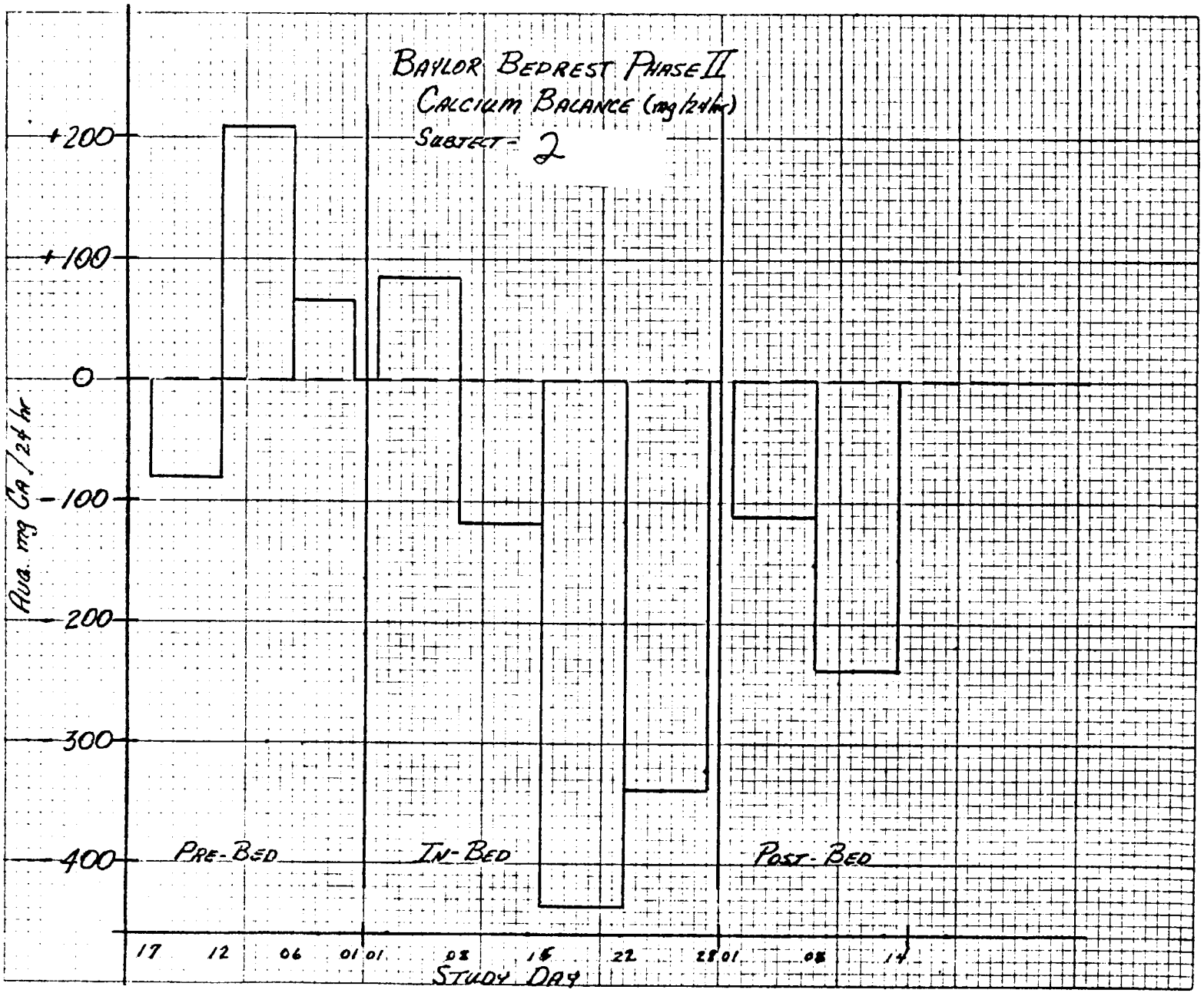
To determine why the negative calcium balance became apparent in the "pre-bed" phase instead of the "in-bed" phase as originally postulated. In observation of numerous experimental conditions it was determined that it was due to a improper dietary Calcium-Phosphorus (C:P) ratio intake. The National Research Council (NRC) recommends a C:P ratio of 1:1 with upper limits of 1:2. It was determined that diet utilized in this study is >1:2 C:P dietary ratio. To substantiate this conclusion a look at all data collected pertaining to metabolic studies involving the "Skylab" diet was examined. A total of 533 individual data points [in - (fecal+urine)=delta] for a "pre" study phase in which the "Skylab" diet was observed and taken into consideration. It demonstrated that a negative calcium metabolic balance was the normal condition when utilizing the >1:2 Ca-P ratio "Skylab" diet.

The enclosed calcium balance graphs show the magnitude of the negative calcium balance throughout the Phase II study. Again it should be pointed out that the "pre" data is on an absolute dry weight basis while the "in" and "post" analytical data are on a freeze-dried basis.

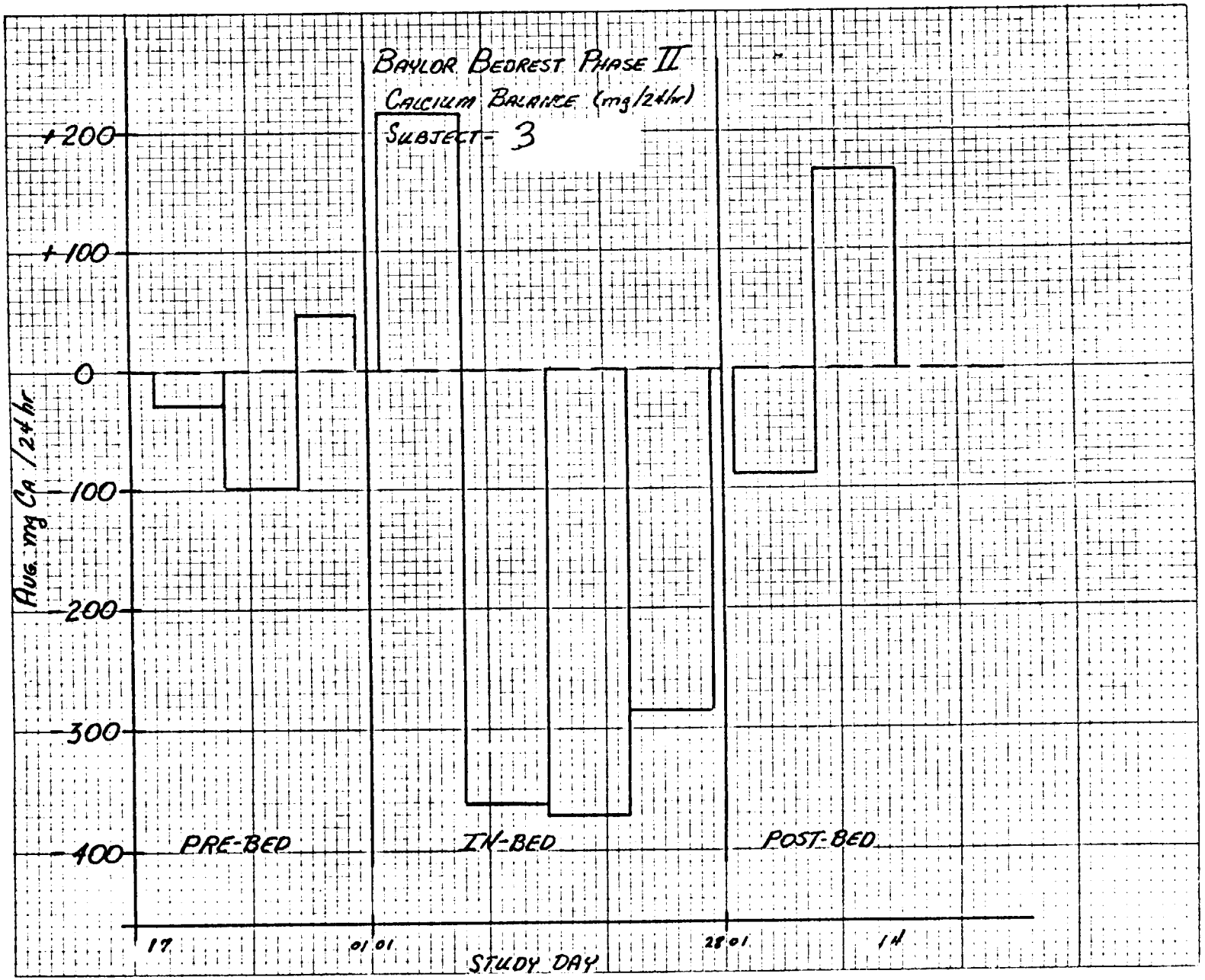
CONCLUSIONS

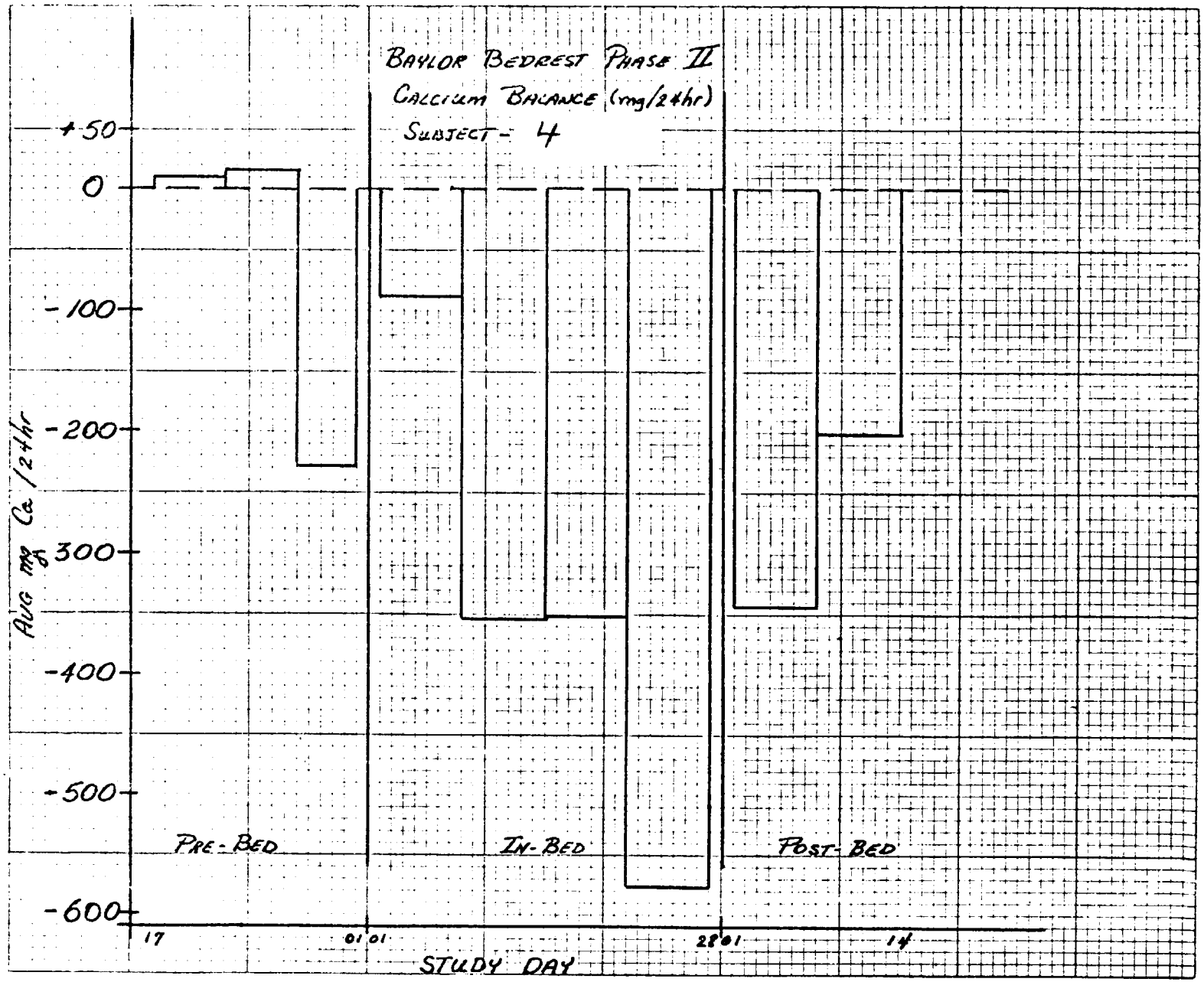
It is concluded that the dietary Ca:P ratio congributed to the negative calcium balance in all subjects. No conclusions on the other experimental measurements can be drawn due to lack of data. All physiological data of this study should be examined under the knowledge of this dietary anomaly (Ca:P of >1:2 ratio) and realize the data collected was outside the so-called "normal" conditions.

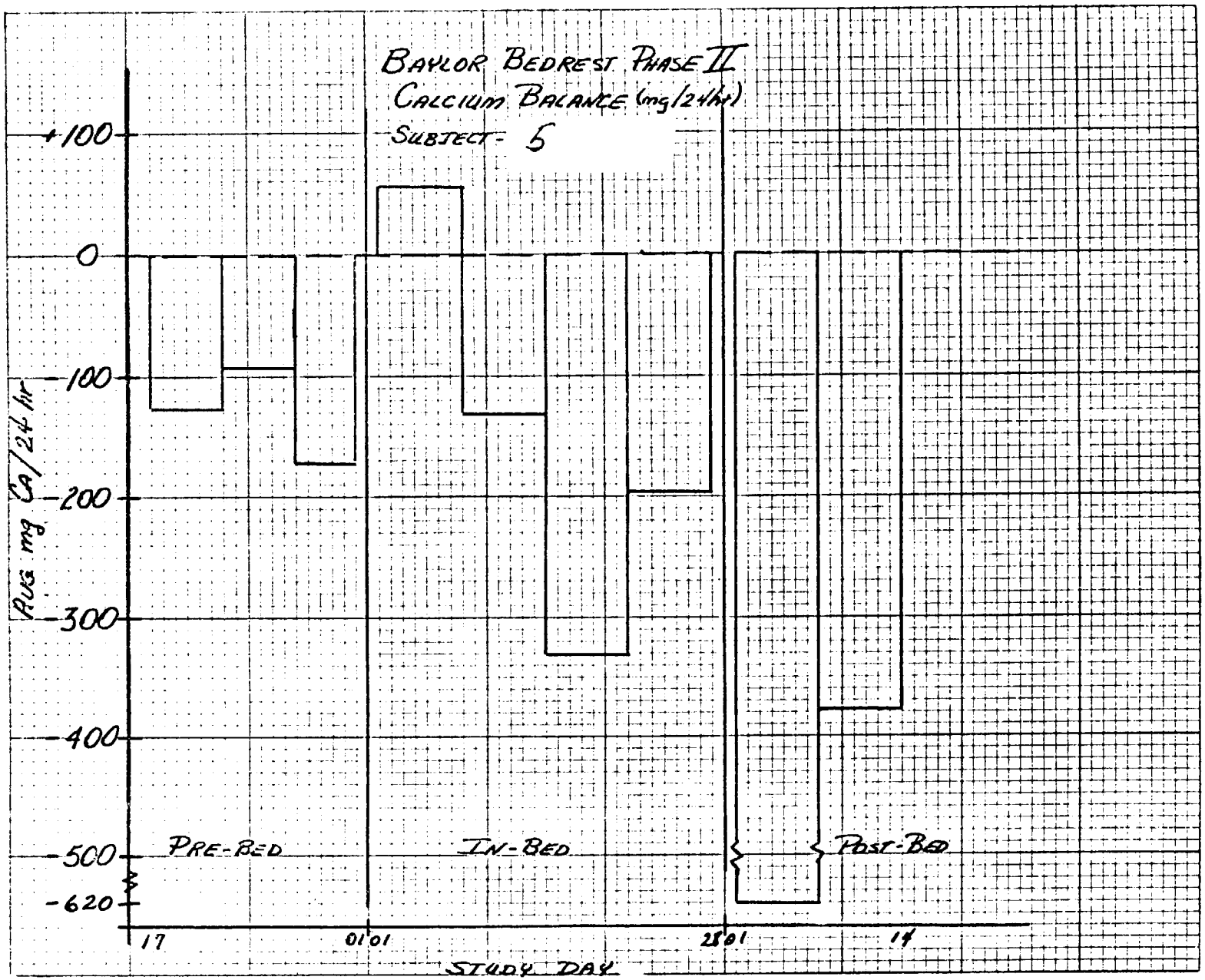

BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT- 1
+100
0
-100
-200
-300
-400
-500
Avg mg Ca/24hr
PRE-BED
IN-BED
POST-BED
17
12
06
01
01
07
14
21
28
01
08
14
STUDY DAY


BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT - 2
+200
+100
0
-100
-200
-300
-400
AVG. mg Ca / 24 hr
PRE-BED
IN-BED
POST-BED
17
12
06
01
01
08
15
22
28
01
08
14
STUDY DAY

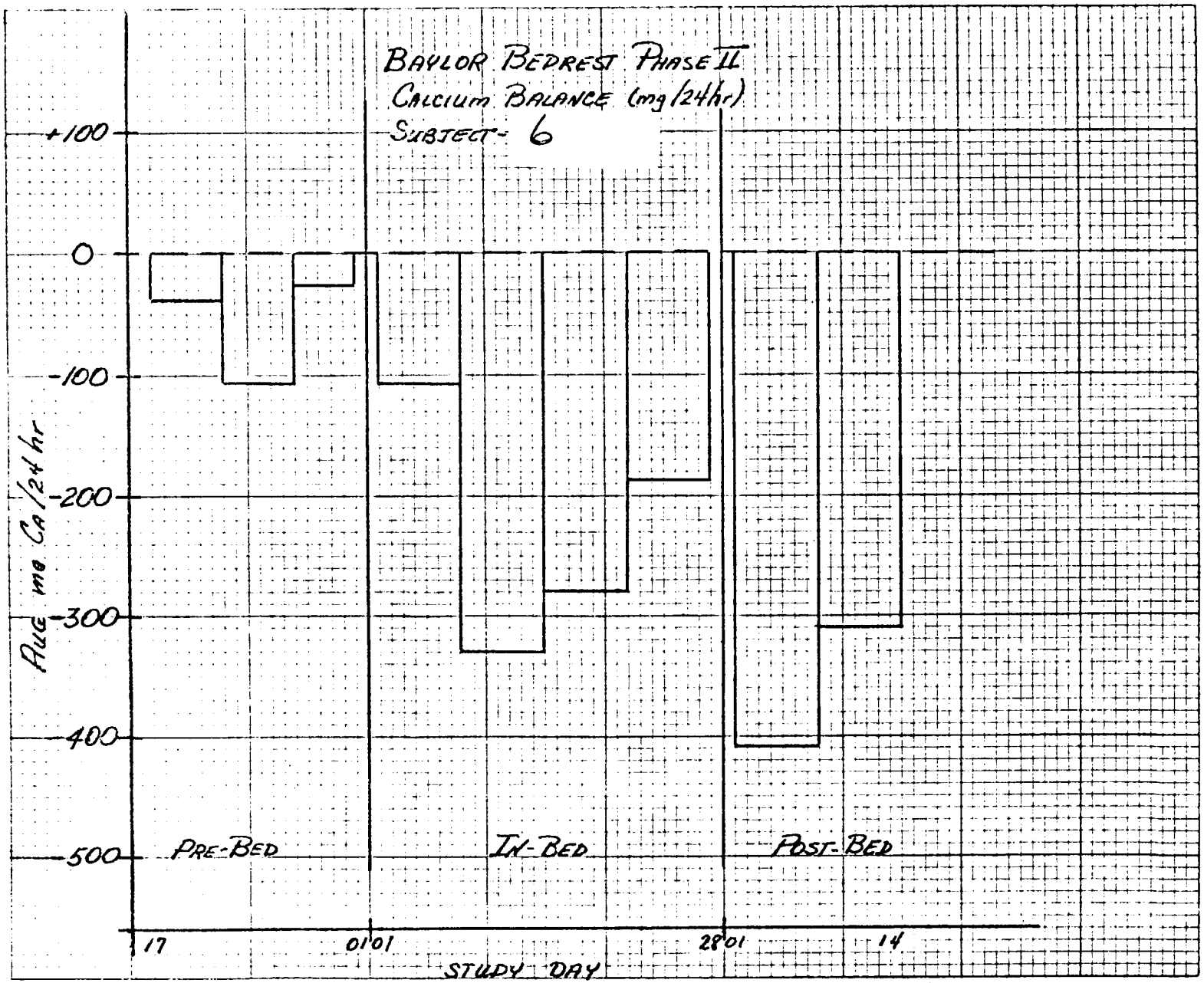
BEE 10x10


BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT - 3
+200
+100
0
-100
-200
-300
-400
AVG. mg CA /24 hr
PRE-BED
IN-BED
POST-BED
17
01 01
28 01
14
STUDY DAY


BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT - 4
+50
0
-100
-200
-300
-400
-500
-600
AVG mg Ca /24hr
PRE-BED
IN-BED
POST-BED
17
01 01
28 01
14
STUDY DAY
BEE 10x10


BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT - 5
+100
0
-100
-200
-300
-400
-500
-620
AVG mg Ca/24 hr
PRE-BED
IN-BED
POST-BED
17
01 01
28 01
14
STUDY DAY

EEE 10x10


BAYLOR BEDREST PHASE II
CALCIUM BALANCE (mg/24hr)
SUBJECT- 6
+100
0
-100
-200
-300
-400
-500
AVG mg CA/24 hr
PRE-BED
IN-BED
POST-BED
17
01 01
28 01
14
STUDY DAY

K&E 10x10

BODY/FECAL

SUBJECT #1

STUDY DAY			BODY WT.	FECAL WT.
PRE	1-5	MEAN	76.1800	221.330
		SDEV	.604669	33.4880
		SIZE	5	5
		SUM	380.900	1106.65
	6-11	MEAN	76.3333	191.938
		SDEV	.295803	42.9057
		SIZE	6	6
		SUM	458.000	1151.63
	12-17	MEAN	76.7333	227.985
		SDEV	.281365	57.5664
		SIZE	6	6
		SUM	460.400	1367.91
TOTAL		MEAN	76.4294	213.305
		SDEV	.445566	46.5124
		SIZE	17	17
		SUM	1299.30	3626.19

SUBJECT #1

STUDY DAY			W-IN	W-FECAL	W-URINE	W-DELTA
PRE	1-5	MEAN	6652.19	176.000	4068.00	2408.20
		SDEV	934.775	28.8530	1256.15	638.756
		SIZE	5	5	5	5
		SUM	33261.0	880.000	20340.0	12041.0
	6-11	MEAN	6422.50	151.000	4275.00	1996.50
		SDEV	481.969	34.2111	758.254	490.698
		SIZE	6	6	6	6
		SUM	38535.0	906.000	25650.0	11979.0
	12-17	MEAN	6391.50	180.200	3987.50	2053.83
		SDEV	1090.93	45.9793	1215.30	348.228
		SIZE	6	6	6	6
		SUM	38349.0	1081.20	23925.0	12323.0
TOTAL		MEAN	6391.50	180.200	3987.50	2053.83
		SDEV	1090.93	45.9793	1215.30	348.228
		SIZE	6	6	6	6
		SUM	38349.0	1081.20	23925.0	12323.0

BAYLOR BEDREST PHASE II
Nitrogen Balance (g/24Hr)

SUBJECT #1

STUDY DAY			N-IN	N-FECAL	N-URINE	N-DELTA
PRE	1-5	MEAN	16.9400	0	12.53	0
		SDEV	.531801	0	1.370	0
		SIZE	5	0	5	0
		SUM	84.7000	0	62.68	0
	6-11	MEAN	16.9250	0	16.26	0
		SDEV	.743986	0	9.349	0
		SIZE	6	0	6	0
		SUM	101.550	0	97.61	0
	12-17	MEAN	16.9833	0	12.81	0
		SDEV	.693909	0	2.020	0
		SIZE	6	0	6	0
		SUM	101.900	0	76.90	0
TOTAL		MEAN	16.9500	0	13.95	0
		SDEV	.628299	0	5.673	0
		SIZE	17	0	17	0
		SUM	288.150	0	237.1	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #1

STUDY DAY		P-Intake	P-Fecal	P-Urine	P-Delta
Pre-Bed 12-17	Mean	1743	489	1225	29
	SDEV	71.8	97.9	143.8	172.0
	Size	6	6	6	6
Pre-Bed 06-11	Mean	1736	458	1150	129
	SDEV	88.0	153.5	194.9	224.7
	Size	6	6	6	6
Pre-Bed 01-05	Mean	1736	497	1075	164
	SDEV	109.1	74.2	101.8	133.4
	Size	5	5	5	5
Pre-Bed Total	Mean	1738	480	1155	104
	SDEV	83.8	109.7	157.4	181.5
	Size	17	17	17	17

BAYLOR DEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #1

STUDY DAY.			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	270.80	4.9360	162.59	103.20
		SDEV	21.856	1.8415	32.715	44.941
		SIZE	5	5	5	5
		SUM	1354.0	24.680	813.00	516.00
	6-11	MEAN	278.33	143.48	184.83	88.333
		SDEV	18.151	340.75	31.524	35.970
		SIZE	6	6	6	6
		SUM	1670.0	860.90	1109.0	530.00
	12-17	MEAN	282.33	6.4833	168.83	107.45
		SDEV	5.7503	2.1367	52.875	56.648
		SIZE	6	6	6	6
		SUM	1694.0	38.900	1013.0	644.70
TOTAL		MEAN	277.52	54.381	172.64	99.452
		SDEV	15.992	202.20	39.300	44.573
		SIZE	17	17	17	17
		SUM	4718.0	924.48	2935.0	1690.7

SKYLAB
Potassium Balance (mEq/24Hr.)

SUBJECT #1

STUDY DAY			K-IN	K-FECAL	K-URINE	K-DELTA
PRE	1-5	MEAN	109.39	19.444	73.799	16.000
		SDEV	13.667	2.7683	22.038	35.531
		SIZE	5	5	5	5
		SUM	547.00	97.220	369.00	80.000
	6-11	MEAN	109.33	18.766	75.500	15.333
		SDEV	10.782	4.8508	12.501	13.808
		SIZE	6	6	6	6
		SUM	656.00	112.60	453.00	92.000
	12-17	MEAN	107.66	21.000	72.833	19.583
		SDEV	14.719	4.7396	27.491	33.113
		SIZE	6	6	6	6
		SUM	646.00	126.00	437.00	117.50
TOTAL		MEAN	108.76	19.754	74.058	17.029
		SDEV	12.306	4.1553	20.194	26.864
		SIZE	17	17	17	17
		SUM	1849.0	335.82	1259.0	289.49

BAYLOR BEDREST PHASE II

Magnesium Balance (mg/24 hrs.)

SUBJECT #1

STUDY DAY		MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE 1-5	MEAN	31.800	20.474	11.160	.40000
	SDEV	3.7013	3.9923	2.0476	7.5696
	SIZE	5	5	5	5
	SUM	159.00	102.37	55.800	2.0000
6-11	MEAN	32.333	16.783	13.000	2.6666
	SDEV	4.0824	4.2667	1.6625	7.0616
	SIZE	6	6	6	6
	SUM	194.00	100.70	78.000	16.000
12-17	MEAN	32.166	19.083	13.233	-.216
	SDEV	4.0702	5.0594	1.8980	6.7454
	SIZE	6	6	6	6
	SUM	193.00	114.50	79.400	-1.30
TOTAL	MEAN	32.117	18.680	12.541	.98235
	SDEV	3.7229	4.4820	1.9729	6.7702
	SIZE	17	17	17	17
	SUM	546.00	317.57	213.20	16.699

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #1

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	231.20	0	127.79	0
		SDEV	22.465	0	47.012	0
		SIZE	5	0	5	0
		SUM	1156.0	0	639.00	0
	6-11	MEAN	238.16	0	145.33	0
		SDEV	21.775	0	28.535	0
		SIZE	6	0	6	0
		SUM	1429.0	0	872.00	0
	12-17	MEAN	243.16	0	134.16	0
		SDEV	17.736	0	54.966	0
		SIZE	6	0	6	0
		SUM	1459.0	0	805.00	0
TOTAL		MEAN	237.88	0	136.23	0
		SDEV	19.927	0	42.497	0
		SIZE	17	0	17	0
		SUM	4044.0	0	2316.0	0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT # 1

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Pre-Bed 12-17	Mean	833	670	301	-138
	SDEV	15.5	133.5	78.4	136.3
	Size	6	6	6	6
Pre-Bed 06-11	Mean	834	635	287	-88
	SDEV	9.2	204.4	45.9	213.8
	Size	6	6	6	6
Pre-Bed 01-05	Mean	842	649	298	-141
	SDEV	12.6	85.1	78.8	78.5
	Size	5	5	5	5
Pre-Bed Total	Mean	836	662	295	-121
	SDEV	12.5	144.6	64.6	149.3
	Size	17	17		17

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #1

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	820	636	313	-129
	SDEV	9.5	235.2	32.2	233.3
	Size	7	7	7	7
In-Bed 08-14	Mean	826	625	399	-198
	SDEV	16.2	259.5	70.3	213.1
	Size	7	7	7	7
In-Bed 15-21	Mean	837	736	479	-378
	SDEV	4.8	199.0	43.0	190.0
	Size	7	7	7	7
In-Bed 21-28	Mean	839	761	481	-402
	SDEV	3.6	338.8	76.3	383.3
	Size	7	7	7	7
In-Bed Total	Mean	831	690	418	-277
	SDEV	12.3	255.4	89.4	277.3
	Size	28	28	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #1

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	822	909	503	-460
	SDEV	30.2	231.9	214.8	376.3
	Size	7	6	7	7
Post-Bed 08-14	Mean	815	717	332	-234
	SDEV	48.3	164.6	50.7	150.4
	Size	7	7	7	7
Post-Bed Total	Mean	818	805	418	-347
	SDEV	38.8	214.2	174.1	299.4
	Size	14	13	14	14

BODY/FECAL

SUBJECT #2

STUDY DAY			BODY WT.	FECAL WT.
PRE	1-5	MEAN	69.1600	149.460
		SDEV	.068465	102.848
		SIZE	5	5
		SUM	345.800	747.300
	6-11	MEAN	68.9500	117.826
		SDEV	.451848	52.6779
		SIZE	6	6
		SUM	413.700	706.960
	12-17	MEAN	69.4000	187.903
		SDEV	.502078	74.2315
		SIZE	6	6
		SUM	416.400	1127.42
TOTAL		MEAN	69.1706	151.863
		SDEV	.428746	78.4661
		SIZE	17	17
		SUM	1175.90	2581.68

Water Balance (ml/24Hr.)

SUBJECT #2

STUDY DAY			W-IN	W-FECAL	W-URINE	W-DELTA
PRE	1-5	MEAN	2399.59	111.799	596.000	1691.79
		SDEV	311.548	83.7925	129.344	257.206
		SIZE	5	5	5	5
		SUM	11998.0	559.000	2980.00	8459.00
	6-11	MEAN	2362.33	86.6666	698.333	1577.33
		SDEV	606.403	44.2116	217.293	723.484
		SIZE	6	6	6	6
		SUM	14174.0	520.000	4190.00	9464.00
	12-17	MEAN	2513.33	145.316	910.833	1455.33
		SDEV	375.611	64.4256	234.274	361.214
		SIZE	6	6	6	6
		SUM	15080.0	871.900	5465.00	8732.00
TOTAL		MEAN	2426.58	114.758	743.235	1567.94
		SDEV	433.435	65.6662	232.708	480.068
		SIZE	17	17	17	17
		SUM	41252.0	1950.89	12635.0	26655.0

BAYLOR BEDREST PHASE II
Nitrogen Balance (g/24Hr)

SUBJECT #2

STUDY DAY		N-IN	N-FECAL	N-URINE	N-DELTA
PRE 1-5	MEAN	15.2000	0	8.424	0
	SDEV	.367370	0	2.649	0
	SIZE	5	0	5	0
	SUM	76.0000	0	42.12	0
6-11	MEAN	15.2666	0	9.283	0
	SDEV	.361564	0	2.383	0
	SIZE	6	0	6	0
	SUM	91.6000	0	55.70	0
12-17	MEAN	15.3500	0	11.54	0
	SDEV	.497127	0	1.542	0
	SIZE	6	0	6	0
	SUM	92.1000	0	69.25	0

TOTAL

MEAN	15.2764	0	9.827	0
SDEV	.394557	0	2.470	0
SIZE	17	0	17	0
SUM	259.700	0	167.0	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #2

STUDY DAY		P-Intake	P-Fecal	P-Urine	P-Delta
Pre-Bed 12-17	Mean	1526	621	824	81
	SDEV	76.9	134.1	108.9	157.6
	Size	6	6	6	6
Pre-Bed 06-11	Mean	1508	450	804	254
	SDEV	97.1	159.7	308.0	365.1
	Size	6	6	6	6
Pre-Bed 01-05	Mean	1486	553	674	259
	SDEV	81.0	300.8	266.6	298.8
	Size	5	5	5	
Pre-Bed Total	Mean	1508	541	755	194
	SDEV	81.9	204.4	233.4	281.4
	Size	17	17	17	17

BAYLOR BEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #2

STUDY DAY			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	227.59	7.0200	111.79	108.60
		SDEV	22.501	10.009	25.733	25.125
		SIZE	5	5	5	5
		SUM	1138.0	35.100	559.00	543.00
	6-11	MEAN	225.00	5.2333	122.16	97.666
		SDEV	21.250	4.7407	44.656	49.826
		SIZE	6	6	6	6
		SUM	1350.0	31.400	733.00	586.00
	12-17	MEAN	234.83	10.816	178.50	45.500
		SDEV	11.856	6.5645	32.303	37.750
		SIZE	6	6	6	6
		SUM	1409.0	64.900	1071.0	273.00
TOTAL		MEAN	229.23	7.7294	139.00	82.470
		SDEV	18.191	7.1837	45.137	46.813
		SIZE	17	17	17	17
		SUM	3897.0	131.40	2363.0	1402.0

BAYLOR BEDREST PHASE II

Potassium Balance (mEq/24Hr.)

SUBJECT #2

STUDY DAY			K-IN	K-FECAL	K-URINE	K-DELTA
PRE	1-5	MEAN	85.799	13.500	50.000	31.000
		SDEV	6.9785	10.642	5.9581	22.483
		SIZE	5	5	5	5
		SUM	429.00	67.500	250.00	155.00
	6-11	MEAN	86.833	13.383	56.833	16.750
		SDEV	6.7946	7.6077	16.067	12.797
		SIZE	6	6	6	6
		SUM	521.00	80.300	341.00	100.50
	12-17	MEAN	89.833	15.433	72.000	2.5000
		SDEV	6.8532	4.9998	5.8309	8.6890
		SIZE	6	6	6	6
		SUM	539.00	92.600	432.00	15.000
TOTAL		MEAN	87.588	14.141	60.176	15.911
		SDEV	6.6620	7.4286	13.753	18.439
		SIZE	17	17	17	17
		SUM	1489.0	240.40	1023.0	270.50

BAYLOR BEDREST PHASE II

Magnesium Balance (mEq/24Hr.)

SUBJECT #2

STUDY DAY			MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE	1-5	MEAN	28.199	22.600	6.5600	-1.00
		SDEV	4.2071	11.477	2.9432	8.7464
		SIZE	5	5	5	5
		SUM	141.00	113.00	32.800	-5.00
	6-11	MEAN	29.166	18.750	6.2500	4.0333
		SDEV	4.7504	6.2943	2.4873	5.3746
		SIZE	6	6	6	6
		SUM	175.00	112.50	37.500	24.200
	12-17	MEAN	29.833	24.550	17.450	-12.3
		SDEV	4.6224	4.2359	23.411	24.800
		SIZE	6	6	6	6
		SUM	179.00	147.30	104.70	-74.0
TOTAL		MEAN	29.117	21.929	10.294	-3.22
		SDEV	4.3139	7.5780	14.320	16.515
		SIZE	17	17	17	17
		SUM	495.00	372.80	175.00	-54.8

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #2

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	199.00	0	109.00	0
		SDEV	22.124	0	25.228	0
		SIZE	5	0	5	0
		SUM	995.00	0	545.00	0
	6-11	MEAN	191.33	0	109.83	0
		SDEV	19.724	0	47.880	0
		SIZE	6	0	6	0
		SUM	1148.0	0	659.00	0
	12-17	MEAN	204.33	0	168.83	0
		SDEV	16.585	0	34.002	0
		SIZE	6	0	6	0
		SUM	1226.0	0	1013.0	0
TOTAL		MEAN	198.17	0	130.41	0
		SDEV	19.023	0	45.743	0
		SIZE	17	0	17	0
		SUM	3369.0	0	2217.0	0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24Hr.)

SUBJECT #2

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Pre-Bed 12-17	Mean	793	709	164	-81
	SDEV	9.8	162.7	50.6	160.2
	Size	6	6	6	6
Pre-Bed 06-11	Mean	789	489	93	207
	SDEV	11.5	163.4	37.9	120.8
	Size	6	6	6	6
Pre-Bed 01-05	Mean	788	611	111	66
	SDEV	12.0	317.5	37.1	283.3
	Size	5	5	5	5
Pre-Bed Total	Mean	790	603	123	64
	SDEV	10.5	225.7	51.1	219.5
	Size	17	17	17	17

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #2

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	789	494	210	85
	SDEV	6.2	308.4	34.5	293.5
	Size	7	7	7	7
In-Bed 08-14	Mean	797	828	323	-117
	SDEV	13.7	697.6	49.8	686.7
	Size	7	5	7	7
In-Bed 15-21	Mean	787	899	451	-435
	SDEV	18.5	446.0	70.3	550.3
	Size	7	6	7	7
In-Bed 21-28	Mean	792	1286	396	-339
	SDEV	15.0	241.8	50.2	697.5
	Size	7	4	7	7
In-Bed Total	Mean	791	824	345	-201
	SDEV	13.8	504.1	104.5	584.4
	Size	28	22	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #2

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	790	1156	242	-112
	SDEV	10.3	163.3	94.0	658.9
	Size	7	4	7	7
Post-Bed 08-14	Mean	788	978	189	-239
	SDEV	8.6	484.6	48.4	571.4
	Size	7	6	7	7
Post-Bed Total	Mean	789	1049	215	-175
	SDEV	9.2	384.5	76.9	596.2
	Size	14	10	14	14

BODY/FECAL

SUBJECT #3

STUDY DAY			BODY WT.	FECAL WT.
PRE	1-5	MEAN	72.6200	223.480
		SDEV	.111803	59.4594
		SIZE	5	5
		SUM	363.100	1117.40
	6-11	MEAN	72.4000	199.578
		SDEV	.111803	59.2895
		SIZE	6	6
		SUM	434.400	1197.47
	12-17	MEAN	72.6000	245.042
		SDEV	.949780	129.370
		SIZE	6	5
		SUM	435.600	1225.21
TOTAL		MEAN	72.5353	221.255
		SDEV	.547386	83.4017
		SIZE	17	16
		SUM	1233.10	3540.08

BAYLOR BEDREST PHASE II

Water Balance (ml/24Hr.)

SUBJECT #3

STUDY DAY			W-IN	W-FECAL	W-URINE	W-DELTA
PRE	1-5	MEAN	3747.20	185.200	760.000	2782.00
		SDEV	886.762	51.9297	198.997	967.894
		SIZE	5	5	5	5
		SUM	18736.0	926.000	3800.00	13910.0
	6-11	MEAN	3002.00	161.500	1373.33	1467.16
		SDEV	646.061	52.9405	387.901	754.026
		SIZE	6	6	6	6
		SUM	18012.0	969.000	8240.00	8803.00
	12-17	MEAN	3308.33	200.980	1232.50	1908.33
		SDEV	760.331	110.585	393.926	703.222
		SIZE	6	5	6	6
		SUM	19850.0	1004.90	7395.00	11450.0
TOTAL		MEAN	3329.29	181.243	1143.23	2009.58
		SDEV	776.271	72.1488	417.316	931.148
		SIZE	17	16	17	17
		SUM	56598.0	2899.90	19435.0	34163.0

BAYLOR BEDREST PHASE II
Nitrogen Balance (g/24Hr)

SUBJECT #3

STUDY DAY			N-IN	N-FECAL	N-URINE	N-DELTA
PRE	1-5	MEAN	17.0200	0	9.114	0
		SDEV	.705101	0	2.779	0
		SIZE	5	0	5	0
		SUM	85.1000	0	45.57	0
	6-11	MEAN	17.0666	0	12.91	0
		SDEV	.691842	0	5.760	0
		SIZE	6	0	6	0
		SUM	102.400	0	77.50	0
	12-17	MEAN	17.4000	0	13.92	0
		SDEV	1.27903	0	2.892	0
		SIZE	6	0	6	0
		SUM	104.400	0	83.56	0
TOTAL		MEAN	17.1705	0	12.15	0
		SDEV	.903234	0	4.381	0
		SIZE	17	0	17	0
		SUM	291.900	0	206.6	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #3

STUDY DAY		P-Intake	P-Fecal	P-Urine	P-Delta
Pre-Bed 12-17	Mean	1761	500	937	408
	SDEV	41.3	234.1	522.6	729.5
	Size	6	5	6	6
Pre-Bed 06-11	Mean	1734	474	1117	145
	SDEV	77.7	109.3	433.5	397.5
	Size	6	6	6	6
Pre-Bed 01-05	Mean	1746	440	712	594
	SDEV	29.2	113.8	248.4	316.7
	Size	5	5	5	5
Pre-Bed Total	Mean	1747	471	934	370
	SDEV	52.6	150.5	432.9	525.2
	Size	17	16	17	17

BAYLOR BEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #3

STUDY DAY.			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	266.40	14.320	115.60	136.40
		SDEV	23.723	5.3802	43.661	34.746
		SIZE	5	5	5	5
		SUM	1332.0	71.600	578.00	682.00
	6-11	MEAN	274.16	8.1833	184.50	81.500
		SDEV	7.9603	5.6047	51.879	53.046
		SIZE	6	6	6	6
		SUM	1645.0	49.100	1107.0	489.00
	12-17	MEAN	269.66	15.280	187.66	69.333
		SDEV	21.676	9.4202	33.909	43.564
		SIZE	6	5	6	6
		SUM				
TOTAL		MEAN	270.29	12.318	165.35	93.352
		SDEV	17.828	7.2769	52.675	51.209
		SIZE	17	16	17	17
		SUM	4595.0	197.10	2811.0	1587.0

BAYLOR BEDREST PHASE II

Potassium Balance (mEq/24Hr.)

SUBJECT #3

STUDY DAY			K-IN	K-FECAL	K-URINE	K-DELTA
PRE	1-5	MEAN	106.00	12.819	51.199	42.000
		SDEV	16.232	4.4807	19.892	10.222
		SIZE	5	5	5	5
		SUM	530.00	64.100	256.00	210.00
	6-11	MEAN	102.16	13.116	61.500	27.549
		SDEV	15.445	6.5545	13.171	21.180
		SIZE	6	6	6	6
		SUM	613.00	78.700	369.00	165.29
	12-17	MEAN	103.83	15.180	69.666	21.666
		SDEV	14.497	7.0888	9.0700	25.049
		SIZE	6	5	6	6
		SUM	623.00	75.900	418.00	130.00
TOTAL		MEAN	103.88	13.668	61.352	29.723
		SDEV	14.443	5.8479	15.394	20.871
		SIZE	17	16	17	17
		SUM	1766.0	218.70	1043.0	505.30

BAYLOR BEDREST PHASE II

Magnesium Balance (mEq/24Hr.)

SUBJECT #3

STUDY DAY		MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE 1-5	MEAN	32.600	17.340	7.9000	7.6000
	SDEV	2.3021	3.6541	3.4713	6.2289
	SIZE	5	5	5	5
	SUM	163.00	86.700	39.500	38.000
6-11	MEAN	32.166	17.416	12.400	2.3833
	SDEV	2.9268	4.4750	4.1679	5.0201
	SIZE	6	6	6	6
	SUM	193.00	104.50	74.400	14.299
12-17	MEAN	32.166	19.760	12.766	3.0000
	SDEV	2.3166	10.406	3.6075	13.461
	SIZE	6	5	6	6
	SUM	193.00	98.800	76.600	18.000
TOTAL	MEAN	32.294	18.125	11.205	4.1352
	SDEV	2.3917	6.3569	4.1679	8.9211
	SIZE	17	16	17	17
	SUM	549.00	290.00	190.50	70.300

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #3

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	222.20	0	120.20	0
		SDEV	26.817	0	40.702	0
		SIZE	5	0	5	0
		SUM	1111.0	0	601.00	0
	6-11	MEAN	231.16	0	178.33	0
		SDEV	11.822	0	48.714	0
		SIZE	6	0	6	0
		SUM	1387.0	0	1070.0	0
	12-17	MEAN	226.83	0	183.83	0
		SDEV	28.895	0	31.517	0
		SIZE	6	0	6	0
		SUM	1361.0	0	1103.0	0
TOTAL		MEAN	227.00	0	163.17	0
		SDEV	22.318	0	47.849	0
		SIZE	17	0	17	0
		SUM	3859.0	0	2774.0	0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJEDT #3

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Pre-Bed 12-17	Mean	788	582	332	-29
	SDEV	12.4	278.4	96.7	356.9
	Size	6	5	6	6
Pre-Bed 06-11	Mean	785	536	348	-99
	SDEV	5.8	115.4	101.8	126.3
	Size	6	6	6	6
Pre-Bed 01-05	Mean	782	493	242	47
	SDEV	53.8	99.1	63.7	112.8
	Size	5	5	5	5
Pre-Bed Total	Mean	785	537	311	-31
	SDEV	28.1	170.5	96.7	227.2
	Size	17	16	17	17

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #3

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	778	399	390	216
	SDEV	5.9	330.6	49.4	317.8
	Size	7	3	7	7
In-Bed 08-14	Mean	777	1215	444	-361
	SDEV	2.4	536.0	42.8	740.3
	Size	7	4	7	7
In-Bed 15-21	Mean	782	1124	512	-372
	SDEV	13.8	403.5	110.0	750.5
	Size	7	4	7	7
In-Bed 21-28	Mean	778	989	498	-285
	SDEV	11.2	316.7	146.6	505.9
	Size	7	4	7	7
In-Bed Total	Mean	779	967	461	-200
	SDEV	9.1	476.9	104.0	622.5
	Size	28	15	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #3

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	780	730	228	-88
	SDEV	16.7	277.9	108.4	402.5
	Size	7	6	7	7
Post-Bed 08-14	Mean	780	496	189	166
	SDEV	5.3	213.5	59.6	271.1
	Size	7	6	7	7
Post-Bed Total	Mean	780	613	216	39
	SDEV	11.9	266.2	80.3	355.2
	Size	14	12	14	14

SUBJECT #4

STUDY DAY			BODY WT.	FECAL WT.
PRE	1-5	MEAN	61.5000	190.040
		SDEV	.273861	74.9309
		SIZE	5	5
		SUM	307.500	950.200
	6-11	MEAN	61.5166	123.583
		SDEV	.102062	69.9095
		SIZE	6	6
		SUM	369.100	741.500
	12-17	MEAN	61.4667	156.150
		SDEV	.384599	53.8681
		SIZE	6	6
		SUM	368.800	936.900
TOTAL		MEAN	61.4941	154.623
		SDEV	.264297	67.7638
		SIZE	17	17
		SUM	1045.40	2628.60

BAYLOR BEDREST PHASE II

Water Balance (ml/24Hr.)

SUBJECT #4

STUDY DAY			W-IN	W-FECAL	W-URINE	W-DELTA
PRE	1-5	MEAN	3489.20	148.000	1226.00	2115.59
		SDEV	504.678	62.2494	386.238	830.932
		SIZE	5	5	5	5
		SUM	17446.0	740.000	6130.00	10578.0
	6-11	MEAN	3197.33	95.0000	1832.50	1269.83
		SDEV	328.591	58.4328	322.147	414.978
		SIZE	6	6	6	6
		SUM	19184.0	570.000	10995.0	7619.00
	12-17	MEAN	3024.16	124.333	1730.00	1169.83
		SDEV	605.514	46.5861	557.101	377.595
		SIZE	6	6	6	6
		SUM	18145.0	746.000	10380.0	7019.00
TOTAL		MEAN	3222.05	120.941	1617.94	1483.29
		SDEV	499.211	56.5635	486.508	670.714
		SIZE	17	17	17	17
		SUM	54775.0	2056.0	27505.0	25216.0

BAYLOR BEDREST PHASE II

Nitrogen Balance (g/24Hr)

SUBJECT #4

STUDY DAY		N-IN	N-FECAL	N-URINE	N-DELTA
PRE 1-5	MEAN	16.2800	0	12.06	0
	SDEV	.725848	0	2.380	0
	SIZE	5	0	5	0
	SUM	81.4000	0	60.32	0
6-11	MEAN	16.2000	0	12.96	0
	SDEV	.784783	0	1.098	0
	SIZE	6	0	6	0
	SUM	97.2000	0	77.76	0
12-17	MEAN	15.9683	0	12.09	0
	SDEV	.666243	0	1.628	0
	SIZE	6	0	6	0
	SUM	95.8100	0	72.57	0
TOTAL					
	MEAN	16.1417	0	12.39	0
	SDEV	.693738	0	1.676	0
	SIZE	17	0	17	0
	SUM	274.410	0	210.6	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #4

STUDY DAY			P-Intake	P-Fecal	P-Urine	P-Delta
Pre-Bed	12-17	Mean	1668	584	1004	80
		SDEV	121.8	144.4	110.9	98.6
		Size	6	6	6	6
Pre-Bed	06-11	Mean	1706	568	1021	117
		SDEV	88.5	270.2	186.6	220.7
		Size	6	6	6	6
Pre-Bed	01-05	Mean	1712	896	921	-105
		SDEV	103.1	273.9	234.9	393.3
		Size	5	5	5	5
Pre-Bed	Total	Mean	1694	670	985	39
		SDEV	100.8	265.9	174.4	257.4
		Size	17	17	17	17

BAYLOR BEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #4

STUDY DAY.			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	252.79	8.0800	193.40	51.399
		SDEV	18.740	5.5233	60.541	62.564
		SIZE	5	5	5	5
		SUM	1264.0	40.400	967.00	257.00
	6-11	MEAN	258.16	5.6216	191.83	60.666
		SDEV	23.438	3.8157	37.498	38.970
		SIZE	6	6	6	6
		SUM	1549.0	33.730	1151.0	364.00
	12-17	MEAN	258.50	7.2666	209.16	42.166
		SDEV	21.714	3.4863	18.400	19.508
		SIZE	6	6	6	6
		SUM	1551.0	43.600	1255.0	253.00
TOTAL		MEAN	256.70	6.9252	198.41	51.411
		SDEV	20.336	4.1319	39.102	40.450
		SIZE	17	17	17	17
		SUM	4364.0	117.72	3373.0	874.00

BAYLOR BEDREST PHASE II

Potassium Balance (mEq/24Hr.)

SUBJECT #4

STUDY DAY			K-IN	K-FECAL	K-URINE	K-DELTA
PRE	1-5	MEAN	109.60	18.000	89.600	2.0000
		SDEV	5.0299	6.0000	17.357	21.130
		SIZE	5	5	5	5
		SUM	548.00	90.000	448.00	10.000
	6-11	MEAN	110.50	11.410	80.500	18.500
		SDEV	5.9916	5.1632	16.777	19.796
		SIZE	6	6	6	6
		SUM	663.00	68.460	483.00	111.00
	12-17	MEAN	108.50	11.316	82.666	14.666
		SDEV	15.215	3.5762	13.880	8.7330
		SIZE	6	6	6	6
		SUM	651.00	67.899	496.00	88.000
TOTAL		MEAN	109.52	13.315	83.941	12.294
		SDEV	9.5204	5.5718	15.445	17.538
		SIZE	17	17	17	17
		SUM	1862.0	226.35	1427.0	209.00

BAYLOR BEDREST PHASE II

Magnesium Balance (mEq/24Hr.)

SUBJECT #4

STUDY DAY			MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE	1-5	MEAN	30.599	29.000	7.1400	-5.79
		SDEV	3.5071	9.7211	1.6727	10.940
		SIZE	5	5	5	5
		SUM	153.00	145.00	35.700	-29.0
	6-11	MEAN	30.333	20.215	8.6500	1.5000
		SDEV	3.3266	9.0845	1.4597	8.6660
		SIZE	6	6	6	6
		SUM	182.00	121.29	51.900	9.0000
	12-17	MEAN	29.666	19.816	9.0666	.78333
		SDEV	3.0767	4.8614	3.0624	8.2433
		SIZE	6	6	6	6
		SUM	178.00	118.90	54.400	4.7000
TOTAL		MEAN	30.176	22.658	8.3529	-.900
		SDEV	3.1071	8.6391	2.2316	9.2389
		SIZE	17	17	17	17
		SUM	513.00	385.19	142.00	-15.2

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #4

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	222.59	0	181.20	0
		SDEV	17.826	0	62.110	0
		SIZE	5	0	5	0
		SUM	1113.0	0	906.00	0
	6-11	MEAN	225.50	0	173.00	0
		SDEV	18.907	0	46.904	0
		SIZE	6	0	6	0
		SUM	1353.0	0	1038.0	0
	12-17	MEAN	222.16	0	203.50	0
		SDEV	14.091	0	18.052	0
		SIZE	6	0	6	0
		SUM	1333.0	0	1221.0	0
TOTAL		MEAN	223.47	0	186.17	0
		SDEV	15.988	0	44.035	0
		SIZE	17	0	17	0
		SUM	3799.0	0	3165.0	0

BAYLOR BEDREST PHASE II

Calcium Balance (g/24Hr)

SUBJECT #4

STUDY DAY			CA-IN	CA-FECAL	CA-URINE	CA-DELTA
PRE	1-5	MEAN	837.39	884.60	192.40	-229.19
		SDEV	27.437	288.23	49.145	174.703
		SIZE	5	5	5	5
		SUM	4187.0	4423.0	962.00	-1496.0
	6-11	MEAN	822.50	578.50	228.50	15.5000
		SDEV	9.6332	269.32	51.391	281.798
		SIZE	6	6	6	6
		SUM	4935.0	3471.0	1371.0	93.0000
	12-17	MEAN	812.33	592.33	210.00	10.1666
		SDEV	10.405	115.86	9.2951	118.974
		SIZE	6	6	6	6
		SUM	4874.0	3554.0	1260.0	61.0000
TOTAL		MEAN	823.29	673.41	211.35	-78.941
		SDEV	18.942	259.64	40.980	241.562
		SIZE	17	17	17	17
		SUM	13996.	11448.	3593.0	-1342.0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #4

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	808	1070	283	-86
	SDEV	11.4	264.1	51.6	622.5
	Size	7	4	7	7
In-Bed 08-14	Mean	826	787	392	-353
	SDEV	11.3	166.4	81.8	149.5
	Size	7	7	7	7
In-Bed 15-21	Mean	825	913	394	-351
	SDEV	7.1	439.5	82.8	546.1
	Size	7	6	7	
In-Bed 21-28	Mean	826	1353	435	-576
	SDEV	10.5	709.0	137.6	916.0
	Size	7	5	7	7
In-Bed Total	Mean	821	1001	376	-341
	SDEV	12.3	455.6	105.7	612.4
	Size	28	22	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #4

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	810	969	323	-343
	SDEV	30.9	573.1	54.6	610.8
	Size	7	6	7	7
Post-Bed 08-14	Mean	828	794	234	-201
	SDEV	7.2	208.6	76.8	251.7
	Size	7	7	7	7
Post-Bed Total	Mean	819	875	279	-272
	SDEV	23.3	408.5	78.8	454.8
	Size	14	13	14	14

BODY/FECAL

SUBJECT #5

STUDY DAY		BODY WT.	FECAL WT.
PRE 1-5	MEAN	74.9500	112.220
	SDEV	.190940	52.6427
	SIZE	4	5
	SUM	299.800	561.100
6-11	MEAN	74.8833	107.423
	SDEV	.188193	51.3812
	SIZE	6	6
	SUM	449.300	644.540
12-17	MEAN	75.0333	128.988
	SDEV	.144337	64.6263
	SIZE	6	6
	SUM	450.200	773.930
TOTAL			
	MEAN	74.9562	116.445
	SDEV	.176776	54.0195
	SIZE	16	17
	SUM	1199.30	1979.57

BAYLOR BEDREST PHASE II

Water Balance (ml/24Hr.)

SUBJECT #5

STUDY DAY		W-IN	W-FECAL	W-URINE	W-DELTA
PRE 1-5	MEAN	3313.00	105.500	2806.00	430.000
	SDEV	144.240	53.5692	462.255	430.546
	SIZE	4	4	5	4
	SUM	13252.0	422.000	14030.0	1720.00
6-11	MEAN	3339.16	78.8333	2427.50	684.000
	SDEV	397.834	37.9863	282.333	587.826
	SIZE	6	6	6	6
	SUM	20035.0	473.000	14565.0	4104.0
12-17	MEAN	3102.00	96.8333	1941.66	1063.50
	SDEV	199.946	49.9576	477.638	477.663
	SIZE	6	6	6	6
	SUM	18612.0	581.000	11650.0	6381.00
TOTAL	MEAN	3243.68	92.2500	2367.35	762.812
	SDEV	288.458	44.8783	528.260	544.513
	SIZE	16	16	17	16
	SUM	51899.0	1476.00	40245.0	12205.0

BAYLOR BEDREST PHASE II
Nitrogen Balance (g/24Hr)

SUBJECT #5

STUDY DAY			N-IN	N-FECAL	N-URINE	N-DELTA
PRE	1-5	MEAN	17.1500	0	13.22	0
		SDEV	.568400	0	1.165	0
		SIZE	4	0	5	0
		SUM	68.6000	0	66.14	0
	6-11	MEAN	16.7166	0	13.50	0
		SDEV	.803637	0	1.331	0
		SIZE	6	0	6	0
		SUM	100.300	0	81.00	0
	12-17	MEAN	16.7500	0	12.79	0
		SDEV	.882556	0	2.838	0
		SIZE	6	0	6	0
		SUM	100.500	0	76.78	0
TOTAL		MEAN	16.8375	0	13.17	0
		SDEV	.757858	0	1.872	0
		SIZE	16	0	17	0
		SUM	269.400	0	223.9	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #5

STUDY DAY			P-Intake	P-Fecal	P-Urine	P-Delta
Pre-Bed	12-17	Mean	1765	588	1024	152
		SDEV	87.0	282.8	184.4	352.0
		Size	6	6	6	6
Pre-Bed	06-11	Mean	1767	500	1127	140
		SDEV	77.4	229.7	183.6	166.0
		Size	6	6	6	6
Pre-Bed	01-05	Mean	1756	604	937	171
		SDEV	69.6	327.5	60.3	402.3
		Size	4	5	5	4
Pre-Bed	Total	Mean	1763	562	1035	152
		SDEV	74.2	265.6	168.2	288.1
		Size	16	17	17	16

BAYLOR BEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #5

STUDY DAY			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	269.00	10.740	239.59	13.000
		SDEV	16.370	17.523	48.895	48.414
		SIZE	4	5	5	5
		SUM	1076.0	53.700	1198.0	52.000
	6-11	MEAN	278.50	1.9350	231.50	45.166
		SDEV	16.170	.88872	27.595	28.031
		SIZE	6	6	6	6
		SUM	1671.0	11.610	1389.0	271.00
	12-17	MEAN	277.16	3.2466	192.83	81.166
		SDEV	22.964	2.0410	53.849	48.300
		SIZE	6	6	6	6
		SUM	1663.0	19.480	1157.0	487.00
TOTAL		MEAN	275.62	4.9876	220.23	50.625
		SDEV	18.234	9.6584	46.778	47.654
		SIZE	16	17	17	16
		SUM	4410.0	84.790	3744.0	810.00

BAYLOR BEDREST PHASE II

Potassium Balance (mEq/24hr.)

SUBJECT #5

STUDY DAY		K-IN	K-FECAL	K-URINE	K-DELTA
PRE 1-5	MEAN	108.50	18.000	92.399	-4.79
	SDEV	6.1913	9.2736	4.2190	7.3620
	SIZE	4	5	5	5
	SUM	434.000	90.000	462.00	-24.0
6-11	MEAN	112.33	15.216	93.166	4.0000
	SDEV	8.4774	7.1820	15.328	14.587
	SIZE	6	6	6	6
	SUM	674.00	91.300	559.00	24.000
12-17	MEAN	109.66	19.833	74.833	15.000
	SDEV	10.670	10.479	19.924	15.491
	SIZE	6	6	6	6
	SUM	658.00	119.00	449.00	90.000
TOTAL	MEAN	110.37	17.664	86.470	5.2941
	SDEV	8.5000	8.7168	16.748	14.928
	SIZE	16	17	17	17
	SUM	1766.0	300.30	1470.0	90.000

BAYLOR BEDREST PHASE II

Magnesium Balance (mEq/24Hr.)

SUBJECT #5

STUDY DAY			MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE	1-5	MEAN	27.500	16.400	14.360	-10.0
		SDEV	1.0000	8.1424	1.5630	14.071
		SIZE	4	5	5	4
		SUM	110.00	82.000	71.800	-40.0
	6-11	MEAN	28.500	12.790	14.950	.41666
		SDEV	2.2583	5.7680	1.7386	3.5555
		SIZE	6	6	6	6
		SUM	171.00	76.740	89.700	2.5000
	12-17	MEAN	27.666	15.933	12.750	-2.50
		SDEV	2.2509	6.8368	2.7355	5.8906
		SIZE	6	6	6	6
		SUM	166.00	95.600	76.500	-15.0
TOTAL		MEAN	27.937	14.961	14.000	-3.28
		SDEV	1.9482	6.6594	2.2042	8.5517
		SIZE	16	17	17	16
		SUM	447.00	254.34	238.00	-52.5

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #5

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	232.25	0	212.40	0
		SDEV	21.884	0	36.977	0
		SIZE	4	0	5	0
		SUM	929.00	0	1062.0	0
	6-11	MEAN	242.66	0	204.16	0
		SDEV	15.015	0	28.985	0
		SIZE	6	0	6	0
		SUM	1456.0	0	1225.0	0
	12-17	MEAN	236.66	0	195.83	0
		SDEV	29.850	0	75.239	0
		SIZE	6	0	6	0
		SUM	1420.0	0	1175.0	0
TOTAL		MEAN	237.81	0	203.64	0
		SDEV	22.049	0	49.197	0
		SIZE	16	0	17	0
		SUM	3805.0	0	3462.0	0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT # 5

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Pre-Bed 12-17	Mean	812	694	243	-127
	SDEV	7.0	316.8	62.5	284.0
	Size	6	6	6	6
Pre-Bed 06-11	Mean	810	605	298	-93
	SDEV	8.4	285.2	55.9	269.0
	Size	6	6	6	6
Pre-Bed 01-05	Mean	811	633	304	-172
	SDEV	6.2	307.9	61.6	321.8
	Size	4	5	5	4
Pre-Bed Total	Mean	811	645	280	-125
	SDEV	6.9	286.4	63.0	269.6
	Size	16	17	17	16

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #5

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	811	477	348	55
	SDEV	11.7	143.8	56.4	261.4
	Size	7	6	7	7
In-Bed 08-14	Mean	820	551	400	-131
	SDEV	14.4	224.2	50.0	234.9
	Size	7	7	7	7
In-Bed 15-21	Mean	825	663	494	-331
	SDEV	12.6	167.2	149.1	241.8
	Size	7	7	7	7
In-Bed 21-28	Mean	800	705	472	-377
	SDEV	36.2	203.4	99.1	182.3
	Size		7	7	7
In-Bed Total	Mean	814	604	428	-196
	SDEV	22.4	199.4	109.0	280.1
	Size	28	27	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #5

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	813	1137	297	-621
	SDEV	10.0	204.7	38.5	210.1
	Size	7	7	7	7
Post-Bed 08-14	Mean	811	734	208	-131
	SDEV	8.5	396.5	47.3	375.1
	Size	7	7		7
Post-Bed Total	Mean	812	935	253	-376
	SDEV	9.0	368.3	62.2	387.4
	Size	7	14	14	14

BODY/FECAL

SUBJECT #6

STUDY DAY			BODY WT.	FECAL WT.
PRE	1-5	MEAN	63.9600	131.480
		SDEV	.265164	55.0532
		SIZE	5	5
		SUM	319.800	657.400
	6-11	MEAN	64.2833	193.863
		SDEV	.136930	66.7268
		SIZE	6	6
		SUM	385.700	1163.18
	12-17	MEAN	64.2833	193.863
		SDEV	.136930	66.7268
		SIZE	6	6
		SUM	385.700	1163.18
TOTAL		MEAN	64.2117	155.469
		SDEV	.238715	58.7071
		SIZE	17	17
		SUM	1091.60	2642.98

BAYLOR BEDREST PHASE II

Water Balance (ml/24Hr.)

SUBJECT #6

STUDY DAY			W-IN	W-FECAL	W-URINE	W-DELTA
PRE	1-5	MEAN	2875.79	99.6000	2120.00	1080.20
		SDEV	444.586	41.9797	473.849	703.214
		SIZE	5	5	4	5
		SUM	14379.0	498.000	8480.00	5401.00
	6-11	MEAN	3128.00	156.000	1846.66	1125.33
		SDEV	397.420	55.2050	323.645	577.620
		SIZE	6	6	6	6
		SUM	18768.0	936.000	11080.0	6752.00
	12-17	MEAN	3128.00	156.000	1846.66	1125.33
		SDEV	397.420	55.2050	323.645	577.620
		SIZE	6	6	6	6
		SUM	18768.0	936.000	11080.0	6752.00
TOTAL		MEAN	2953.41	121.176	1890.93	1052.52
		SDEV	397.464	48.7932	325.623	507.105
		SIZE	17	17	16	17
		SUM	50208.0	2060.00	30255.0	17893.0

BAYLOR BEDREST PHASE II
Nitrogen Balance (g/24Hr)

SUBJECT #6

STUDY DAY			N-IN	N-FECAL	N-URINE	N-DELTA
PRE	1-5	MEAN	15.5800	0	10.35	0
		SDEV	.408646	0	2.368	0
		SIZE	5	0	4	0
		SUM	77.9000	0	41.43	0
	6-11	MEAN	15.5500	0	10.53	0
		SDEV	.441646	0	1.669	0
		SIZE	6	0	6	0
		SUM	93.3000	0	63.18	0
	12-17	MEAN	15.5500	0	10.53	0
		SDEV	.441646	0	1.669	0
		SIZE	6	0	6	0
		SUM	93.3000	0	63.18	0
TOTAL		MEAN	15.5411	0	10.14	0
		SDEV	.412215	0	2.198	0
		SIZE	17	0	16	0
		SUM	264.200	0	162.2	0

BAYLOR BEDREST - PHASE II
Phosphorus Balance (mg/24hr)

SUBJECT #6

STUDY DAY			P -Intake	P-Fecal	P-Urine	P -Delta
Pre-Bed	12-17	Mean	1675	513	984	178
		SDEV	37.4	186.7	174.0	181.2
		Size	6	6	6	6
Pre-Bed	06-11	Mean	1667	458	844	365
		SDEV	41.7	134.6	288.8	310.2
		Size	6	6	6	6
Pre-Bed	01-05	Mean	1670	512	824	339
		SDEV	45.6	146.8	122.3	164.0
		Size	5	5	4	4
Pre-Bed	Total	Mean	1670	493	891	288
		SDEV	38.9	150.5	215.5	229.7
		Size	17	17	16	16

BAYLOR BEDREST PHASE II

Sodium Balance (mEq/24Hr.)

SUBJECT #6

STUDY DAY.			NA-IN	NA-FECAL	NA-URINE	NA-DELTA
PRE	1-5	MEAN	237.40	3.8000	173.50	113.60
		SDEV	59.256	2.9495	30.424	77.219
		SIZE	5	5	4	5
		SUM	1187.0	19.000	694.00	568.00
	6-11	MEAN	256.50	6.4900	165.16	84.833
		SDEV	16.884	7.7077	42.348	43.906
		SIZE	6	6	6	6
		SUM	1539.0	38.940	991.00	509.00
	12-17	MEAN	264.83	9.7833	178.33	76.666
		SDEV	18.159	5.8802	54.334	54.342
		SIZE	6	6	6	6
		SUM	1589.0	58.700	1070.0	460.00
TOTAL		MEAN	253.82	6.8611	172.18	90.411
		SDEV	34.675	6.1423	42.453	57.153
		SIZE	17	17	16	17
		SUM	4315.0	116.64	2755.0	1537.0

BAYLOR BEDREST PHASE II

Magnesium Balance (mEq/24Hr.)

SUBJECT #6

STUDY DAY			MG-IN	MG-FECAL	MG-URINE	MG-DELTA
PRE	1-5	MEAN	27.800	19.599	5.9250	3.1999
		SDEV	2.5884	5.7271	2.1406	6.9065
		SIZE	5	5	4	5
		SUM	139.00	98.000	23.700	16.000
	6-11	MEAN	27.500	19.841	6.9666	.50000
		SDEV	2.8106	7.8914	2.2069	5.6124
		SIZE	6	6	6	6
		SUM	165.00	119.05	41.800	3.0000
	12-17	MEAN	27.833	18.150	7.4666	2.3499
		SDEV	3.4302	6.6815	1.4292	7.7572
		SIZE	6	6	6	6
		SUM	167.00	108.90	44.800	14.099
TOTAL		MEAN	27.705	19.173	6.8937	1.9470
		SDEV	2.8009	6.4983	1.8985	6.4738
		SIZE	17	17	16	17
		SUM	471.00	325.95	110.30	33.100

BAYLOR BEDREST PHASE II

Potassium Balance (mEq/24Hr.)

SUBJECT #6

STUDY DAY			K-IN	K-FECAL	K-URINE	K-DELTA
PRE	1-5	MEAN	109.60	10.400	81.750	33.800
		SDEV	15.962	5.4129	28.698	42.481
		SIZE	5	5	4	5
		SUM	548.00	52.000	327.00	169.00
	6-11	MEAN	105.50	12.648	72.500	20.333
		SDEV	17.840	7.4357	15.096	22.861
		SIZE	6	6	6	6
		SUM	633.00	75.890	435.00	122.00
	12-17	MEAN	106.83	13.416	68.000	25.500
		SDEV	16.582	6.1629	19.768	21.229
		SIZE	6	6	6	6
		SUM	641.00	80.500	408.00	153.00
TOTAL		MEAN	107.17	12.258	73.125	26.117
		SDEV	15.875	6.1735	20.036	28.044
		SIZE	17	17	16	17
		SUM	1822.0	208.39	1170.0	444.00

BAYLOR BEDREST PHASE II

Chloride Balance (mEq/24 Hr.)

SUBJECT #6

STUDY DAY			CL-IN	CL-FECAL	CL-URINE	CL-DELTA
PRE	1-5	MEAN	224.00	0	146.50	0
		SDEV	27.631	0	43.859	0
		SIZE	5	0	4	0
		SUM	1120.0	0	586.00	0
	6-11	MEAN	220.33	0	150.83	0
		SDEV	21.593	0	36.438	0
		SIZE	6	0	6	0
		SUM	1322.0	905.00	0	
	12-17	MEAN	223.94	0	154.68	0
		SDEV	21.915	0	43.870	0
		SIZE	17	0	16	0
		SUM	3807.0	0	2475.0	0

TOTAL

MEAN	223.94	0	154.68	0
SDEV	21.915	0	43.870	0
SIZE	17	0	16	0
SUM	3807.0	0	2475.0	0

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #6

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Pre-Bed 12-17	Mean	803	669	172	-39
	SDEV	5.5	243.2	30.9	237.8
	Size	6	6	6	6
Pre-Bed 06-11	Mean	799	684	221	-105
	SDEV	3.6	266.0	126.9	207.6
	Size	6	6	6	6
Pre-Bed 01-05	Mean	799	603	206	-26
	SDEV	5.0	135.4	40.3	124.6
	Size	5	5	4	4
Pre-Bed Total	Mean	801	655	199	-60
	SDEV	4.8	215.4	80.6	194.0
	Size	17	17	16	16

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #6

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
In-Bed 01-07	Mean	802	1049	309	-106
	SDEV	9.6	185.9	45.1	609.6
	Size	7	4	7	7
In-Bed 08-14	Mean	803	763	370	-330
	SDEV	6.0	216.5	117.9	273.6
	Size	7	7	7	7
In-Bed 15-21	Mean	808	825	380	-279
	SDEV	8.9	273.1	128.4	376.6
	Size	7	6	7	7
In-Bed 21-28	Mean	804	801	303	-186
	SDEV	6.8	144.4	50.5	326.4
	Size	7	6	7	7
In-Bed Total	Mean	804	839	341	-225
	SDEV	7.9	222.4	95.1	402.7
	Size	28	23	28	28

BAYLOR BEDREST - PHASE II
Calcium Balance (mg/24hr)

SUBJECT #6

STUDY DAY		Ca-Intake	Ca-Fecal	Ca-Urine	Ca-Delta
Post-Bed 01-07	Mean	804	988	224	-408
	SDEV	21.5	231.1	96.2	252.2
	Size	7	7		7
Post-Bed 08-14	Mean	796	901	204	-310
	SDEV	6.3	104.0	37.3	99.9
	Size	7	5	5	5
Post-Bed Total	Mean	800	952	215	-367
	SDEV	15.7	187.3	75.3	202.3
	Size	14	12	12	12

HEMATOLOGY AND IMMUNOLOGY

The purpose of these studies of selected hematologic parameters during and following a 28-day bedrest study, was to compare the effects of bedrest with the changes observed during spaceflights of comparable duration (Kimzey, 1975). The overall design of the study and the specific test methodology are described in the "Volume I, "Protocols" section of this report (October, 1976). Briefly, blood samples were collected from the six subjects 4 times during the 40 days preceeding the bedrest phase, weekly during the 28-day bedrest, and for two weeks following the test. The specific schedule and volumes of blood withdrawn from each subject are described in Volume I.

This report is divided into five sections reflecting more detailed analyses of some aspects of the data.

HEMATOLOGY SUMMARY

Stephen L. Kimzey

The routine hematology and serum electrophoresis data are summarized in Tables 1-6. There was a consistent elevation in red cell count, hemoglobin concentration and hematocrit during the bedrest phase of the study. These elevations are similar in magnitude and direction to those observed in previous bedrest studies, and reflect the reduction in the circulating plasma volume (See Section E; Johnson and Driscoll). A more detailed analysis of the relationship between hemoglobin concentration (Hb), plasma volume (PVOL) and the per cent change in plasma volume (PVOL PCT) follows in the next section of this project.

There is a modest reduction in the absolute reticulocyte number during bedrest and an elevation during the post recovery period. These changes are discussed in more detail (Dunn, et. al.) below, and are consistent with the change in red blood cell mass (Johnson and Driscoll, Section E).

No consistent changes were noted in while blood cell counts or differentials, although there were some fluyuations in the absolute lymphocyte numbers.

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 1

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.80	0.9	40.6	13.9	42.2	88.2	29.2	32.7	5400	3015	2087	238	6.4	3.6	.3	.6	.8	1.1
MEAN ± SD	.13	0.2	10.7	0.3	0.5	1.5	1.5	1.2	707	316	227	35	0.2	0.2	0	.1	.1	0.2
BR 08	5.23	0.8	41.8	15.4	46.5	89.0	29.0	33.0	5700	2850	2679	235	6.6	3.5	.3	.7	.8	1.3
13	5.21	0.9	46.9	16.0	47.5	91.0	31.0	34.0	6300	3150	2772		6.8	3.5	.3	.7	.8	1.5
13PM	5.10	0.6	30.6	15.5	46.5	91.0	30.0	33.0	6300				6.6	3.9	.3	.6	.8	1.0
14	4.89	0.6	29.3	14.9	44.0	90.0	30.0	34.0	6400				-	-	-	-	-	-
14PM	4.83	0.7	33.8	14.8	43.0	89.0	31.0	34.0	6500				6.3	3.7	.3	.6	.7	1.0
15	5.10	0.6	30.1	15.3	45.0	90.0	31.0	34.0	6600				-	-	-	-	-	-
15PM	4.95	0.7	34.6	15.5	45.0	91.0	31.0	34.0	6700				6.7	3.6	.3	.6	.9	1.3
21	5.35	1.2	64.2	15.8	47.0	88.0	29.0	34.0	6000	3000	2820	221	6.9	3.6	.3	.7	.8	1.5
27	5.29	0.8	42.3	15.2	45.0	85.0	29.0	34.0	5300	2703	2385	200	6.5	3.7	.3	.6	.7	1.2
R + 00PM	5.13	0.7	35.9	14.6	43.0	84.0	28.0	34.0	8700									
01	4.50	1.0	45.0	13.4	40.0	89.0	30.0	33.0	5600	3360	2128	296	6.1	3.4	.3	.6	.7	1.1
06	4.53	0.6	27.2	13.3	39.0	86.0	29.0	34.0	3700	1443	1998	290	6.2	3.5	.3	.5	.7	1.2
13	4.25	0.9	38.3	12.3	38.0	89.0	29.0	32.0	3800	1596	1900	240	6.0	3.3	.3	.5	.7	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 2

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	5.15	0.8	41.0	14.7	44.0	85.2	28.7	33.5	6100	3301	2425	322	6.4	3.7	.3	.6	.7	1.1
MEAN ± SD	0.12	0.2	9.2	0.4	1.5	1.2	0.5	0.6	698	528	161	38	0.1	0.3	.1	.1	.1	0.1
BR 08	5.30	0.9	47.7	15.4	45.0	85.0	29.0	34.0	5600	2912	2352	295	6.4	3.6	.3	.6	.7	1.2
13	5.46	0.8	43.7	16.3	46.5	85.0	30.0	35.0	6100	3355	2501		6.6	3.5	.3	.6	.7	1.5
13PM	5.15	1.0	51.5	15.5	43.5	84.0	30.0	36.0	5000				6.2	3.4	.3	.6	.7	1.2
14	5.15	0.7	36.1	15.6	44.0	85.0	30.0	35.0	7000				-	-	-	-	-	-
14PM	5.18	0.7	36.3	15.8	45.5	88.0	31.0	35.0	5300				6.6	3.7	.3	.6	.8	1.2
15	5.35	0.7	37.5	16.0	46.0	89.0	30.0	34.0	6700				-	-	-	-	-	-
15PM	5.18	0.8	41.4	15.6	46.0	89.0	30.0	34.0	5600				6.6	3.7	.3	.6	.8	1.2
21	5.64	0.9	50.8	16.4	48.0	85.0	29.0	34.0	6200	3534	2480	320	7.0	3.7	.3	.7	.8	1.5
27	5.53	0.9	49.8	16.0	47.0	85.0	29.0	34.0	5700	3534	1881	305	6.8	3.9	.3	.6	.7	1.3
R + 00PM	5.32	1.0	53.2	15.4	44.0	83.0	29.0	35.0	8400									
01	5.01	1.0	50.1	14.9	42.5	85.0	30.0	35.0	4900	3038	1617	303	6.4	3.8	.3	.6	.7	1.0
06	5.23	1.2	62.8	15.2	45.0	86.0	29.0	34.0	4900	2450	2205	322	6.7	4.1	.3	.5	.6	1.2
13	4.97	1.5	74.6	14.1	43.5	87.0	28.0	32.0	5200	2912	2132	310	6.4	3.4	.4	.6	.8	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 3

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.82	0.8	37.4	14.4	43.1	89.0	29.7	33.5	4600	2314	2066	237	6.6	4.1	.3	.5	.7	1.0
MEAN ± SD	.12	0.3	14.2	0.2	1.3	1.8	1.0	0.6	182	292	188	13	0.1	0.4	.1	.1	.1	.2
BR 08	5.19	0.5	26.0	15.3	45.0	87.0	29.0	34.0	5300	3127	2014	247	6.7	4.3	.3	.5	.7	0.9
13	5.03	0.5	25.2	15.6	46.5	89.0	31.0	35.0	5900	3186	2478		6.6	4.0	.3	.5	.7	1.0
13PM	4.83	0.6	29.0	15.1	43.0	89.0	31.0	35.0	5600	-	-		6.5	3.8	.3	.6	.7	1.1
14	4.96	0.8	39.7	15.1	44.0	89.0	30.0	34.0	6000	-	-		-	-	-	-	-	-
14PM	4.76	0.6	28.6	14.8	42.0	88.0	31.0	35.0	5700	-	-		6.5	4.4	.2	.5	.6	0.8
15	4.88	[illegible]	29.3	14.8	43.5	89.0	30.0	34.0	5500	-	-		-	-	-	-	-	-
15PM	4.69	[illegible]	28.1	14.4	41.0	87.0	31.0	35.0	5500	-	-		6.2	3.8	.3	.5	.7	0.9
21	5.15	0.7	35.1	15.0	45.0	87.0	29.0	33.0	5500	3025	2200	279	6.9	3.7	.3	.7	.8	1.4
27	4.84	0.6	29.0	14.8	43.5	90.0	31.0	34.0	5000	2550	2000	274	6.6	3.7	.3	.6	.7	1.3
R + 00PM	4.65	0.9	41.8	14.0	40.0	86.0	30.0	35.0	7300									
01	4.71	1.2	56.5	14.0	40.0	85.0	30.0	35.0	4700	3149	1504	282	6.6	4.1	.3	.6	.7	0.9
06	4.61	0.9	41.5	13.3	40.0	87.0	29.0	33.0	3300	1155	2046	274	6.3	3.8	.3	.5	.7	1.0
13	4.35	0.9	39.2	12.8	38.5	88.0	29.0	33.0	5200	2600	2392	290	6.6	4.1	.3	.5	.7	1.0

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 4

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.80	0.9	44.4	13.6	41.8	86.7	28.2	32.5	5475	3032	2196	276	6.8	3.9	.2	.6	.8	1.2
MEAN ± SD	.04	0.2	10.0	0.1	0.5	1.0	0.5	0.6	562	296	325	15	0.1	0.1	0	0	0	0.2
BR 08	5.24	0.9	47.2	14.6	45.0	86.0	28.0	32.0	7600	4028	3344	265	7.1	4.1	.3	.7	.8	1.2
13	4.92	0.7	34.4	14.4	43.0	87.0	29.0	33.0	7200	3744	3312		6.7	4.1	.2	.6	.7	1.1
13PM	4.83	0.9	43.5	14.0	42.0	87.0	29.0	33.0	6500	-	-		6.7	4.2	.2	.6	.7	1.0
14	4.74	0.7	33.2	14.0	40.0	84.0	30.0	35.0	7900				-	-	-	-	-	-
14PM	4.67	0.6	28.0	14.1	41.0	88.0	30.0	34.0	6700	-	-		6.4	3.9	.2	.6	.6	1.1
15	4.78	0.6	28.7	14.0	42.0	88.0	29.0	33.0	7300	-	-		-	-	-	-	-	-
15PM	4.91	0.6	29.5	13.4	43.0	88.0	27.0	31.0	6300	-	-		7.0	3.7	.2	.8	.8	1.5
21	5.25	0.7	36.7	14.6	44.5	85.0	28.0	33.0	6900	4278	2553	330	7.1	3.6	.3	.8	.9	1.5
27	5.29	0.6	31.7	14.4	44.0	83.0	27.0	33.0	6600	3498	2970	294	7.1	4.0	.2	.7	.8	1.4
R + 00PM	4.86	0.8	29.2	13.9	41.0	84.0	29.0	34.0	7200									
01	4.76	0.6	28.6	13.7	42.0	88.0	29.0	33.0	5700	3420	2280	289	6.7	4.3	.2	.5	.7	1.0
06	4.70	0.9	42.3	13.2	40.0	85.0	28.0	33.0	5700	3819	1767	304	6.7	3.9	.3	.6	.8	1.1
13	4.82	1.1	53.0	13.7	41.5	86.0	28.0	33.0	5800	3132	2552	315	6.7	3.9	.3	.6	.7	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 5

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.53	0.8	36.3	13.8	41.4	91.2	30.5	33.2	7475	4271	2898	235	6.6	3.7	.3	.7	.8	1.2
MEAN ± SD	.14	0.1	4.7	0.3	1.5	1.7	0.6	0.5	1607	1717	275	17	0.1	0.1	.1	.1	.1	0.1
8R 08	4.65	0.7	32.6	14.1	42.0	90.0	30.0	34.0	6500	3640	2535	263	6.4	3.8	.2	.6	.6	1.2
13	4.41	0.8	35.3	13.9	40.5	92.0	32.0	34.0	7100	3408	3550		6.2	3.9	.2	.5	.6	1.0
13PM	4.29	0.6	25.7	13.5	39.0	91.0	31.0	35.0	6700	-			6.0	3.8	.2	.5	.6	0.9
14	4.22	0.6	25.3	13.1	38.0	90.0	31.0	34.0	7200	-			-	-	-	-	-	-
14PM	4.18	0.7	29.3	13.2	38.0	91.0	32.0	35.0	6300	-			5.9	3.4	.3	.6	.6	1.0
15	4.22	0.6	25.3	13.4	38.5	91.0	32.0	35.0	6400	-			-	-	-	-	-	-
15PM	4.39	0.5	22.0	13.7	39.5	90.0	31.0	35.0	6800	-			6.4	4.0	.2	.6	.6	1.0
21	4.57	0.5	22.8	14.0	40.0	87.0	31.0	35.0	6600	3036	3234	258	6.4	3.9	.3	.5	.7	1.0
27	4.61	0.9	[illegible]	[illegible]	41.5	90.0	31.0	34.0	6000	3540	2220	289	6.7	4.4	.2	.5	.6	1.0
R + 00PM	4.29	0.6	[illegible]	1[illegible]	37.5	87.0	30.0	35.0	8000									
01	3.59	1.6	62.6	12.0	35.0	90.0	31.0	34.0	6000	3300	2340	186	6.0	3.6	.2	.5	.6	1.1
06	4.09	1.6	55.5	12.3	36.5	89.0	30.0	34.0	5700	[illegible]82	2337	255	6.2	3.5	.3	.6	.7	1.1
13	3.77	1.0	37.7	11.7	34.5	91.0	31.0	34.0	7300	4088	2920	262	5.9	3.8	.2	.5	.6	0.8

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 6

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.38	0.6	28.4	13.1	39.6	90.7	29.7	33.0	4875	2112	2507	232	6.7	3.8	.3	.6	.8	1.2
MEAN ± SD	.07	0.1	2.2	0.4	0.8	1.0	0.5	0.8	330	376	225	22	0.2	0.1	.1	0	0	0.1
BR 08	4.61	0.5	23.1	13.7	41.0	89.0	30.0	33.0	5600	2576	2912	238	6.9	3.8	.3	.6	.8	1.4
13	4.48	0.7	31.4	13.7	40.0	89.0	31.0	34.0	6500	3445	2730		6.7	4.3	.3	.5	.7	0.9
13PM	4.44	0.8	35.5	13.6	39.5	89.0	31.0	34.0	6300	-	-		6.8	4.4	.3	.6	.7	0.8
14	4.40	0.6	26.4	13.4	38.0	86.0	30.0	35.0	5700	-	-		-	-	-	-	-	-
14PM	4.54	0.5	22.7	13.7	41.0	90.0	30.0	33.0	6500	-	-		7.1	4.5	.3	.6	.8	0.9
15	4.14	0.5	20.7	12.4	36.5	88.0	30.0	34.0	5500	-	-		-	-	-	-	-	-
15PM	4.20	0.5	21.0	12.7	36.0	86.0	30.0	35.0	5100	-	-		6.1	3.7	.3	.5	.6	1.0
21	4.51	0.6	27.1	13.2	39.0	86.0	29.0	34.0	6000	3180	2400	241	6.6	4.0	.2	.7	.6	1.1
27	4.46	0.6	26.8	13.3	39.0	87.0	30.0	34.0	5600	3080	2464	242	6.8	4.4	.2	.5	.7	1.0
R + 00PM	4.28	0.7	30.0	12.8	37.0	86.0	30.0	35.0	8100									
01	3.95	0.9	35.6	11.6	34.0	86.0	29.0	34.0	5400	3564	1620	261	6.3	3.7	.3	.5	.7	1.1
06	3.95	1.0	39.5	11.8	35.0	89.0	30.0	34.0	4700	2256	2115	275	6.5	3.5	.3	.6	.8	1.3
13	3.84	1.3	49.9	11.5	34.5	90.0	30.0	33.0	4500	1890	2305	256	6.4	4.0	.3	.5	.6	1.0

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 1

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.80	0.9	40.6	13.9	42.2	88.2	29.2	32.7	5400	3015	2087	238	6.4	3.6	.3	.6	.8	1.1
MEAN ± SD	.13	0.2	10.7	0.3	0.5	1.5	1.5	1.2	707	316	227	35	0.2	0.2	0	.1	.1	0.2
BR 08	5.23	0.8	41.8	15.4	46.5	89.0	29.0	33.0	5700	2850	2679	235	6.6	3.5	.3	.7	.8	1.3
13	5.21	0.9	46.9	16.0	47.5	91.0	31.0	34.0	6300	3150	2772		6.8	3.5	.3	.7	.8	1.5
13PM	5.10	0.6	30.6	15.5	46.5	91.0	30.0	33.0	6300				6.6	3.9	.3	.6	.8	1.0
14	4.89	0.6	29.3	14.9	44.0	90.0	30.0	34.0	6400				-	-	-	-	-	-
14PM	4.83	0.7	33.8	14.8	43.0	89.0	31.0	34.0	6500				6.3	3.7	.3	.6	.7	1.0
15	5.10	0.6	30.1	15.3	46.0	90.0	31.0	34.0	6600				-	-	-	-	-	-
15PM	4.95	0.7	34.6	15.5	45.0	91.0	31.0	34.0	6700				6.7	3.6	.3	.6	.9	1.3
21	5.35	1.2	64.2	15.8	47.0	88.0	29.0	34.0	6000	3000	2820	221	6.9	3.6	.3	.7	.8	1.5
27	5.29	0.8	42.3	15.2	45.0	85.0	29.0	34.0	5300	2703	2385	200	6.5	3.7	.3	.6	.7	1.2
R + 00PM	5.13	0.7	35.9	14.6	43.0	84.0	28.0	34.0	8700									
01	4.50	1.0	45.0	13.4	40.0	89.0	30.0	33.0	5600	3360	2128	296	6.1	3.4	.3	.6	.7	1.1
06	4.53	0.6	27.2	13.3	39.0	86.0	29.0	34.0	3700	1443	1998	290	6.2	3.5	.3	.5	.7	1.2
13	4.25	0.9	38.3	12.3	38.0	89.0	29.0	32.0	3800	1596	1900	240	6.0	3.3	.3	.5	.7	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 2

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	5.15	0.8	41.0	14.7	44.0	85.2	28.7	33.5	6100	3301	2425	322	6.4	3.7	.3	.6	.7	1.1
MEAN ± SD	0.12	0.2	9.2	0.4	1.5	1.2	0.5	0.6	698	528	161	38	0.1	0.3	.1	.1	.1	0.1
BR 08	5.30	0.9	47.7	15.4	45.0	85.0	29.0	34.0	5600	2912	2352	295	6.4	3.6	.3	.6	.7	1.2
13	5.46	0.8	43.7	16.3	46.5	85.0	30.0	35.0	6100	3355	2501		6.6	3.5	.3	.6	.7	1.5
13PM	5.15	1.0	51.5	15.5	43.5	84.0	30.0	36.0	5000				6.2	3.4	.3	.6	.7	1.2
14	5.15	0.7	36.1	15.6	44.0	85.0	30.0	35.0	7000				-	-	-	-	-	-
14PM	5.18	0.7	36.3	15.8	45.5	88.0	31.0	35.0	5300				6.6	3.7	.3	.6	.8	1.2
15	5.35	0.7	37.5	16.0	46.0	89.0	30.0	34.0	6700				-	-	-	-	-	-
15PM	5.18	0.8	41.4	15.6	46.0	89.0	30.0	34.0	5600				6.6	3.7	.3	.6	8	1.2
21	5.64	0.9	50.8	16.4	48.0	85.0	29.0	34.0	6200	3534	2480	320	7.0	3.7	.3	.7	8	1.5
27	5.53	0.9	49.8	16.0	47.0	85.0	29.0	34.0	5700	3534	1881	305	6.8	3.9	.3	.6	7	1.3
R + 00PM	5.32	1.0	53.2	15.4	44.0	83.0	29.0	35.0	8400									
01	5.01	1.0	50.1	14.9	42.5	85.0	30.0	35.0	4900	3038	1617	303	6.4	3.8	.3	.6	7	1.0
06	5.23	1.2	62.8	15.2	45.0	86.0	29.0	34.0	4900	2450	2205	322	6.7	4.1	.3	.5	6	1.2
13	4.97	1.5	74.6	14.1	43.5	87.0	28.0	32.0	5200	2912	2132	310	6.4	3.4	.4	.6	8	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 3

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.82	0.8	37.4	14.4	43.1	89.0	29.7	33.5	4600	2314	2066	237	6.6	4.1	.3	.5	.7	1.0
MEAN ± SD	.12	0.3	14.2	0.2	1.3	1.8	1.0	0.6	182	292	188	13	0.1	0.4	.1	.1	.1	.2
BR 08	5.19	0.5	26.0	15.3	45.0	87.0	29.0	34.0	5300	3127	2014	247	6.7	4.3	.3	.5	.7	0.9
13	5.03	0.5	25.2	15.6	46.5	89.0	31.0	35.0	5900	3186	2478		6.6	4.0	.3	.6	.7	1.0
13PM	4.83	0.6	29.0	15.1	43.0	89.0	31.0	35.0	5600	-	-		6.5	3.8	.3	.6	.7	1.1
14	4.96	0.8	39.7	15.1	44.0	89.0	30.0	34.0	6000	-	-		-	-	-	-	-	-
14PM	4.76	0.6	28.6	14.8	42.0	88.0	31.0	35.0	5700	-	-		6.5	4.4	.2	.5	.6	0.8
15	4.88	0.6	29.3	14.8	43.5	89.0	30.0	34.0	5500	-	-		-	-	-	-	-	-
15PM	4.69	0.6	28.1	14.4	41.0	87.0	31.0	35.0	5500	-	-		6.2	3.8	.3	.5	.7	0.9
21	5.15	0.7	36.1	15.0	45.0	87.0	29.0	33.0	5500	3025	2200	279	6.9	3.7	.3	.7	.8	1.4
27	4.84	0.6	29.0	14.8	43.5	90.0	31.0	34.0	5000	2550	2000	274	6.6	3.7	.3	.6	.7	1.3
R + 00PM	4.65	0.9	41.8	14.0	40.0	86.0	30.0	35.0	7300									
01	4.71	1.2	56.5	14.0	40.0	85.0	30.0	35.0	4700	3149	1504	282	6.6	4.1	.3	.6	.7	0.9
06	4.61	0.9	41.5	13.3	40.0	87.0	29.0	33.0	3300	1155	2046	274	6.3	3.8	.3	.5	.7	1.0
13	4.35	0.9	39.2	12.8	38.5	88.0	29.0	33.0	5200	2600	2392	290	6.6	4.1	.3	.5	.7	1.0

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 4

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.80	0.9	44.4	13.6	41.8	86.7	28.2	32.5	5475	3032	2196	276	6.8	3.9	.2	.6	.8	1.2
MEAN ± SD	.04	0.2	10.0	0.1	0.5	1.0	0.5	0.6	562	296	325	15	0.1	0.1	0	0	0	0.2
BR 08	5.24	0.9	47.2	14.6	45.0	86.0	28.0	32.0	7600	4028	3344	265	7.1	4.1	.3	.7	.8	1.2
13	4.92	0.7	34.4	14.4	43.0	87.0	29.0	33.0	7200	3744	3312		6.7	4.1	.2	.6	.7	1.1
13PM	4.83	0.9	43.5	14.0	42.0	87.0	29.0	33.0	6500	-	-		6.7	4.2	.2	.6	.7	1.0
14	4.74	0.7	33.2	14.0	40.0	84.0	30.0	35.0	7900				-	-	-	-	-	-
14PM	4.67	0.6	28.0	14.1	41.0	88.0	30.0	34.0	6700	-	-		6.4	3.9	.2	.6	.6	1.1
15	4.78	0.6	28.7	14.0	42.0	88.0	29.0	33.0	7300	-	-		-	-	-	-	-	-
15PM	4.91	0.6	29.5	13.4	43.0	88.0	27.0	31.0	6300	-	-		7.0	3.7	.2	.8	.8	1.5
21	5.25	0.7	36.7	14.6	44.5	85.0	28.0	33.0	6900	4278	2553	330	7.1	3.6	.3	.8	.9	1.5
27	5.29	0.6	31.7	14.4	44.0	83.0	27.0	33.0	6600	3498	2970	294	7.1	4.0	.2	.7	.8	1.4
R + 00PM	4.86	0.8	29.2	13.9	41.0	84.0	29.0	34.0	7200									
01	4.76	0.6	28.6	13.7	42.0	88.0	29.0	33.0	5700	3420	2280	289	6.7	4.3	.2	.5	.7	1.0
06	4.70	0.9	42.3	13.2	40.0	85.0	28.0	33.0	5700	3819	1767	304	6.7	3.9	.3	.6	.8	1.1
13	4.82	1.1	53.0	13.7	41.5	86.0	28.0	33.0	5800	3132	2552	315	6.7	3.9	.3	.6	.7	1.2

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 5

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.53	0.8	36.3	13.8	41.4	91.2	30.5	33.2	7475	4271	2898	235	6.6	3.7	.3	.7	.8	1.2
MEAN ± SD	.14	0.1	4.7	0.3	1.5	1.7	0.6	0.5	1607	1717	275	17	0.1	0.1	.1	.1	.1	0.1
BR 08	4.65	0.7	32.6	14.1	42.0	90.0	30.0	34.0	6500	3640	2535	263	6.4	3.8	.2	.6	.6	1.2
13	4.41	0.8	35.3	13.9	40.5	92.0	32.0	34.0	7100	3408	3550		6.2	3.9	.2	.5	.6	1.0
13PM	4.29	0.6	25.7	13.5	39.0	91.0	31.0	35.0	6700	-			6.0	3.8	.2	.5	.6	0.9
14	4.22	0.6	25.3	13.1	38.0	90.0	31.0	34.0	7200	-			-	-	-	-	-	-
14PM	4.18	0.7	29.3	13.2	38.0	91.0	32.0	35.0	6300	-			5.9	3.4	.3	.6	.6	1.0
15	4.22	0.6	25.3	13.4	38.5	91.0	32.0	35.0	6400	-			-	-	-	-	-	-
15PM	4.39	0.5	22.0	13.7	39.5	90.0	31.0	35.0	6800	-			6.4	4.0	.2	.6	.6	1.0
21	4.57	0.5	22.8	14.0	40.0	87.0	31.0	35.0	6600	3036	3234	258	6.4	3.9	.3	.5	.7	1.0
27	4.61	0.9	41.5	14.1	41.5	90.0	31.0	34.0	6000	3540	2220	289	6.7	4.4	.2	.5	.6	1.0
R + 00PM	4.29	0.8	34.3	13.0	37.5	87.0	30.0	35.0	8000									
01	3.89	1.6	62.2	12.0	35.0	90.0	31.0	34.0	6000	3360	2340	186	6.0	3.6	.2	.5	.6	1.1
06	4.09	1.6	65.4	12.3	36.5	89.0	30.0	34.0	5700	3192	2337	255	6.2	3.5	.3	.6	.7	1.1
13	3.77	1.0	37.7	11.7	34.5	91.0	31.0	34.0	7300	4088	2920	262	5.9	3.8	.2	.5	.6	0.8

HEMATOLOGY SUMMARY DATA / SUBJECT NO. 6

MISSION DAY	RBC	RETIC	RETIC NO	HB	HCT	INDICES MCV	MCH	MCHC	WBC	NEUT NO	LYMPH NO	PLAT	PROT	ALB	ELECTROPHORESIS A1-M	A2-M	B-M	G-M
PRE TEST	4.38	0.6	28.4	13.1	39.6	90.7	29.7	33.0	4875	2112	2507	232	6.7	3.8	.3	.6	.8	1.2
MEAN ± SD	.07	0.1	2.2	0.4	0.8	1.0	0.5	0.8	330	376	225	22	0.2	0.1	.1	0	0	0.1
BR 08	4.61	0.5	23.1	13.7	41.0	89.0	30.0	33.0	5600	2576	2912	238	6.9	3.8	.3	.6	.8	1.4
13	4.48	0.7	31.4	13.7	40.0	89.0	31.0	34.0	6500	3445	2730		6.7	4.3	.3	.5	.7	0.9
13PM	4.44	0.8	35.5	13.6	39.5	89.0	31.0	34.0	6300	-	-		6.8	4.4	.3	.6	.7	0.8
14	4.40	0.6	26.4	13.4	38.0	86.0	30.0	35.0	5700	-	-		-	-	-	-	-	-
14PM	4.54	0.5	22.7	13.7	41.0	90.0	30.0	33.0	6500	-	-		7.1	4.5	.3	.6	.8	0.9
15	4.14	0.5	20.7	12.4	36.5	88.0	30.0	34.0	5500	-	-		-	-	-	-	-	-
15PM	4.20	0.5	21.0	12.7	36.0	86.0	30.0	35.0	5100	-	-		6.1	3.7	.3	.5	.6	1.0
21	4.51	0.6	27.1	13.2	39.0	86.0	29.0	34.0	6000	3180	2400	241	6.6	4.0	.2	.7	.6	1.1
27	4.46	0.6	26.8	13.3	39.0	87.0	30.0	34.0	5600	3080	2464	242	6.8	4.4	.2	.5	.7	1.0
R + 00PM	4.28	0.7	30.0	12.8	37.0	86.0	30.0	35.0	8100									
01	3.95	0.9	35.6	11.6	34.0	86.0	29.0	34.0	5400	3564	1620	261	6.3	3.7	.3	.5	.7	1.1
06	3.95	1.0	39.5	11.8	35.0	89.0	30.0	34.0	4700	2256	2115	275	6.5	3.5	.3	.6	.8	1.3
13	3.84	1.3	49.9	11.5	34.5	90.0	30.0	33.0	4500	1890	2305	256	6.4	4.0	.3	.5	.6	1.0

HEMOGLOBIN AND PLASMA VOLUME
A STATISTICAL ANALYSIS

Stephen L. Kimzey and A. Baky

The details of the crossover study to evaluate the influence of fluid ingestion and lower body negative pressure on the restoration and maintenance of plasma volume have been discussed elsewhere in this report.

The effects of bedrest and the ingestion of fluids during bedrest on Hb, PVOL and PVOL-PCT may be summarized as follows:

I. Effect of Bedrest and Ingestion on Hb

The analysis of variance of two way classification with some contrasts of concern for Hb are given in Table 1 from which the following could be concluded:

a. There are significant differences between subjects ($P < .001$), treatments ($P < .001$) and the interaction between subjects and treatments ($P < .01$).

b. The variability between subjects contributed 55.7% of the total variability of the experiment, while the contribution of the treatments is 26.1%, the interaction is 7.6% and the variabilities within individuals contributed 10.6% of the total variabilities.

c. The significance of the interaction indicates that the response of the subjects was not the same for the different treatments. By analyzing the interaction, it was found that Hb increased significantly ($P < .01$) during bedrest for subjects 1, 2, 3 and 4, but the increase was not significant for subjects 5 and 6.

d. There is no significant difference between pre- bedrest and R+0 relative to Hb indicating that in individuals whose Hb increased significantly during bedrest were back to normal at R+0.

e. Concerning the ingestion effect on Hb, it was found that the effect of bedrest was not maintained by ingestion. In spite of a significant decrease ($P < .01$) for all of the subjects in Hb due to ingestion, the decrease was not enough to cause the Hb values during bedrest to be not significant from pre- bedrest values. It was found that there is highly significant different ($P < .001$) between the ingestion effect on Hb and the pre- bedrest mean Hb. Also, it was found that the effect of ingestion at AM the day

after ingestion was not significantly different from the at PM the say day of ingestion.

f. Bedrest and ingestion effects on Hb are shown for individuals in Table 2 and for all subjects in Table 4. The percentage changes in Hb as effected by bedrest and ingestion are shown for individuals in Table 3 and for all subjects in Table 5.

II. Effect of Bedrest and Ingestion on PVOL

The analysis of variance of two way classifications with some contrasts of concern for PVOL parameter are given in Table 6 from which the following could be concluded:

a. There are significant differences between subjects ($P < .001$), and between treatments ($P < .001$). The interaction between the subjects and treatment was found to be not significant which indicated that the different subjects responded the same for the different treatments. The indication of significant interaction between subjects and treatments for Hb but not significant for PVOL may be due to the slower rate of change in Hb than in PVOL.

b. The PVOL decreased significantly for each subject and for all subjects ($P < .001$).

c. The increase in PVOL due to fluid ingestion raised the PVOL to the pre- bedrest levels. On the morning following the day of ingestion it was found that there was a significant decrease in PVOL compared to the PM sample the day of ingestion or to the pre- bedrest mean. In other words, the ingestion effect was not maintained.

d. Bedrest and ingestion effects on PVOL are shown for individuals in Table 7 and for all subjects in Table 9. The percentage changes in PVOL as effected by bedrest and ingestion are shown for individuals in Table 8 and for all subjects in Table 10.

III. Effect of Bedrest and Ingestion on PVOL-PCT

Because PVOL-PCT data are obtained from PVOL using the mean pre-bedrest value for each individual as 100. The partitioning of the effects by the linear statistical modeling which was applied in analyzing bedrest and ingestion effects will show that the analyses of PVOL or PVOL-PCT are the same except for the differences in magnitude

The weighted magnitude differences indicated by the F-tests for sources other than subjects will be the same except for rounding errors. In summary, the analysis of PVOL and PVOL-PCT will give the same conclusions except that PVOL-PCT eliminates differences due to subjects pre- bedrest which will not have any effect except on the reducing the magnitude difference between subjects. However, if the subjects are different pre- bedrest, the statistical routine that considers the subjects different will eliminate and test subjects effects without any other device. In addition, if the subjects are different in pre-bedrest, they will be the same during and after treatments.

To prove the previous discussion, the PVOL-PCT data were analyzed and tabulated in Tables 11, 12, 13, 14 and 15. Corresponding to Tables 6, 7, 8, 9 and 10 respectively for PVOL data from which we could indicate that the conclusion concerning bedrest and ingestion effects on PVOL or PVOL-PCT are the same. The subjects effect was found to be significant in PVOL-PCT analysis but the differences are due to their differences during and at post-bedrest. This is natural, because if the subjects are different in pre- bedrest, they will be also different during bedrest and at post-bedrest. PVOL-PCT analysis showed significant differences between subjects during and at post-bedrest but no significant differences between subjects at pre-bedrest which is not true. According using PVOL-PCT only is not practical and does not serve any objective. The whole information could be obtained if PVOL data not PVOL-PCT data are used in the analysis.

To prove algebraically that the percentage change due to any treatment is the same using PVOL or PVOL-PCT, let:

$\bar{x}_1$ = bedrest mean of subject 1

a_1 = pre-bedrest mean of subject 1

$\bar{P}_1$ = PVOL-PCT mean at bedrest for subject 1

Then, the percentage change due bedrest using PVOL-PCT is given by:

$$\% \text{ change due to bedrest} = \bar{P}_1 - 100$$

where $\bar{P}_1$ is calculated by the same equation for calculating PVOL-PCT, that is:

$$\bar{P}_1 = \frac{\bar{x}(100)}{\bar{a}_1}$$

The percentage change due bedrest using PVOL is given by:

$$\% \text{ change due to bedrest} = \frac{\bar{x} - a_1 \ (100)}{a_1}$$

$$= \frac{\bar{x}}{a_1} (100) - 100$$

$$= \bar{P}_1 - 100$$

and the proof if complete.

IV. The relation between Hb and PVOL

If the values for Hb and PVOL are plotted on each other, a straight line can be found by using the following equation:

$$y = a + bx$$

where :

y = Hb values
x = PVOL values
a = y-intercept
b = slope of Hb on PVOL

The two variables Hb and PVOL will be correlated to each other of the slope b or the correlation r is found to significant.

When calculating the percentage changes using:

$$\Delta\% = \frac{100 \ (x - \bar{x} \text{ pre})}{\bar{x} \text{ pre}}$$

where:

$\Delta\%$ = percentage change
x = any value during bedrest
$\bar{x}_{pre}$ = pre-bedrest mean for the corresponding variable x

it is noted that at pre-bedrest, there is a zero change for both the two parameters Hb and PVOL, and any increase or decrease during bedrest in any parameter will be associated with a decrease or increase in the other parameter if the two parameter are correlated. This means that the straight line should go to zero point which is the calibration point for 0 change at pre-bedrest. In other words, when plotting percentage changes, the intercept a is zero and the equation of straight line will be:

$$y = bx$$

where:

y = Hb values
x = PVOL values
b = slope

When plotting PVOL on Hb, then:

$$x = \left(\frac{1}{b}\right)4$$

Thus indicate that the slope of x is the inverse of the slope of y, and if one is estimated, the other could be found using the inverse relationship:

$$b_x = \frac{1}{b_y}$$

The correlation coefficient r was calculated from the percentage changes during bedrest and it was found to be -0.6382 and it is significant at 1% level. This indicates that the relation between Hb and PVOL is a negative relationship; if one increases (decreases) the other decreases (increases). An approximation estimates of the slopes which validate the requirement that the slope should go through the point $(\bar{x},\bar{y})$ is given by:

$$b_{Hb} = \frac{\bar{\Delta}Hb}{\bar{\Delta}PVOL} = \frac{7.79}{-9.11} = -0.86$$

$$b_{PVOL} = \frac{1}{b_{Hb}} = \frac{\bar{\Delta}PVOL}{\bar{\Delta}_{Hb}} = \frac{-9.11}{7.79} = -1.17$$

The equations of straight lines for PH and PVOL are:

$$\Delta\%Hb = -0.86\ (\Delta\%PVOL)$$

$$\Delta\%PVOL = -1.17\ (\Delta\%Hb)$$

TABLE 1. ANALYSIS OF VARIANCE (Hb)

Source of Variation	Degrees of Freedom	Sum Squares	Mean Squares	F
Subjects	5	66.5621	13.3124	75.53***
Treatments	4	31.2016	7.8004	44.26***
Interaction	20	9.0954	0.4548	2.58**
Error	72	12.6900	0.1763	
Total	101	119.5491		
<u>Contrasts of Concern</u>				
Ingestion Effect vs BR	(1)	1.8144	1.8144	10.29**
Ingestion Effect vs Pre-BR	(1)	2.2721	2.2721	12.89***
Ingestion Effect vs AM After Ingestion	(1)	0.0180	0.0180	0.10
BR vs Pre-BR	(1)	9.5052	9.5052	53.93***
R+O vs Pre-BR	(1)	0.0077	0.0077	0.04
Post-BR vs Pre-BR	(1)	4.9152	4.9152	27.89***
BR vs Pre-BR, Subject 1	(1)	5.7800	5.7800	32.79***
BR vs Pre-BR, Subject 2	(1)	3.2768	3.2768	18.59***
BR vs Pre-BR, Subject 3	(1)	1.3778	1.3778	7.82**
BR vs Pre-BR, Subject 4	(1)	1.8050	1.8050	10.24**
BR vs Pre-BR, Subject 5	(1)	0.0800	0.0800	0.45
BR vs Pre-BR, Subject 6	(1)	0.2888	0.2888	1.64
Post-BR vs Pre-BR, Subject 1	(1)	0.5000	0.5000	2.84
Post-BR vs Pre-BR, Subject 2	(1)	0.0450	0.0450	0.26
Post-BR vs Pre-BR, Subject 3	(1)	1.3448	1.3448	7.63**
Post-BR vs Pre-BR, Subject 4	(1)	0.0128	0.0128	0.07
Post-BR vs Pre-BR, Subject 5	(1)	4.9928	4.9928	28.33***
Post-BR vs Pre-BR, Subject 6	(1)	2.7378	2.7378	15.53***

TABLE 2. BEDREST AND INGESTION EFFECTS ON HB PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	13.90	14.75	14.35	13.55	13.83	13.10
Bedrest	15.60***	16.03***	15.18**	14.50**	14.03	13.48
Ingestion	15.27**	15.63**	14.77	13.83a	13.47	13.33
R+0	14.60	15.40	14.00	13.90	13.00	12.80
Post-Bedrest	13.40	14.90	13.53**	13.63	12.25***	11.93***

*** P < .001 Compared to Pre-Bedrest

** P < .01 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 3. PERCENTAGE CHANGES IN HB AS AFFECTED BY BEDREST AND INGESTION PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	0	0	0	0	0	0
Bedrest Effect	12.23***	8.68***	5.78***	7.01**	1.45	2.90
Ingestion Effect	-2.37**	-2.71**	-2.86	-4.94a	-4.05	-1.15
R+0	5.04	4.41	-2.44	2.58	-6.00	-2.29
Post-Bedrest	-3.60	1.02	-5.71**	0.59	-11.42***	-8.93***

*** P < .001 Compared to Pre-Bedrest

** P < .01 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 4. BEDREST AND INGESTION EFFECTS ON HB OVER ALL SUBJECTS

Treatment	Mean Effect
Pre-Bedrest	13.91
Bedrest	14.80***
Ingestion	14.38a***
R+0	13.95
Post-Bedrest	13.27***

*** P < .001 Compared to Pre-Bedrest

a Significant Change Due to Ingestion (P < .01)

TABLE 5. PERCENTAGE CHANGES IN HB AS AFFECTED BY BEDREST AND INGESTION OVER ALL SUBJECTS

Treatment	% Change
Pre-Bedrest	0
Bedrest	6.40***
Ingestion	-3.02a***
R+0	0.29
Post-Bedrest	-4.60***

*** P < .001 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 6. ANALYSIS OF VARIANCE (PVOL)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Subjects	5	3,634,172.30	726,834.46	27.93***
Treatments	4	2,641,094.00	660,273.50	25.37***
Interaction	20	877,651.60	43,882.58	1.69ns
Error	39	1,014,961.00	26,024.64	
Total	68	8,167,878.90		
<u>Contrasts of Concern</u>				
Ingestion vs BR	(1)	1,646,888.66	1,646,888.66	63.28***
Ingestion vs Pre-BR	(1)	17,798.96	17,798.96	0.68ns
Ingestion vs AM After Ingestion	(1)	212,039.94	212,039.94	8.15**
BR vs Pre-BR	(1)	1,629,442.12	1,629.442.12	62.61***
R+O vs Pre-BR	-	-	-	-
Post-BR vs Pre-BR	(1)	3,481.00	3,481.00	0.13ns
BR vs Pre-BR, Subject 1	(1)	453,870.00	453,870.00	17.44**
BR vs Pre-BR, Subject 2	(1)	526,210.61	526,210.61	20.22**
BR vs Pre-BR, Subject 3	(1)	176,947.20	176,947.20	6.80*
BR vs Pre-BR, Subject 4	(1)	243,105.33	243,105.33	9.34**
BR vs Pre-BR, Subject 5	(1)	181,302.08	181,302.08	6.97*
BR vs Pre-BR, Subject 6	(1)	163,800.33	163,800.33	6.29*
Post-BR vs Pre-BR, Subject 1	(1)	21,122.67	21,122.67	.81ns
Post-BR vs Pre-BR, Subject 2	(1)	63,860.17	63,860.17	2.45ns
Post-BR vs Pre-BR, Subject 3	(1)	47,882.67	47,882.67	1.84ns
Post-BR vs Pre-BR, Subject 4	(1)	134,101.50	134,101.50	5.15*
Post-BR vs Pre-BR, Subject 5	(1)	144,770.67	144,770.67	5.56*
Post-BR vs Pre-BR, Subject 6	(1)	352.67	352.67	.01ns

TABLE 7. BEDREST AND INGESTION EFFECTS ON PVOL PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	3463.0	3594.5	3291.0	3270.5	3662.0	3146.0
Bedrest	2849.0**	2932.3**	2907.0*	2843.5**	3293.3*	2795.5*
Ingestion	3255.7a	3235.0a*	3352.0a	3164.7a	3985.3a*	3136.0a
Post-Bedrest	3641.0	3285.0	3559.0	2822.0*	4128.0*	3169.0

** P < .01 Compared to Pre-Bedrest

* P < .05 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 8. PERCENTAGE CHANGES IN PVOL AS AFFECTED BY BEDREST AND INGESTION PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	0	0	0	0	0	0
Bedrest	-17.73**	-18.42**	-11.67*	-13.06**	-10.07*	-11.14*
Ingestion	11.74a	8.42	13.52a	9.82a	18.90a*	10.82a
Post-Bedrest	5.14	-8.61	8.14	-13.71*	12.73*	.73

** P < .01 Compared to Pre-Bedrest

* P < .05 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 9. BEDREST AND INGESTION EFFECTS ON PVOL OVER ALL SUBJECTS

Treatment	Mean Effect
Pre-Bedrest	3404.5
Bedrest	2942.6***
Ingestion	3354.8a
Post-Bedrest	3434.0

*** P < .001 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 10. PERCENTAGE CHANGES IN PVOL AS AFFECTED BY BEDREST AND INGESTION OVER ALL SUBJECTS

Treatment	% Change
Pre-Bedrest	0
Bedrest Effect	-13.57***
Ingestion Effect	12.11a
Post-Bedrest	0.87

*** P < .001 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 11. ANALYSIS OF VARIANCE (PVOL PCT)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Squares	F
Subjects	5	904.8598	180.9720	8.30**
Treatments	4	2194.9052	548.7263	25.17***
Interaction	20	752.8742	37.6437	1.73ns
Error	39	850.1802	21.7995	
Total	68	4702.8194		
Contrasts of Concern				
Ingestion vs BR	(1)	1365.6161	1365.6161	62.64***
Ingestion vs Pre-BR	(1)	15.9847	15.9847	.73ns
Ingestion vs AM After Ingestion	(1)	186.5383	186.5383	8.56**
BR vs Pre-BR	(1)	1363.0115	1363.0115	62.52***
R+O vs Pre-BR	-	-	-	-
Post-BR vs Pre-BR	(1)	2.0736	2.0736	0.10ns
BR vs Pre-BR, Subject 1	(1)	377.2235	377.2235	17.30**
BR vs Pre-BR, Subject 2	(1)	407.5979	407.5979	18.70**
BR vs Pre-BR, Subject 3	(1)	163.4267	163.4267	7.50**
BR vs Pre-BR, Subject 4	(1)	227.0700	227.0700	10.42**
BR vs Pre-BR, Subject 5	(1)	134.6700	134.6700	6.18*
BR vs Pre-BR, Subject 6	(1)	165.7633	165.7633	7.60**
Post-BR vs Pre-BR, Subject 1	(1)	17.3400	17.3400	0.80ns
Post-BR vs Pre-BR, Subject 2	(1)	49.3067	49.3067	2.26ns
Post-BR vs Pre-BR, Subject 3	(1)	43.7400	43.7400	2.01ns
Post-BR vs Pre-BR, Subject 4	(1)	125.1267	125.1267	5.74*
Post-BR vs Pre-BR, Subject 5	(1)	107.5267	107.5267	4.93*
Post-BR vs Pre-BR, Subject 6	(1)	0.3267	0.3267	.02ns

TABLE 12. BEDREST AND INGESTION EFFECTS ON PVOL PCT PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	100.00	100.00	100.00	100.00	100.00	100.00
Bedrest	82.27**	81.57**	88.33**	86.95**	89.95*	88.85*
Ingestion	94.00a	90.00a*	101.83a	96.77a	108.80a*	99.67a
Post-Bedrest	105.10	91.40	108.10	86.30*	112.70*	100.70

** P < .01 Compared to Pre-Bedrest

* P < .05 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 13. PERCENTAGE CHANGES IN PVOL PCT AS AFFECTED BY BEDREST AND INGESTION PER INDIVIDUAL

Treatment	Subjects					
	1	2	3	4	5	6
Pre-Bedrest	0	0	0	0	0	0
Bedrest Effect	-17.73**	-18.43**	-11.67**	-13.05**	-10.05*	-11.15*
Ingestion Effect	11.73a	8.43a*	13.50a	9.82a	18.85a*	10.82a
Post-Bedrest	5.10	-8.60	8.10	-13.70*	12.70*	.70

** P < .01 Compared to Pre-Bedrest

* P < .05 Compared to Pre-Bedrest

a Significant Change Due to Ingestion

TABLE 14. BEDREST AND INGESTION EFFECTS ON PVOL PCT OVER ALL SUBJECTS

Treatment	Mean Effect
Pre-Bedrest	100.00
Bedrest	86.64***
Ingestion	98.51a
Post-Bedrest	100.72

*** P < .001 Compared to Pre-Bedrest

a Significant Change to Ingestion (P < .001)

TABLE 15. PERCENTAGE CHANGES IN PVOL PCT AS AFFECTED BY BEDREST AND INGESTION OVER ALL SUBJECTS

Treatment	% Change
Pre-Bedrest	0
Bedrest Effect	-13.36***
Ingestion	12.87a
Post-Bedrest	0.72

*** P < .001 Compared to Pre-Bedrest

a Significant Change Due to Ingestion (P < .001)

SEM CLASSIFICATION OF RED BLOOD CELLS

S. L. Kimzey, A. Baky, M. Brower, J. Cardano and T. Rogers

METHODS:

Six male subjects were selected by Baylor College of Medicine for the BCM Bedrest-II Study. Blood samples were obtained during scheduled sampling periods for pre-, in-, and post-bedrest periods.

A 0-hr sample from each subject was fixed immediately in 0.5% glutaraldehyde in SIM (pH 7.4 at 340 mOsm). Fixative (approximately 2 ml) was injected into 3 ml clot tubes. The collection needle from the butterfly collecting unit was immediately inserted into the fixative tube. The slight vacuum remaining in the fixative tube would withdraw any blood remaining in the needle into the fixative. The plasma incubation sample was collected in a 2 ml heparin tube and this sample was not opened until the 24-hr plasma sample was taken. One ml of blood was removed from the routine hematology heparin tube upon return to the laboratory and placed in a 5 ml Falcon tube and washed three times with Hanks' medium. The washed cells were resuspended in Hanks' medium to equal the plasma which was removed. Both the washed and plasma samples were spun 5-7 seconds to remove cells from the rubber stopper and sides of the tube prior to placing in the refrigerator for maintenance at 4-5°C.

Samples were fixed after 24 and 48 hours from both the plasma and Hanks' series. The tubes were inverted and agitated gently to insure mixing before removing a sample for fixation (1-2 drops). After the samples were removed, the sample was capped, spun 5-7 seconds and replaced in the refrigerator.

Samples were fixed a minimum of one hour in 0.5% glutaraldehyde prior to washing and postfixing in osmium tetroxide. Samples were processed for SEM examination according to established procedure (see Appendix I) and examined on the ETEC Autoscan SEM.

RESULTS:

The discocyte population shows a uniform decrease in all subjects when samples are compared during each draw date from F-40 to R+0 (0-hr samples). As the discocyte population decreases during 24 hr stress, there is a concurrent increase in echinocyte numbers. The trend toward advanced echinocytes (ECH2, ECH3, and SPHECH1-2) appears at 24 hours stress and continues to increase at 48 hours. Sphero-echinocytes are of primary importance at 48 hours stress while third stage echinocytes appear more often at 24 hours of stress. All subjects seemed to follow the same pattern of change with exception of Subject 2.

Throughout the study, Subject 2 seemed to be more echinocytic with a lower discocyte population than the other subjects involved. When this data is included in correlation with other subjects, however, total cell population is such that this exception is not noticed.

Recovery (R+0) samples showed an increased population of advanced echinocytes which indicates that there is a time factor lag in the final result of morphological change which occurs as a result of bedrest. Post-recovery samples (R+6 and R+13) show a return to normal morphology for all subjects.

Initial analysis of data on the SEM classification of red cells from the BCM Bedrest-II Study failed to show large morphological change in cell populations as a result of bedrest in comparison to storage of samples at $5^{o}C$ for 24 and 48 hours. This effect contributed significantly to a large change in red cell classification categories, thereby, overiding any effect of bedrest alone.

Statistical evaluation of the data was performed by A. Baky and is as follows:

DATA EVALUATION-I

Statistical Results of Blood Cell Shapes as Affected by Bedrest and Storage.

The experimental data were analyzed by the multinomial statistical analysis (1-4). The results are summarized as follows:

I. Bedrest at 0-Hr.

The percentage of the four categories of shape classification for pre-bedrest, in-bedrest, and post-bedrest were found to be:

TREATMENT	DISCO	ECH-1	ECH-SPE	OTHERS	TOTAL
Pre-bedrest	78.5	6.2	1.3	14.0	100
In-bedrest	75.9	5.2	0.4	18.5	100
Recovery	72.2	11.5	.6	15.7	100

The X^2-Test for testing the change in the percentage categories was found to be 304.49 which is very highly significant ($P<.001$). Comparison tests were performed for each category to find where these changes had occurred. The results of these tests indicate the following:

a) The DISCO category decreased significantly during bedrest and also decreased significantly after recovery.

b) The ECH-1 category did not change during bedrest but increased significantly after recovery.

c) The ECH-SPE category decreased significantly during bedrest and remain significantly less than normal after recovery.

d) The OTHERS category increased significantly during bedrest but changed to normal after recovery.

From the previous results, it could be concluded that; in bedrest, the categories DISCO, ECH-SPE significantly decreased while the other categories significantly increased.

After recovery, the category DISCO significantly decreased while the category ECH-1 significantly increased.

II. Storage Effect

The percentages of the four categories of shape classification for 0-hrs, 24-hrs, and 48-hrs were found to be:

TREATMENT	DISCO	ECH-1	ECH-SPE	OTHERS	TOTAL
0-Hrs	76.7	6.3	0.8	16.2	100
24-Hrs	66.3	13.4	9.2	11.1	100
48-Hrs	58.1	15.2	16.7	10.0	100

The X^2-Test for the change in the percentage categories due to storage was found to be 5684.74 compared to the critical value 17.6 which indicates that the test is very highly significant ($P<.0001$) Comparison tests were performed for each category to find where these changes had occurred. The results of these tests indicate that both DISCO and OTHERS categories significantly decreased with storage at

24-hours and continued decreasing significantly at 48 hours, while both ECH-1 and ECH-SPE significantly increased by storage at 24 and 48 hours. It follows that when studying treatment effects on the shape of blood cells, the storage effect should be eliminated.

III. All Categories Included in the Analysis

In the first analysis, two categories and two groups were considered as indicated in Section I. It was found that there were significant changes in the percentage categories and groups due to bedrest and storage. A complete statistical analysis for all different categories included in the study was performed in order to indicate the specific categories that significantly changed by the two stresses. The statistical procedure used for multinomial analysis were same as in Section I. The results are summarized as follows:

1. Bedrest effect:
   a. Five different categories were significantly changed during bedrest and/or recovery which are shown in Table 1 and Figure 1.
   b. During bedrest, only DISCO decreased significantly ($P<.05$); on the other hand, both KNIZO and TORO increased significantly.
   c. At recovery, both DISCO and TORO decreased significantly; on the other hand, both STOMATO and ECH-I increased significantly.
2. Storage effect:
   a. Eight different categories were significantly changed by storage which are shown in Table 2.
   b. At 24-hours, DISCO, KNIZO, and TORO decreased significantly ($P<.05$); on the other hand, ECH-I, ECH-II, ECH-III, SPHECH-I,

and SPECH-II increased significantly ($P<.05$).

c. At 48 hours, DISCO decreased significantly when compared to 24 hours; on the other hand, ECH-I, ECH-II, ECH-III, SPHECH-I, and SPHECH-II also continued to increase significantly compared to 24 hours. Both KNIZO and TORO remained significantly less than 0-hour, but they were not significantly changed from 24-hours.

3. Comparing the effects of bedrest and storage:

From 1 and 2, it could be indicated that the bedrest and the storage effects on the blood cell shapes are significantly different. These differences are shown in Figures 2-7 from which it could be indicated that:

a. DISCO significantly decreased by both bedrest and storage, but the decrease is significantly higher in magnitude than bedrest or recovery.

b. KNIZO significantly increased by bedrest but it was significantly decreased by storage.

c. STOMATO significantly increased at recovery but was not changed by storage.

d. ECH-I was not changed at bedrest but significantly increased at recovery and by storage.

e. ECH-II, ECH-III, SPHECH-I and SPHECH-II were not changed at bedrest or recovery but they significantly increase by storage.

f. TORO significantly increased at bedrest but it was significantly decreased at recovery and by storage.

CHANGES IN RED CELL SHAPE- BAYLOR BEDREST-II*

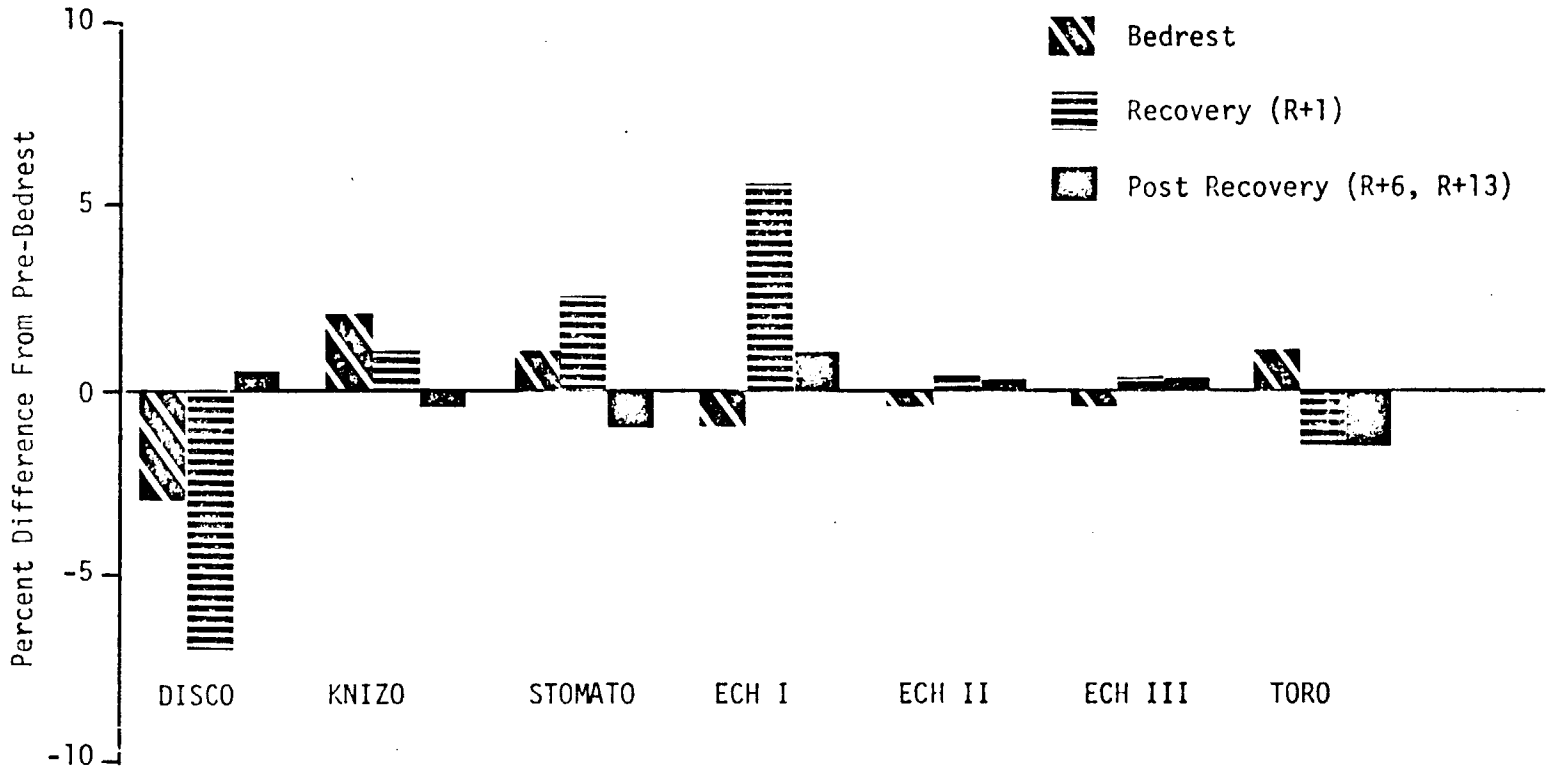


FIG. 1. Changes in red cell shape during the BCM Bedrest-II Study
*Refer to Table 1.

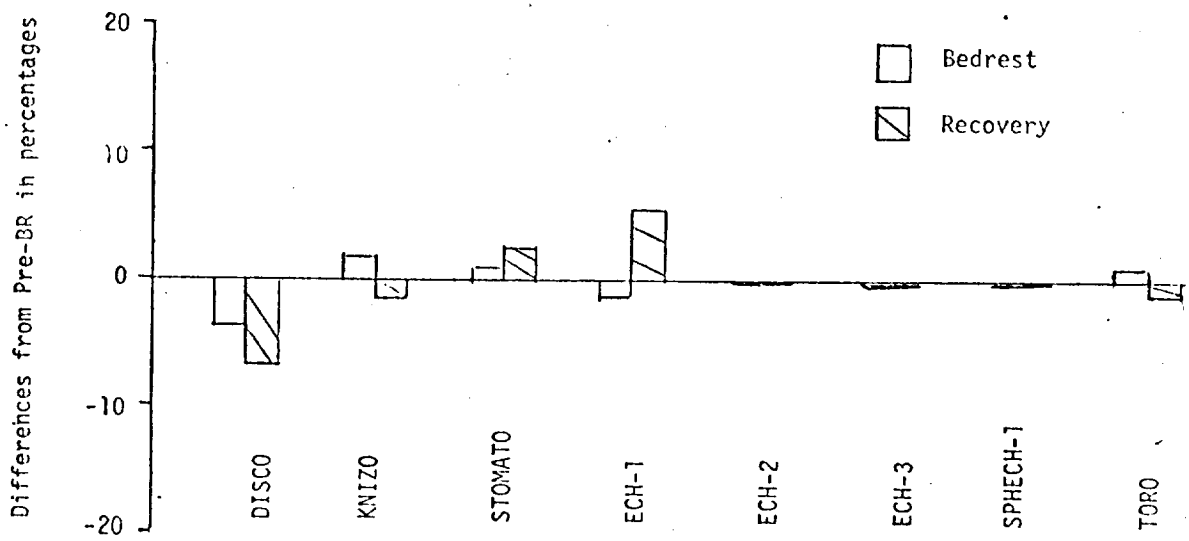


Figure 2. Blood cell categories changed significantly by bedrest and recovery

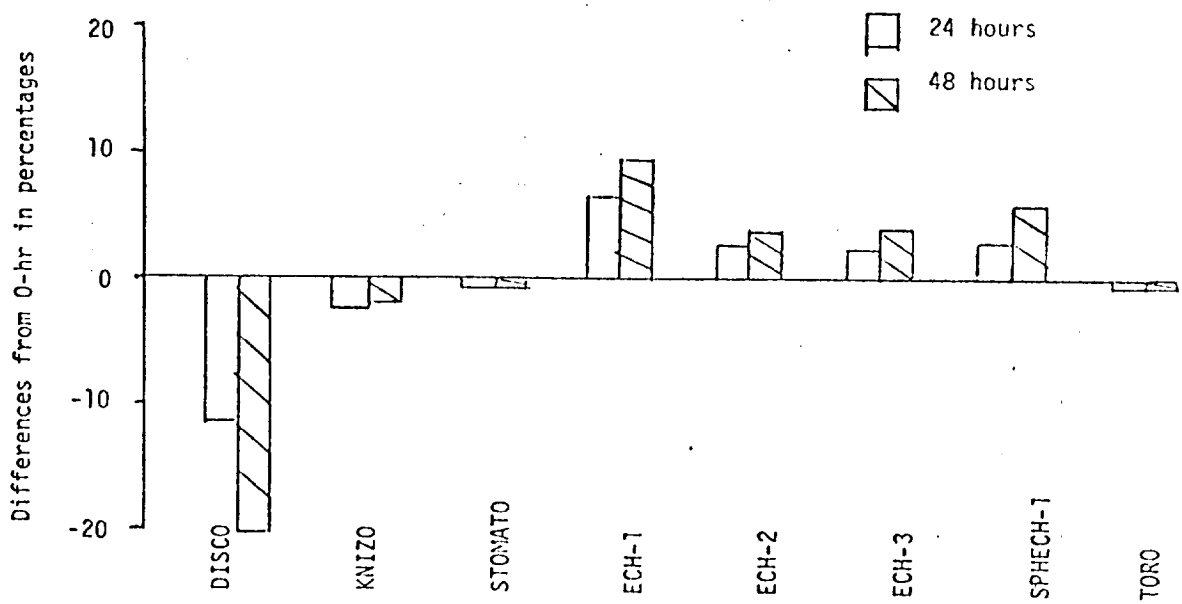


Figure 3. Blood cell categories changed significantly by storage.

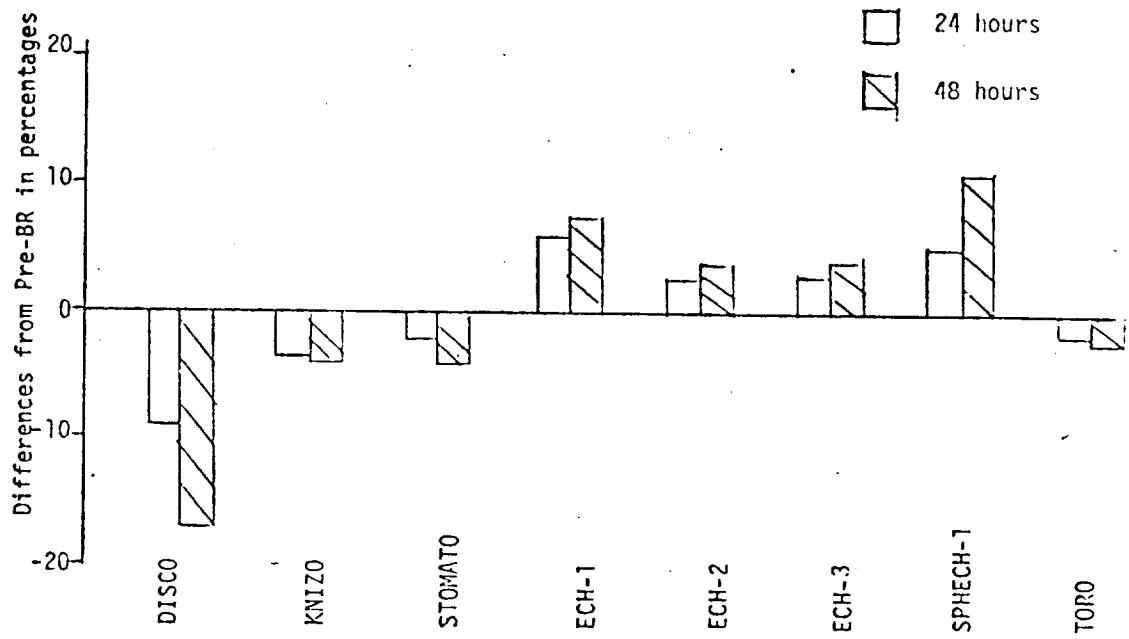


Figure 4. Blood cell categories as affected by storage during Bedrest

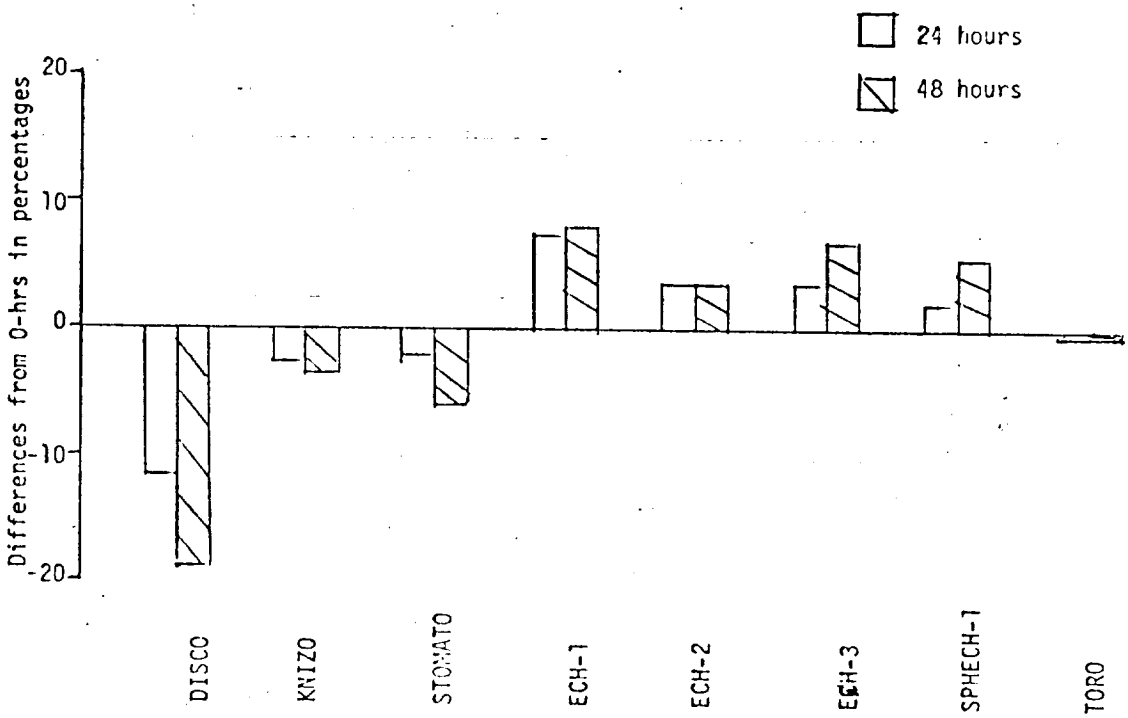


Figure 5. Blood cell categories as affected by storage at Recovery

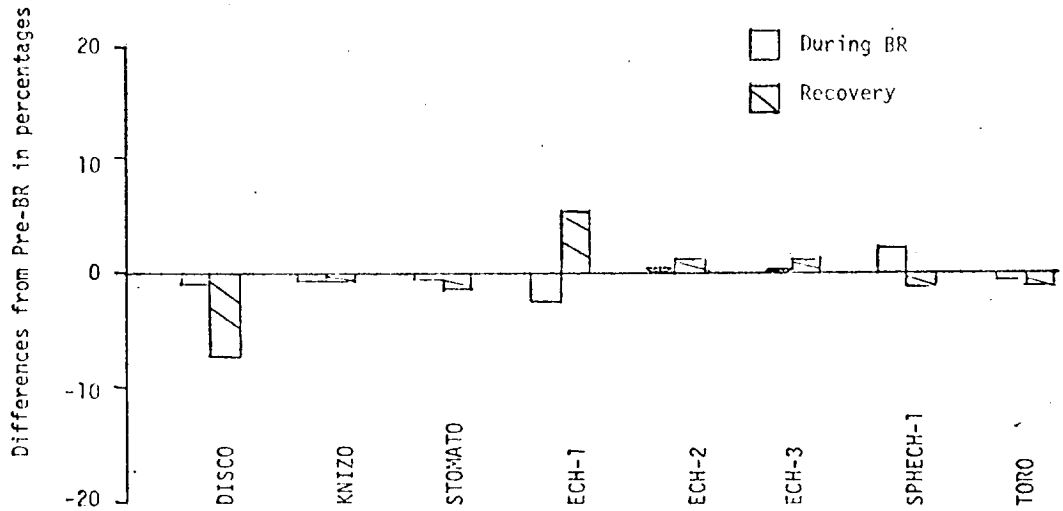


Figure 6. Blood cell categories as affected by Bedrest and Recovery at 24 hrs storage

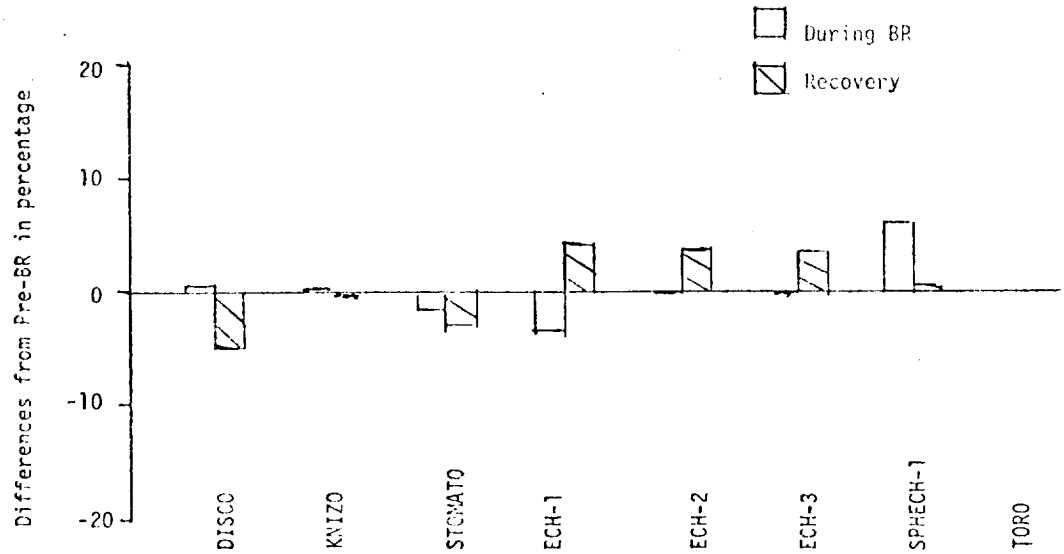


Figure 7. Blood cell categories as affected by Bedrest and Recovery at 48 hours storage.

TABLE 1. RED CELL SHAPE CHANGE- BEDREST II**

CELL TYPE	PRE-BEDREST	BEDREST	RECOVERY (R+1)	POST-BEDREST (R+6, R+13)
DISCO	78.58	75.91*	72.20*	79.35
KNIZO	3.71	5.47*	4.50	3.14
STOMATO	8.58	9.58	10.97*	7.62
SPHERO	0.03	0.11	0.03	0.07
CODO	0	0.01	0	0.01
LEPTO	0.02	0.02	0	0
RETICULO	0.48	0.48	0.03	0.12
ECH-I	6.17	5.19	11.47*	7.25
ECH-II	0.3	0.11	0.3	0.49
ECH-III	0.3	0.11	0.3	0.49
SPHECH-I	0.08	0.05	0	0.69*
SPHECH-II	0.02	0	0	0.1
KERAT	0.01	0	0	0
ELLIPTO	0.29	0.35	0.07	0.08
SCHIZO	0.04	0.02	0	0.01
ACANT	0	0	0	0
TORO	1.23	2.23*	0.13*	0.34*
OTHERS	0.16	0.36	0	0.16

*Significant at 5% level compared to Pre-Bedrest.

**Refer to Fig. 1 .

TABLE 2. PERCENTAGE CATEGORIES AS AFFECTED BY STORAGE AT PRE-BEDREST

CATEGORY	0-HOUR	24-HOURS	48-HOURS
DISCO	78.58	67.40*	58.66*
KNIZO	3.71	1.67*	1.93*
STOMATO	8.58	7.80	7.84
SPHERO	.03	.05	.05
CODO	0	.03	0
LEPTO	.02	.01	0
RETICULO	.48	.46	.62
ECH-I	6.17	13.13*	15.59*
ECH-II	.30	2.58*	3.69*
ECH-III	.30	2.58*	3.69*
SPHECH-I	.08	2.63*	5.18*
SPHECH-II	.02	.82*	1.92*
KERAT	.01	0	0
ELLIP	.29	.20	.10
SCHIZO	.04	.01	.03
ACANT	0	0	0
TORO	1.23	.63*	.69*

*Significant at 5% level

DATA EVALUATION-II

It was suggested that classification percentages of discocytes, echinocyte-1 and stomatocytes be combined into a single category for all Bedrest-II sample series and evaluated since it is possible that these cell types may be interchangeable in shape depending on factors related to fixation and processing.

The Bedrest subjects were compared to each other by combining samples during the pre-, in-, and post-bedrest periods. Figures 8, 9, and 10 show combined comparisons for discocytes, enchinocyte-1 and stomatocytes for 0, 24, and 48 hour plasma samples. Figures 11 and 12 show the data for the Hanks' sample series.

Subjects -0001, -0002, and -0003 were combined as a group (Group I) and subjects -0004, -0005, and -0006 were combined as Group II. Group I and II were compared to each other using the same combined sample days for pre-, in-, and post-bedrest and using the same combined cell classifications (discocyte, echinocyte-1, and stomatocytes). The 0, 24, and 48 hour plasma series are shown in Figure 13, and the 24 and 48 hour Hanks' series are compared in Figure 14.

The combined cell classification (discocyte, echinocyte-1 and stomatocytes) for the six Bedrest subjects was compared by sample date including pre-, in-, and post-bedrest samples for the 0, 24, and 48 hour plasma series and are shown in Figure 15. Figure 16 shows the sample day comparison for the 24 and 48 hour Hanks' series.

The mean of the four samples obtained during the pre-bedrest period (discocytes, echinocyte-1, and stomatocytes) for all six subjects was compared to individual sample days of the in-bedrest and post-bedrest

periods. The classification percentages for the combined cell types (discocytes, echinocyte-1, and stomatocytes) for the six subjects were included in each sample date. Comparison of the 0, 24, and 48 hour plasma series are shown in Figure 17 and the 24 and 48 hour Hanks' series are shown in Figure 18.

Considering 0-hour plasma to assume only Bedrest effect, the discocyte population decreases during bedrest as compared to the pre-bedrest percentages and then increases upon recovery to assume pre-bedrest normalcy. This trend is especially evident when combining discocytes, echinocyte-1, and stomatocytes as one group.

This trend is statistically significant in Group I [(Subjects 1, 2, and 3) (see Table 3)], but an abnormally high value for BR+21 (see Table 4) for Group II (Subjects 4, 5, and 6) produces an insignificant trend for this group. Perhaps a correction for the bias in cell counts could be easily introduced statistically to correct for such an occurrence.

Subject -0003 follows a rate of change throughout the bedrest sampling periods to exhibit a very significant trend in the decrease and subsequent increase in classification percentages (See Table 3). This trend may be considered the profile in what may be expected for cell variation due to bedrest stress.

Table 5 correlates the rate change for each major cell type accounting for all subjects during bedrest as compared to prebedrest. The only cells which significantly appear to exhibit a change through the pre- and in-bedrest periods, allowing for bedrest stress alone,

are the discocytes and knizocytes. The discocytes exhibit a significant decrease and the knizocytes reflect a parallel increase during that sampling time (See Fig. 1 & 2). This bedrest effect reflects a slow change over time, a situation quite opposite from that of storage. Upon recovery (R+0 and R+1) the cells undergo an additional stress and abruptly shift towards normalcy with the exception of echinocytes which increase as a result of the time lag factor previously described. The shift towards normalcy is reflected in the R+6 and R+13 values.

Table 6 compares the effect of storage with that of bedrest. It is interesting to note that the storage effect is 22.86 times that of bedrest.

The change during bedrest could be given by:

$$e^{y} = e^{a}t^{b} \qquad (1)$$

where y = percentage of cell category, a = intercept, b = rate of change(slope), and t = time. By taking natural logarithms for both side of equation (1), then;

$$y = a + b\ln(t) \qquad (2)$$

donating

$$x = \ln(t) \qquad (3)$$

By inserting equation (3) into (2), then;

$$y = a + bx \qquad (4)$$

Equation (4) is a linear function representing a straight line with a as intercept and b as the rate of change or slope over time in days. The period of the study was short in time, so that the exponential function cannot be verified and the linear function (4) was found to be a better fit.

The rate of change for any given percentage category of blood cell shapes due to bedrest is constant over this short time period; however, would vary with increasing time over a longer study period.

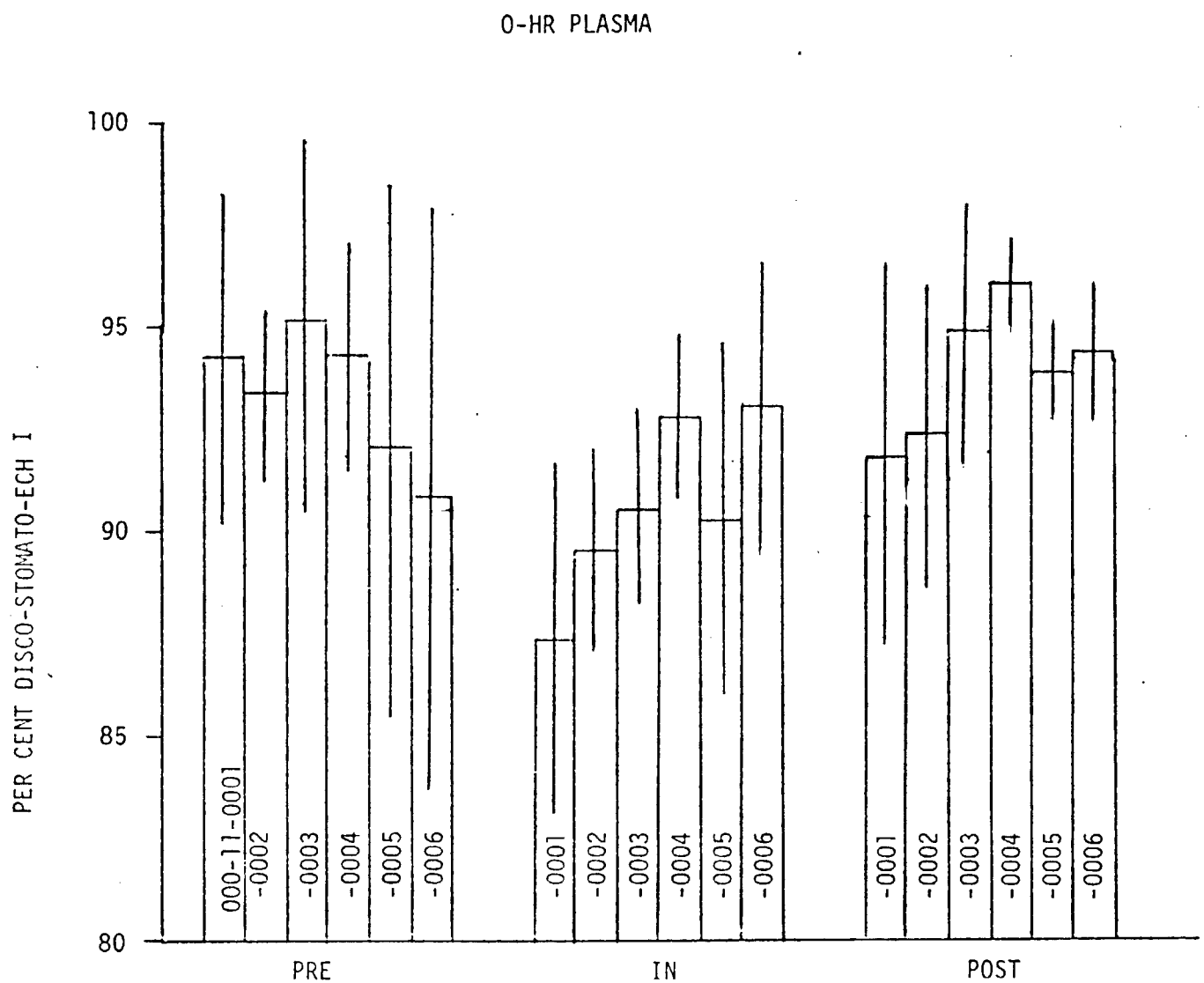


FIG. 8. BCM Bedrest-II. Combined classification percentages for DISCO-STOMATO-ECH I. Pre-bedrest (4 samples), In-bedrest (4 samples) and Post-bedrest (3 samples for subjects-0001, -0002, and -0003; 4 samples for subjects -0004, -0005, and -0006).

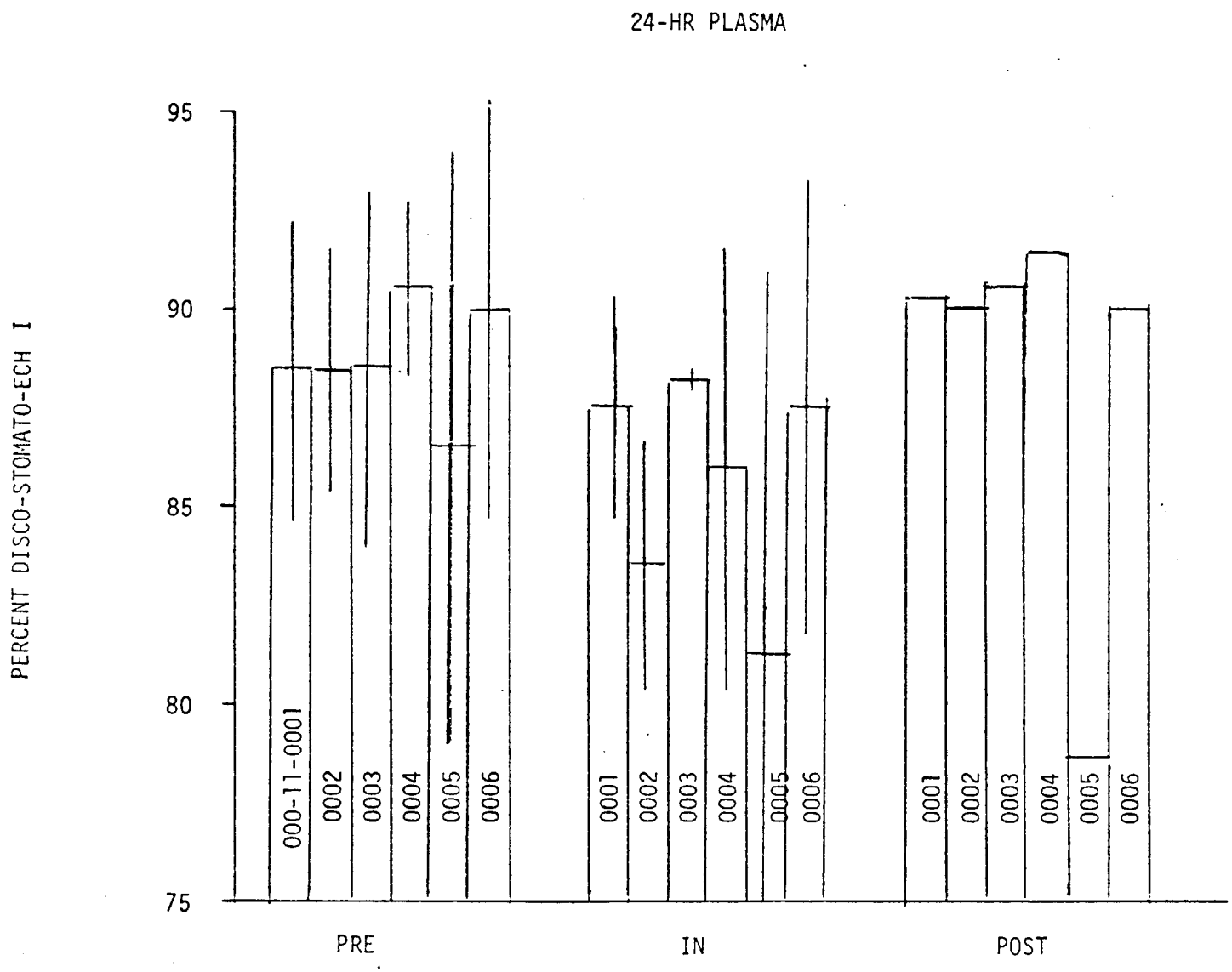


FIG. 9. BCM BEDREST II. Combined classifification percentages for DISCO-STOMATO-ECH I. Pre-bedrest (4 samples), In-bedrest (2 samples) and Post-bedrest(1 sample). Samples were stored in plasma at 4-5°C for 24 hours.

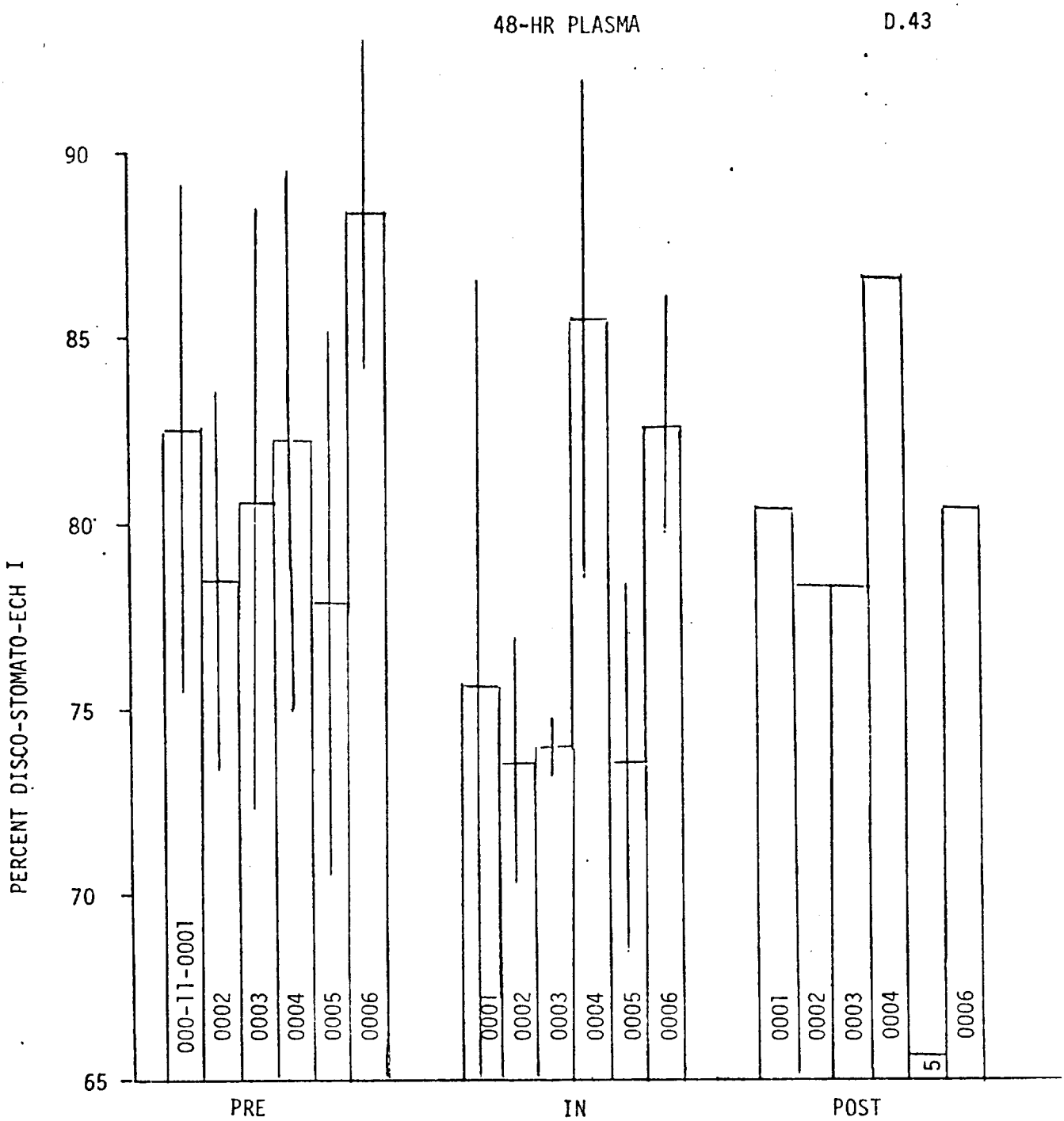


FIG. 10. BCM BEDREST-II. Combined classification percentages for DISCO-STOMATO-ECH I. Pre-bedrest (4 samples), In-bedrest (2 samples), and Post-bedrest (1 sample). Samples were stored in plasma at 4-5°C for 48 hours.

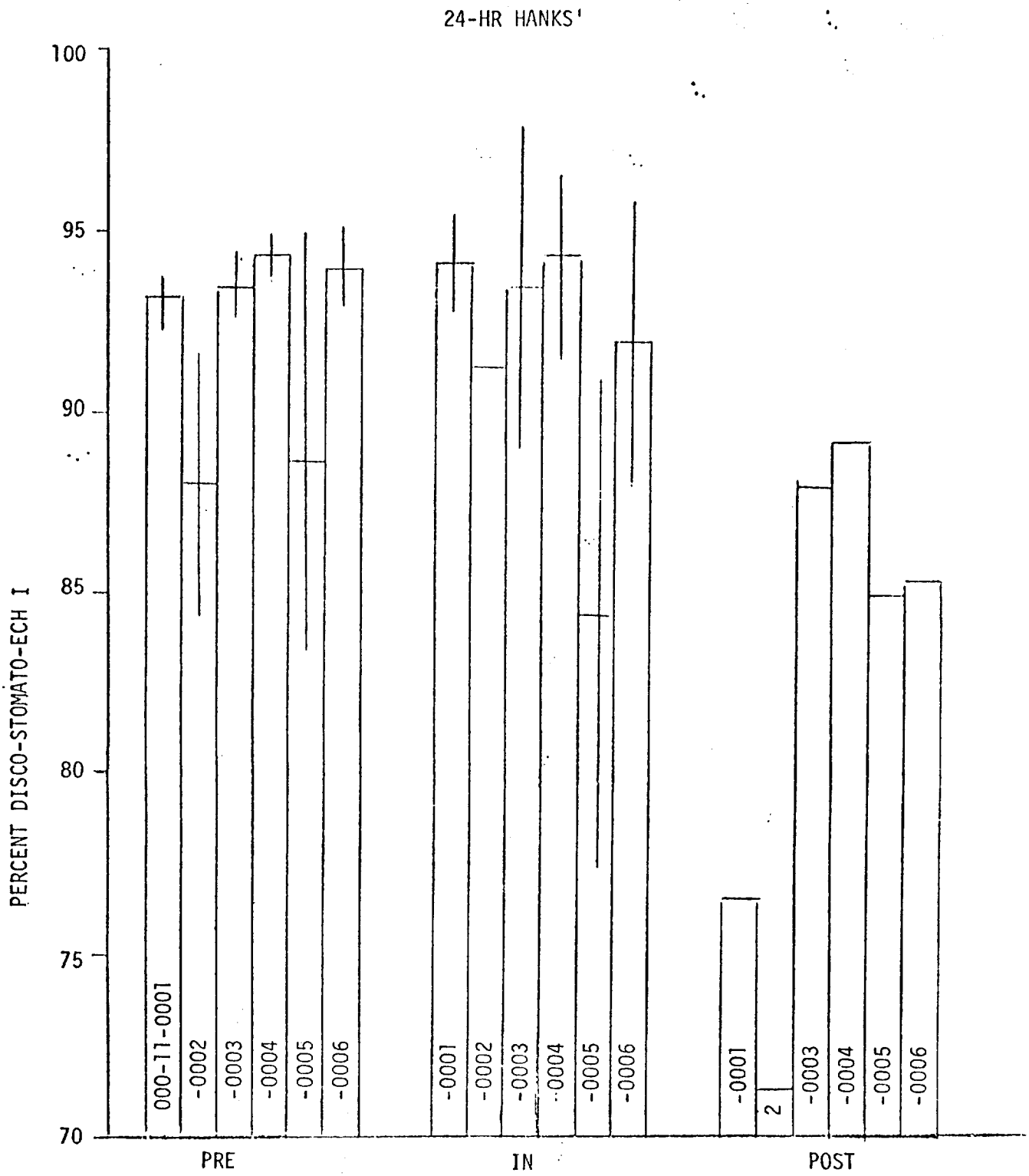


FIG. 11. BCM BEDREST-II. Combined classification percentages for DISCO-STOMATO-ECH I. Pre-bedrest (4 samples), In-bedrest (2 samples), and Post-bedrest (1 sample). Samples were stored in Hanks' medium for 24 hours at 4-5°C.

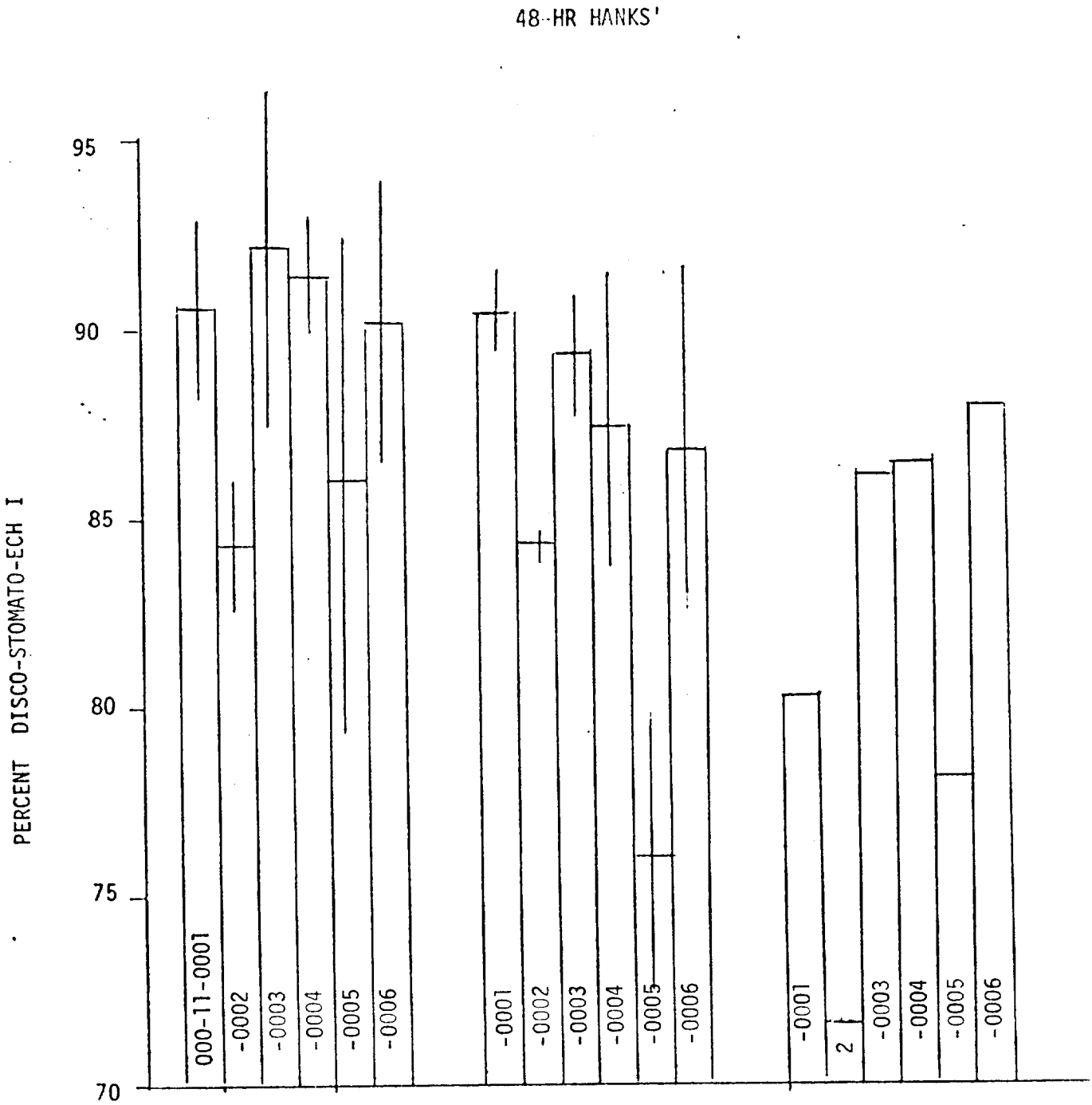


FIG.12. BCM BEDREST-II. Combined classification percentages for DISCO-STOMATO-ECH I. Pre-bedrest (4 samples), In-bedrest (2 samples), and Post-bedrest (1 sample). Samples were stored in Hanks' medium at 4-5°C for 48 hours.

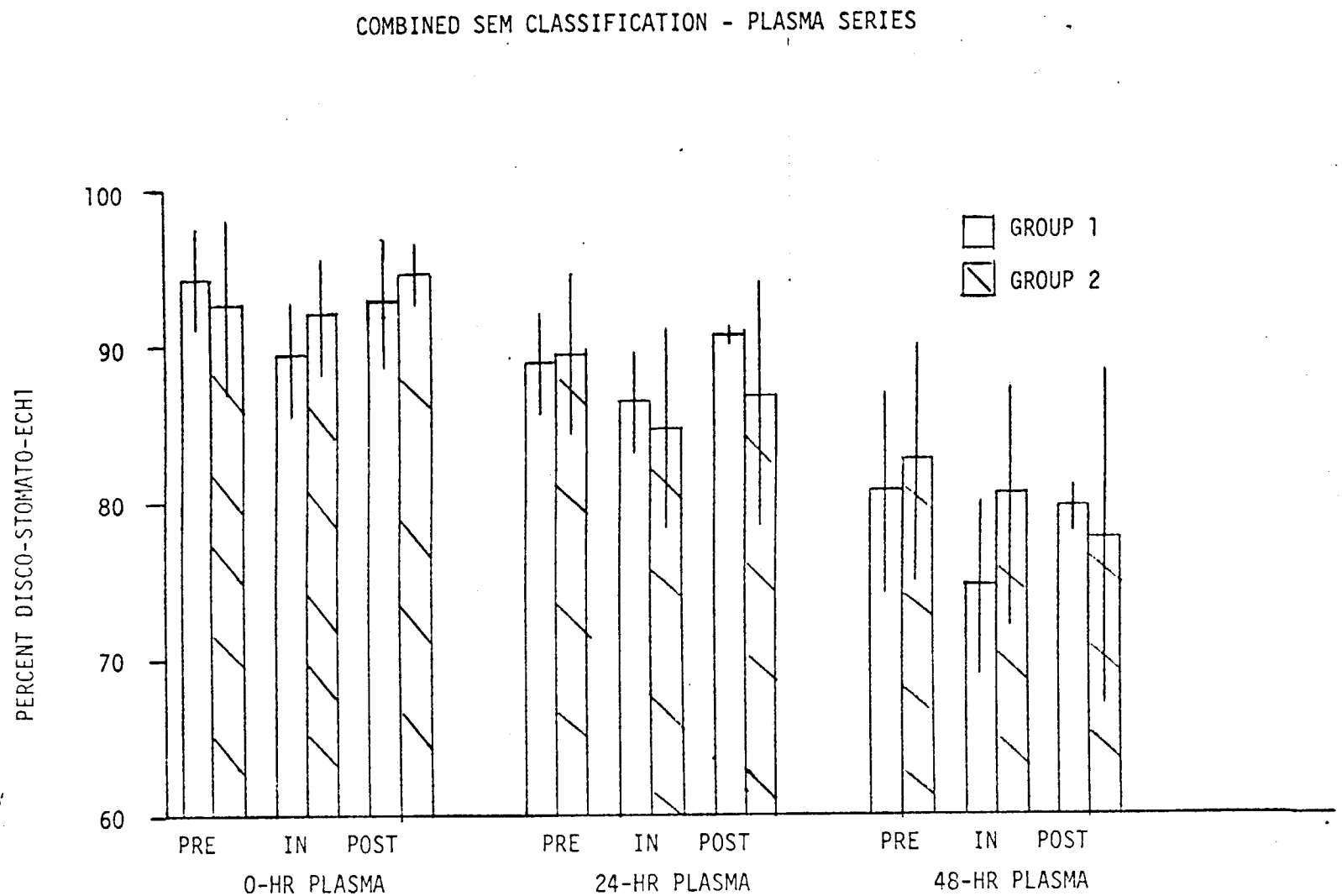


FIG. 13. GROUP 1 - GROUP 2 comparison of classification percentages for combined DISCO-STOMATO-ECHI red cells during BCM Bedrest-II.

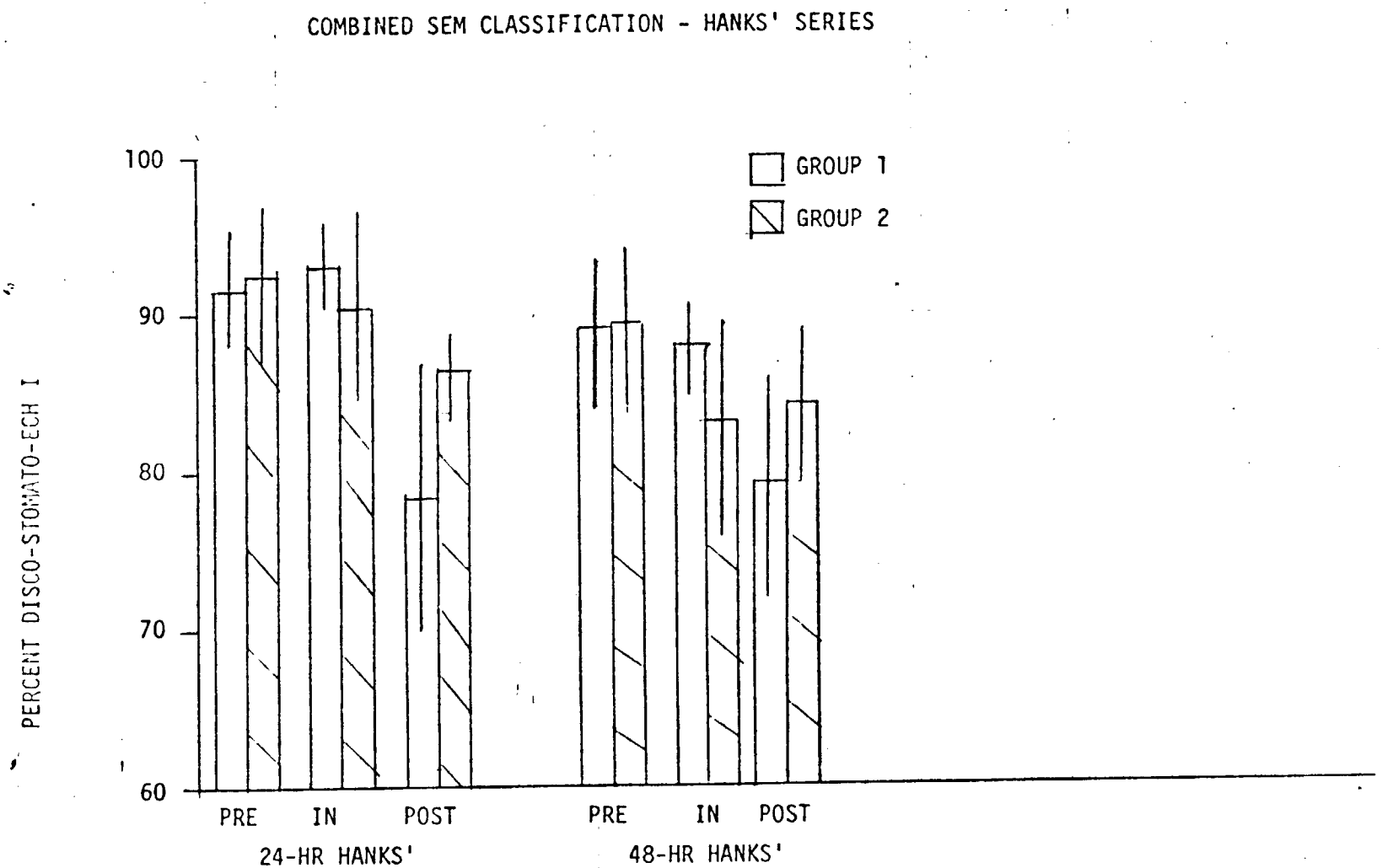


FIG. 14. GROUP 1 - GROUP 2 Comparison of Classification Percentages for Combined DISCO-STOMATO-ECH I red cells during BCM Bedrest-II

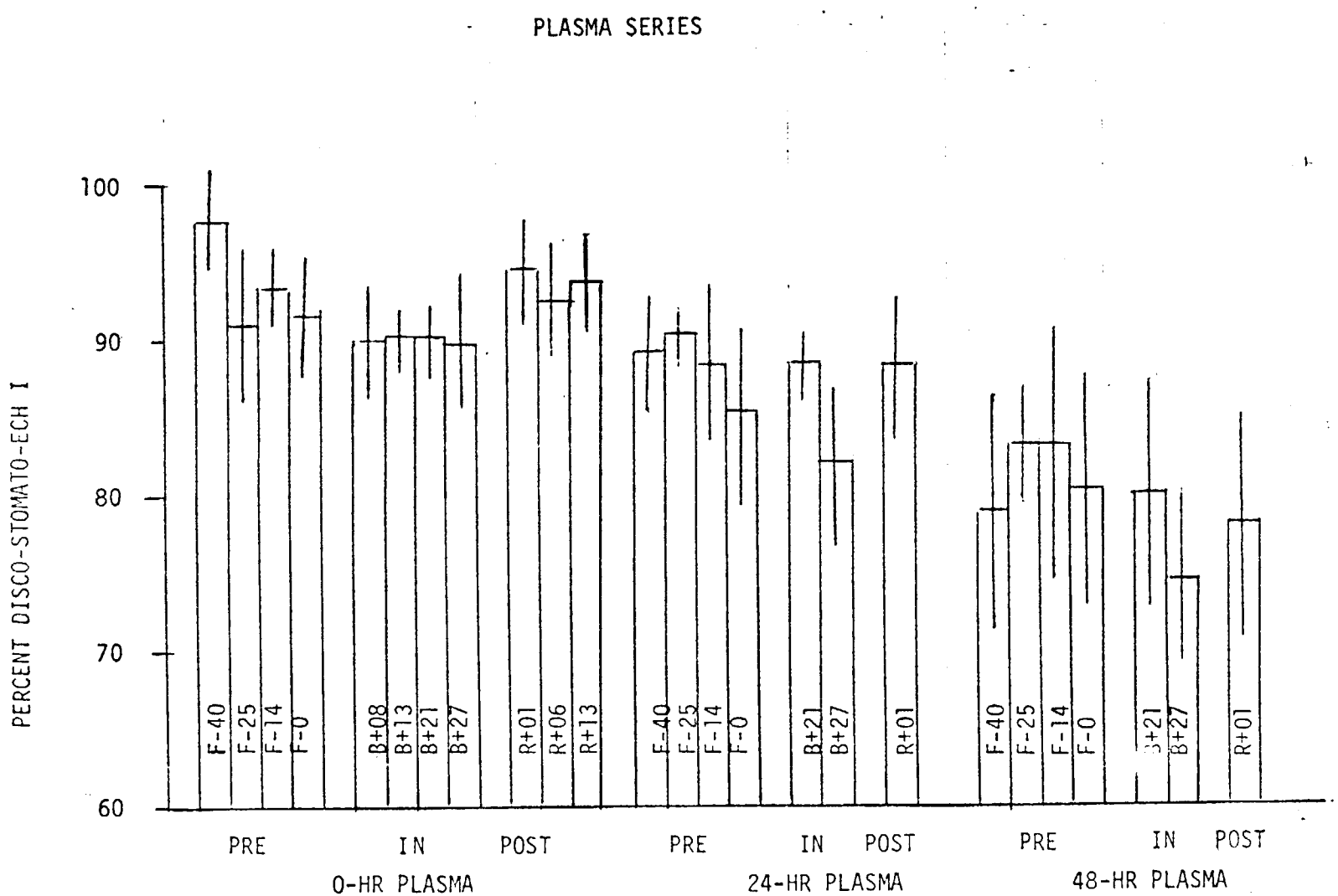


FIG. 15. Draw Date Comparison of Classification Percentages for Combined DISCO-STOMATO-ECH I Involving Six Subjects During BCM Bedrest-II.

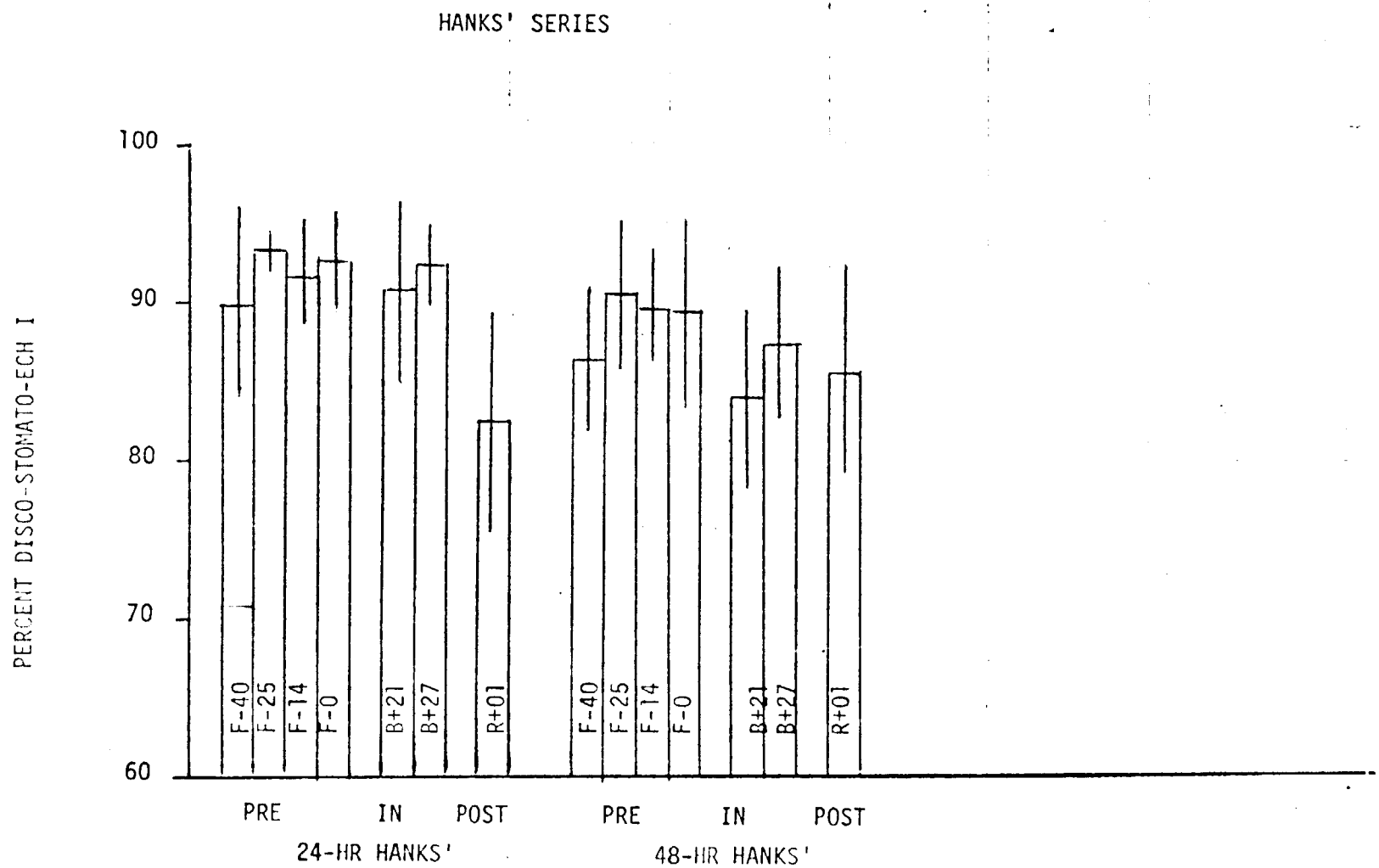


FIG. 16. Draw Date Comparison of Classification Percentages for Combined DISCO-STOMATO-ECH I Involving Six Subjects During BCM Bedrest-II.

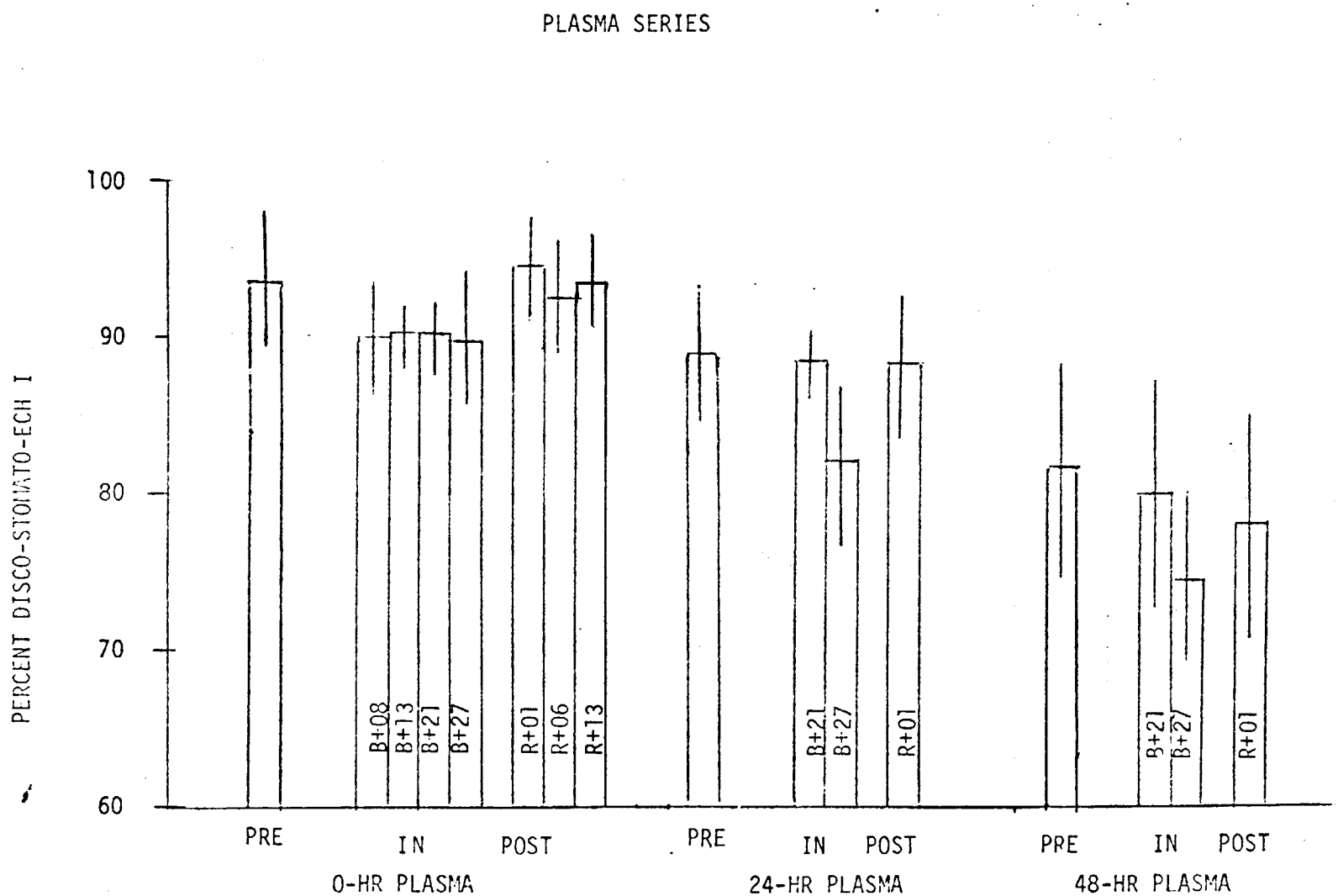


FIG. 17. Comparison of the PRE-Bedrest mean with individual draw dates of IN- and POST-Bed classification percentages for combined DISCO-STOMATO-ECH I involving six subjects during BCH Bedrest-II.

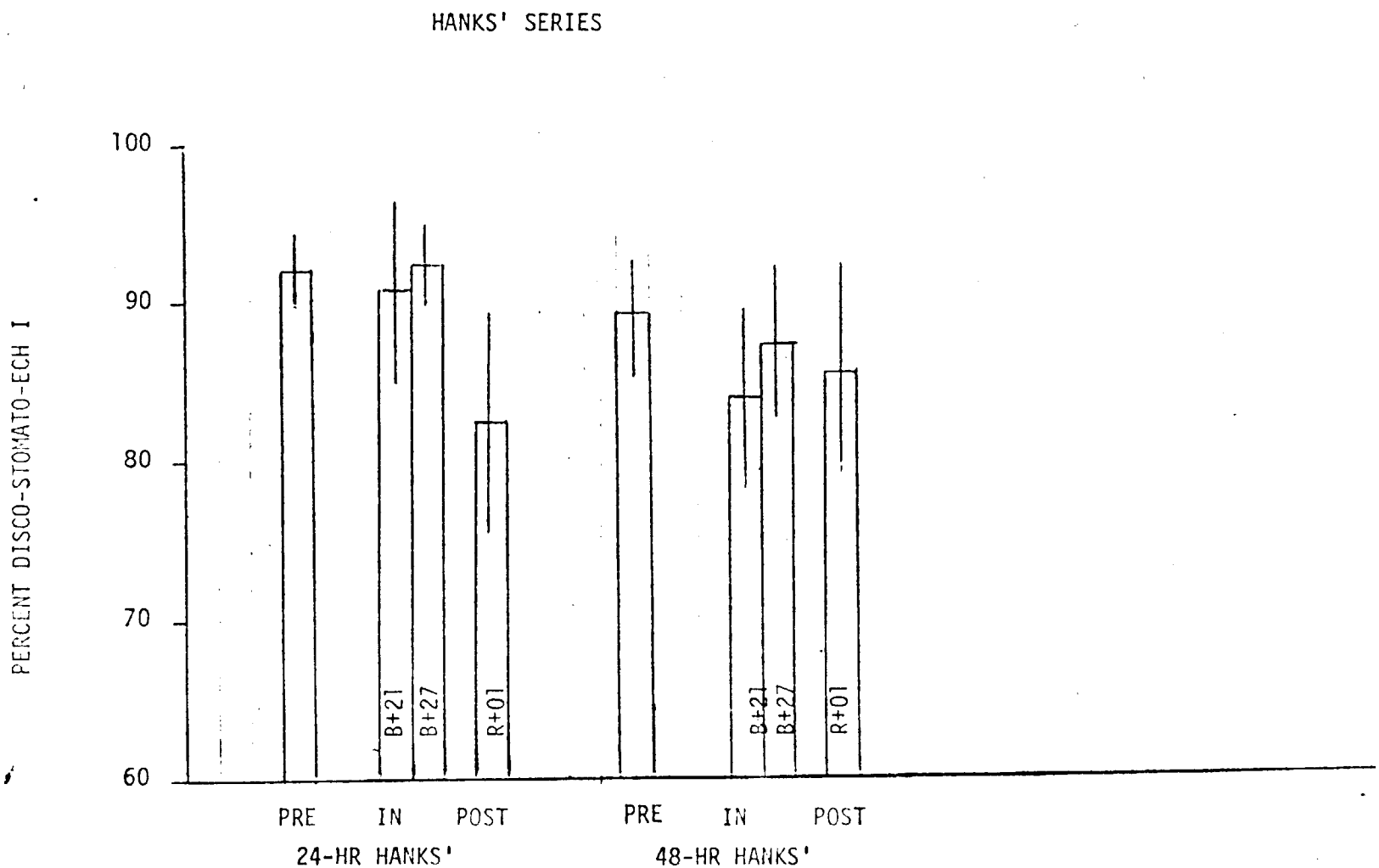


FIG. 18. Comparison of the PRE-Bedrest mean with individual draw dates of IN- and POST-Bed classification percentages for combined DISCO-STOMATO-ECH I involving six subjects during BCM Bedrest-II.

TABLE 3. STATISTICAL RESULTS OF STUDYING THE RELATIONSHIP BETWEEN RED CELL SHAPE CHANGE AND BEDREST TIME (PER DAY RATE OF CHANGE) (Discocytes, Echinocyte-1, and Stomatocytes combined as one class)

The statistical results are summarized as follows:

Subject or Group	Intercept	Value of Change*	Significance of the Slope
1	92.91	-.3018	P<.10
2	92.37	-.1482	P<.10
3	95.59	-.2458	P<.001
Group I	93.62	-0.2354	P<.01
4	93.26	-0.0145	P<.70
5	93.21	-0.0499	P<.50
6	90.14	.1381	P<.90
Group II	91.17	0.0686	P<.30

*(per cent per day)

TABLE 4. Change of DISCO-STOMATO-ECH-1 During Bedrest

0-HR PLASMA

SUBJECT	Pre-Bed		In-Bed								Post-Bed							
	$\bar{x}$ + S.D.		BR+08		BR+13		BR+21		BR+27		R+00		R+01		R+06		R+13	
1	94.3	3.9	85.6		91.2		90.6		82				90.4		88		97.4	
2	93.4	1.9	91.8		88.6		86.4		91				96.8		88.4		93.2	
3	95.2	4.4	94		92.4		91		88.4				90.4		96.8		97.2	
4	94.3	2.6	90.8		93.2		95.4		91.6		94.2		98		96		96.4	
5	92	6.3	86.4		88.2		96.4		89.6		91.4		96		93.6		93.6	
6	91.8	7	91.8		89.3		97.6		93.2		92.2		96.8		93.2		96.4	
Group																		
I	94.3	3.4	90.5	4.4	90.7	1.9	89.3	2.5	87.1	4.6			92.5	3.7	91.1	4.9	93.2	4.3
II	92.7	5.3	89.7	2.9	90.2	2.6	96.5	1.1	91.5	1.8	92.6	1.4	96.9	1.0	94.3	1.5	94.8	1.9

TABLE 5. STATISTICAL RESULTS OF STUDYING THE RELATIONSHIP BETWEEN RED CELL SHAPE CHANGE AND BEDREST TIME (PER DAY RATE OF CHANGE)

CATEGORY	INTERCEPT	RATE OF CHANGE*	SIGNIFICANCE OF THE SLOPE
DISCO	77.89	-0.1048	P<.05
KNIZO	4.29	0.0953	P<.05
STOMATO	9.37	0.0	P<1.00
ECH-1	5.04	0.0251	P<.40
ADVANCED ECH	0.49	-0.0163	P<.20

*(Per cent per day)

TABLE 6. ESTIMATED RATES OF CHANGE

RED CELL SHAPE AS AFFECTED BY STORAGE AND BEDREST

STRESS	EXPERIMENT	DISCO	KNIZO	STOMATO	ECH-1	ADVANCED ECH
Storage	005	-6.80	-0.490	0.890	2.625	3.700
	007	-6.76	-0.775	-1.635	2.025	8.400
	005&007	-6.83	-0.630	-0.395	2.325	6.050
	006	-9.96	-0.890	-0.390	4.710	6.910
	005,006,007	-8.705	-0.785	-0.390	3.880	6.620
Bedrest Effect	006	-0.105	+0.060	0.0	0.025	-0.016

ESTIMATED RATES OF CHANGES FOR DISCO+STOMATO+ECH-1

AS AFFECTED BY STORAGE AND BEDREST

STRESS	RATE OF CHANGE (PERCENT/DAY)	POTENCY
Bedrest	-0.2458*	1
Storage	-5.6200	22.86

*Estimated from Group I in bedrest. (Unusually high discocyte value in BR-21 for Group II interrupts this trend in that group)

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1. Baky, A., 1976. Test Plan for Multinomial Analysis of Data. (Test Plan in preparation).

2. Fisher, R. A., 1950. Statistical Methods for Research Workers. Oliver and Royd, Edinburg.

3. Ostle, B., 1963. Statistics in Research; Basic Concepts and Techniques for Research Workers. Iowa State University Press, Ames, Iowa.

4. Snedecor, G. W. and W. G. Cochran, 1967. Statistical Methods. Iowa State University Press, Ames, Iowa.

APPENDIX I

NEW FIXATION METHOD FOR RBC*

FRESH PERIPHERAL BLOOD

MINIMUM ONE HOUR FIXATION
IN 0.5% GLUTARALDEHYDE/SIM
AT ROOM TEMPERATURE

pH = 7.4
osm = 320

WASH 3 TIMES IN SIM

MINIMUM ONE HOUR POSTFIXATION
IN 1.0% O_sO_4/SIM

Layer onto FM-25 Selas Flotronics
Silver Membrane

DEHYDRATE IN GRADED
SERIES OF ETHANOLS
[20%, 50%, 75%, 90%,
100% (2X)]

CRITICAL POINT DRY

COAT c̄ GOLD/PALLADIUM

EXAMINE

*Revised 17 March 1976

HANKS' BALANCED SALT SOLUTION

	mg/l
$CaCl_2$	140.0
KCl	400.0
KH_2PO_4	60.0
$MgCl_2 \cdot 6H_2O$	100.0
$MgSO_4 \cdot 7H_2O$	100.0
NaCl	8000.0
$NaHCO_3$	350.0
$Na_2HPO_4 \cdot 2H_2O$	60.0
Glucose	1000.0
Phenol Red	10.0

Hanks' Balanced Salt Solution is obtained from Grand Island Biological Company, Grand Island, N. Y. It is at 1X concentration and stored at room temperature until opened. After opening it is kept refrigerated.

NASA Technical Memorandum

SERUM ERYTHROPOIETIN TITERS DURING BEDREST[1]

C. D. R. Dunn, J. Preston, and R. D. Lange

The University of Tennessee Memorial Research Center
Center for the Health Sciences/Knoxville Units
1924 Alcoa Highway
Knoxville, TN 37920

[1]Supported by contract no. NAS 9-15164 from the National Aeronautics and Space Administration.

SUMMARY

Since erythropoietin (Ep) has a central role in the regulation of erythropoiesis, an effort was made to determine if changes in serum Ep could explain the well-documented decrease in red cell mass observed during space flight or space flight simulation (bedrest). Serum for Ep assay was obtained from each of six volunteers at various times during the Johnson Space Center/Methodist Hospital bedrest study.

Changes in serum Ep titers during bedrest were generally insignificant although there was a suggestion of elevated levels on day 8 (the first day that bedrest samples for this study were available). However, the increases in Ep and in reticulocytes observed post-bedrest are typical of erythroid stimulation, suggesting that the changes which occurred during bedrest resulted in a situation requiring enhanced erythropoiesis during re-adaptation to normal activity. No evidence for erythroid inhibitors was obtained in any of the sera tested.

Further studies, particularly during the first week of space flight or of bedrest, when significant changes in plasma volume occur, will be necessary to determine what mechanism is responsible for the decrease in red cell mass and if changes in erythropoietin levels are involved.

One of the most consistent hematological effects of space flight is a decrease in the red cell mass (Kaplan, 1967). Initially, the decrease was thought to be related to the high oxygen tension in the atmosphere of space vehicles (Kaplan, 1967; Breslav *et al.*, 1968; Jensen, 1972). However, similar decreases in the red cell mass were also observed when the atmospheric oxygen tension was comparable to normal ambient air and were also seen in ground-based flight simulation (usually bedrest) (Kaplan, 1967; Vogt and Johnson, 1967). The mechanism responsible for the decreased red cell mass is unknown. An increase in erythroid inhibitors in the serum of rats post-flight has been claimed (Breslav *et al.*, 1968; Shcherba *et al.*, 1975) but these results cannot be considered conclusive.

Erythropoietin (Ep) is the prime regulator of erythropoiesis in mammals (Krantz and Jacobson, 1970) and is generated in response to tissue hypoxia. The hormone acts on a marrow progenitor cell population to trigger cell division with the ultimate production of mature erythrocytes. Since Ep acts in a positive stimulatory way to regulate erythropoiesis, a decrease in Ep might be expected to result in the production of fewer erythrocytes--as occurs, for example, in chronic renal disease (Erslev, 1970). Using a quantitative *in vitro* bioassay (Dunn *et al.*, 1975), we have explored the possible role of serum Erythroid Stimulating Activity (ESA) in the decrease of red cell mass observed in the six volunteers involved in the recent Johnson Space Center/Methodist Hospital bedrest study.

METHODS

All volunteers in this study were maintained under carefully controlled conditions at The Methodist Hospital, Houston, Texas. Blood was taken by

standard procedures from the six volunteers and allowed to clot at room temperature. After centrifugation, the serum was collected and stored at -20°C. At the end of the study period, the samples were packed in dry ice and transported by courier to the University of Tennessee Memorial Research Center, Knoxville, where they were stored at -20°C until assayed. During the entire study period (30 days pre-bedrest, 27 days bedrest, and 17 days post-bedrest), 11 samples were collected for ESA assay from each of subjects 1-3 and 10 samples from each of subjects 4-6.

The *in vitro* fetal mouse liver cell assay for ESA has been described previously (Dunn *et al.*, 1975; Dunn and Napier, 1975). In summary, a cell suspension of the livers of C_3H mouse embryos of 13-14 days gestation was prepared by repeated gentle aspiration through a Pasteur pipette. The cells were suspended in Eagle's Minimal Essential Medium (Burroughs Wellcome Co.) supplemented with 5% heat-inactivated (56°C for 30 minutes) fetal calf serum and 1% heat-inactivated pooled human serum to a final concentration of 5×10^5 cells in 1 ml cultures. Groups of three cultures were incubated with varying concentrations (0-25 mU Ep per culture) of Step III sheep plasma erythropoietin (Connaught Medical Research Laboratories, Toronto) or with varying concentrations (3.125-50 µl/culture) of the heat-inactivated test sera for 24 hours at 37°C in an atmosphere of 5% CO_2 in air. At this time, 1 µCi [^{59}Fe] ferrous citrate in 100 µl saline was added to each culture and the incubations continued for an additional four hours. At the end of the incubation period, heme was extracted into methyl ethyl ketone using a minor modification (Dunn and Napier, 1975) of the method originally described by Teale (1959). Aliquots of the solvent were taken for determination of radioactivity using an automatic gamma counter.

Employing a PDP-15 computer, the results were analyzed by The Analysis

of Variance Technique applicable to parallel line bioassays (Colquhoun, 1971). The mean potency and 95% Confidence Limits were calculated for each test sera only if the sera produced log dose-log response relationships which showed significant ($P < 0.05$) linear regression and slope, and did not deviate significantly ($P > 0.05$) from linearity or from parallelism to the log dose-log response relationship of the Ep standard.

To date, we (Dunn and Napier, 1975; Dunn *et al.*, 1976a,b; Napier *et al.*, 1976) have been unable to separate ESA which enhances hemoglobin synthesis in fetal mouse liver cell cultures from Ep as measured with conventional *in vivo* assays. Nevertheless, the absolute identity of the two factors has not yet been proven; accordingly, we prefer to use the term ESA for the factor which stimulates hemoglobin synthesis in fetal mouse liver cell cultures. One unit of ESA is defined as the quantity of material in the test solution that produces the same amount of hemoglobin synthesis as one unit of erythropoietin in either the International Reference Preparation (IRP) or in standards calibrated against the IRP. Using the fetal mouse liver cell assay, serum ESA titers in 100 normal subjects have been found to be 0.15 ± 0.1 u/ml (mean ± standard error) although values as high as 0.7-0.8 u/ml have been observed (Napier *et al.*, 1976).

Absolute reticulocytes ($10^4/mm^3$) were calculated from the percent reticulocyte counts and the number of erythrocytes/mm^3 determined by other investigators involved in this study.

RESULTS

Assays for ESA in all the test sera fulfilled the criteria of statistically valid assays as defined above. The 95% Confidence Limits never exceeded 50-200% of the mean potency (100%) and were generally in the range

of 75-125% (Table 1).

Serum ESA concentrations obtained for all the samples are shown in Table 1, in graphical form in Figure 1 (i-vi), and are summarized in Figure 2. With the possible exception of the values observed in Subject 2 (Figure 1-ii) on RO (i.e., "Recovery" day) and in Subject 3 (Figure 1-iii) on R6, all fluctuations in serum ESA can be considered to have occurred within the extremes of the normal range (Napier *et al.*, 1976).

ESA titers higher than those seen on FO were observed in two of the three subjects from whom serum was obtained on BR8 (i.e., "Bedrest" day) (Table 1, Figure 1-i, Figure 1-ii). However, serum ESA titers during the pre-bedrest period (designated "F") were somewhat variable in both subjects and, in Subject 2 (Figure 1-ii), the serum ESA titer of F14 was higher than that observed on BR8. No sera from BR8 were available for assay from Subjects 4-6.

No consistent differences from pre-bedrest ESA titers were found on BR14, BR21, and BR27 in the six subjects. However, between RO and R6, Subjects 2-5 showed ESA titers elevated to varying degrees above pre-bedrest values. Generally, these increases were associated with increases in the absolute number of reticulocytes (Figures 1-ii to 1-vi, Figure 2). By R13, serum ESA titers were within the range of concentrations observed in the pre-bedrest samples.

A pattern of serum ESA titers similar to that shown in Figures 1-i to 1-vi was also observed when a hemagglutination inhibition assay for Ep (Lange *et al.*, 1971) was employed.

As shown in Figure 2, the red cell mass fell progressively during the bedrest and post-bedrest study period, averaging 88% of pre-bedrest values by R13 (data provided by NASA).

DISCUSSION

This study represents the first attempt to elucidate the role of Ep in the decrease in red cell mass of humans or animals exposed to space flight or space flight simulation. The results indicate the need for further study.

Although there was a suggestion of elevated serum ESA levels after eight days of bedrest (Figure 2), ESA titers during the bedrest period generally showed no significant changes from the pre-bedrest values. However, elevated ESA titers and a reticulocytosis were observed post-bedrest and were similar to the changes seen when normal animals are exposed to an erythroid stress such as phlebotomy or hypoxia (Krantz and Jacobson, 1970). These changes suggest that re-adaptation to normal activity requires an increase in the red cell mass, presumably to normal values. Apparently there is no compensation for the decreased red cell mass which occurs during bedrest (Kaplan, 1967). Although the decrease in red cell mass may be self-limiting (Johnson *et al.*, 1974), whether it represents a pathological change or a physiological adaptive process reflecting decreased oxygen requirements is unknown (Kaplan, 1967).

Shcherba *et al.* (1975) infer that, at least in the serum of rats post-space flight, the decrease in red cell mass is a pathological change associated with decreased Ep and an increased level of erythroid inhibitors. However, all the sera assayed in the present study produced log dose-log response relationships parallel to the Ep standard preparation. This observation excludes the presence of non-competitive inhibitors in the serum since these would have resulted in log dose-log response relationships of shallower slope than the Ep standard (Gero, 1971). This finding does not necessarily exclude the possibility of competitive inhibitors although these would have the effect of lowering the net ESA titers of the test sera.

Since ESA titers throughout the bedrest and recovery periods were generally within the pre-bedrest range and also within the normal range determined in other studies (Napier *et al.*, 1976), varying activity of competitive inhibitors would seem unlikely.

Food deprivation is known to result in depressed erythropoiesis. This observation has provided the basis for an *in vivo* assay for Ep (Fried *et al.*, 1957). A reduced caloric intake during bedrest (H. O. Wheeler, this volume) resulting in a loss of body weight (Johnston, 1974) therefore may be involved in the pathology of the decreased red cell mass.

Physiologically, the decrease in plasma volume occurring within the first seven days of space flight (Jensen, 1972) may result in a state of relative polycythemia and a shut-down of erythropoiesis until the hematocrit is equilibrated at or near the normal level. The influence of a decrease in plasma volume on erythropoiesis has received only scant experimental attention. Chrysant *et al.* (1976) have claimed that relative ("stress") polycythemia secondary to hypertension is associated with a normal serum Ep titer. However, Kilbridge *et al.* (1969) have shown that the plasma volume decreases in mice as a consequence of dehydration produce a decrease in serum Ep titers. It is possible, therefore, that a decrease in plasma volume producing a state of relative polycythemia could lead to a reduced serum ESA titer which, in turn, could lead to decreased erythropoiesis until the hematocrit is equilibrated at or near the normal level. If the oxygen requirements do not exceed the capacity of the smaller red cell mass, there is no obvious reason why maintenance of a normal hematocrit at a reduced blood volume should be associated with increased or decreased erythropoiesis. The fact that changes do occur which may allow adequate tissue oxygenation from a reduced red cell mass is suggested by the findings that cardiac output

is probably increased during space flight (Thornton and Hoffler, 1974) and hyperphosphatemia (Johnson *et al.*, 1974; Mengel, 1974) which would result in a "shift to the right" of the oxygen dissociation curve (Lichtman *et al.*, 1969) and thereby also facilitate oxygen delivery to the tissues. Since ferrokinetic studies (e.g., plasma iron turnover, red cell survival), thought to reflect erythropoiesis, show little change from normal when determined post-space flight (Kaplan, 1967; Johnson *et al.*, 1974) or during bedrest (P. C. Johnson, this volume), it would appear that adequate compensation for the reduced red cell mass occurs - particularly in situations that do not require energy consumption to overcome gravitational forces. Viewed in this context, the astronauts may not be "anemic" *per se* if this term is applied to tissue oxygenation as opposed to defining the quantity and/or quality of red cells.

Some of our findings (Table 1, Figure 1-i and 1-ii) suggest that ESA titers may be elevated on day 8 of bedrest. This may be significant because serum angiotensin levels were also elevated on BR8 (C. S. Leach, this volume; Leach and Rambaut, 1975). Both Ep and angiotensin are probably produced in the kidney, and hypoxia is known to cause the increased synthesis of both hormones (Gould and Goodman, 1970; Varkarakis *et al.*, 1976). It has been hypothesized that a decreased plasma volume produces a proportionally greater increase in blood viscosity which, in extreme circumstances, may be sufficient to result in poor circulation, tissue hypoxia, and the release of Ep (Castle and Jandl, 1966; Kilbridge *et al.*, 1969).

It seems possible that, with some change in serum Ep titers, the decreased red cell mass is intimately linked to the changes in plasma volume which occur during the first few days of space flight or space flight simulation. Reasons for the decrease in red cell mass and of the involvement

of Ep will probably, therefore, only be found by detailed studies during the first seven days of space flight.

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LEGENDS

TABLE 1. Serum Erythroid Stimulating Activity (ESA) during the bedrest study period: F25-F0, the 25 days preceding bedrest; BR0-BR27, bedrest; R0-R13, the "recovery" or post-bedrest period. Results are expressed as units/ml. Figures in parenthesis indicate the 95% Confidence Limits.

FIGURE 1 (i-vi). Serum ESA and absolute number of reticulocytes ($10^4/mm^3$) in the six subjects over the bedrest study period. Same data as in Table 1.

FIGURE 2. Summary of the changes in serum ESA, reticulocytes, and red cell mass during bedrest and recovery. Results expressed as fractions of the mean pre-bedrest values $\left((F25 + F14 + F0) \div 3\right)$. Serum ESA and reticulocyte data from Figure 1. Red cell mass results provided by NASA.

TABLE 1

BED REST STUDY: ESA titers, u/ml:serum

	Lee (1)	Horwitz (2)	Thorson (3)	McGreer (4)	Anderson (5)	Hudson (6)
F25	0.12 (0.1 - 0.14)	0.3 (0.25-0.36)	0.4 (0.27-0.58)	0.13 (0.11-0.17)	0.1 (0.06-0.15)	0.06 (0.05-0.07)
F14	0.11 (0.09-0.13)	0.74 (0.61-0.9)	0.43 (0.33-0.56)	0.13 (0.09-0.2)	0.07 (0.05-0.1)	0.02 (0.005-0.06)
F0	0.28 (0.22-0.35)	0.37 (0.3 - 0.45)	0.34 (0.24-0.47)	0.28 (0.2 - 0.38)	0.23 (0.16-0.33)	0.24 (0.2 - 0.3)
BR8	0.38 (0.3 - 0.48)	0.55 (0.46-0.66)	0.32 (0.23-0.43)	--	--	--
BR14	0.08 (0.06-0.12)	0.35 (0.25-0.49)	0.22 (0.15-0.35)	0.37 (0.3 - 0.45)	0.24 (0.15-0.39)	0.04 (0.03-0.05)
BR21	0.18 (0.15-0.24)	0.49 (0.34-0.7)	0.48 (0.33-0.7)	0.14 (0.11-0.18)	0.05 (0.02-0.17)	0.07 (0.05-0.1)
BR27	0.21 (0.16-0.26)	0.32 (0.24-0.44)	0.4 (0.27-0.6)	0.21 (0.15-0.3)	0.18 (0.12-0.27)	0.07 (0.05-0.1)
R0	0.21 (0.17-0.26)	1.1 (0.88-1.37)	0.44 (0.31-0.61)	0.27 (0.2 - 0.36)	0.12 (0.08-0.19)	0.29 (0.23-0.37)
R1	0.14 (0.11-0.18)	0.22 (0.18-0.26)	0.44 (0.35-0.55)	0.36 (0.27-0.47)	0.24 (0.16-0.38)	0.14 (0.09-0.22)
R6	0.11 (0.09-0.14)	0.24 (0.18-0.32)	1.13 (0.92-1.38)	0.15 (0.11-0.2)	0.14 (0.1 - 1.21)	0.1 (0.07-0.13)
R13	0.05 (0.03-0.11)	0.38 (0.31-0.48)	0.36 (0.24-0.53)	0.36 (0.28-0.45)	0.1 (0.07-0.15)	0.2 (0.17-0.25)

FIGURE 1-i

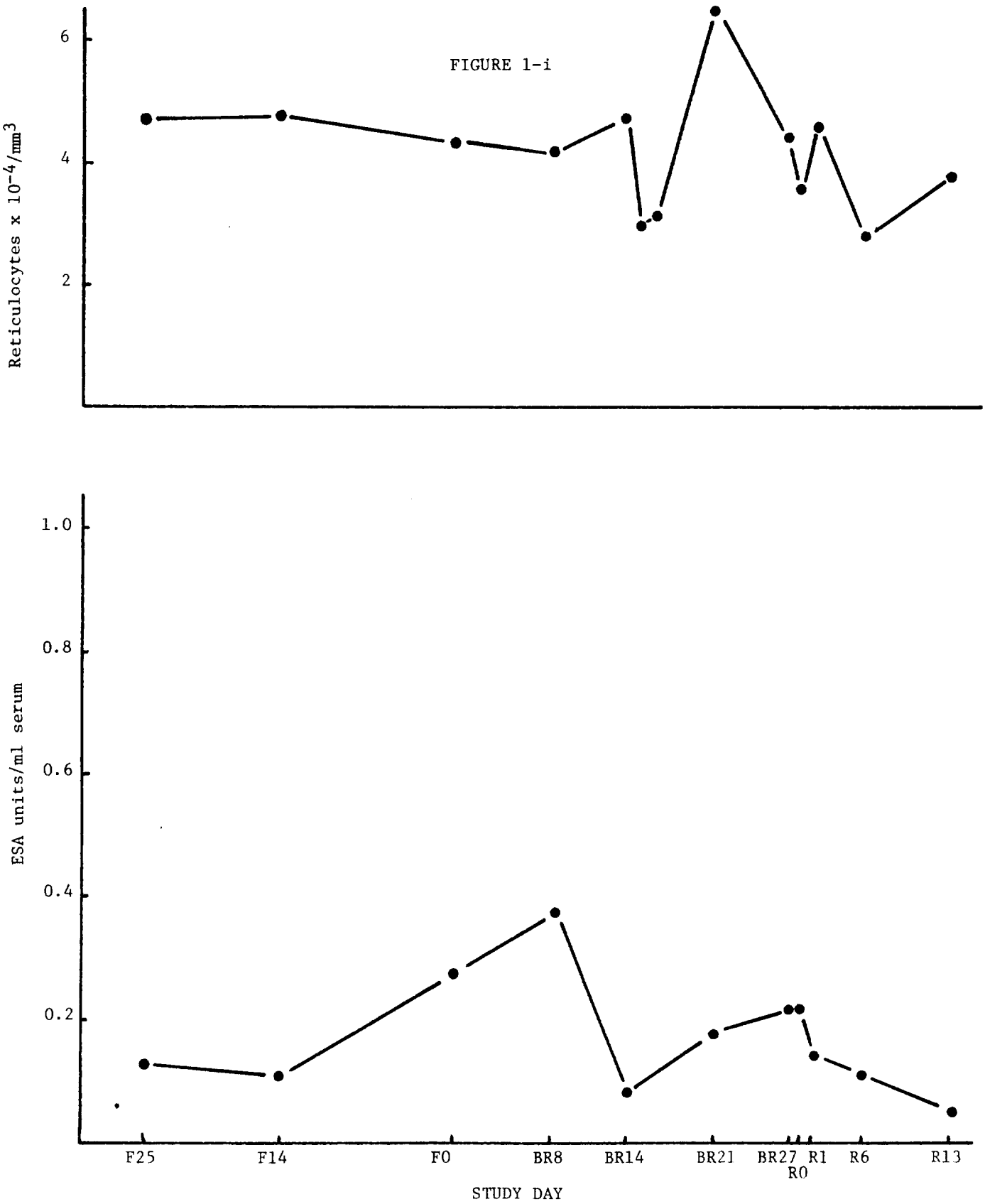

Reticulocytes x $10^{-4}/mm^3$
6
4
2
ESA units/ml serum
1.0
0.8
0.6
0.4
0.2
F25
F14
F0
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY

FIGURE 1-ii

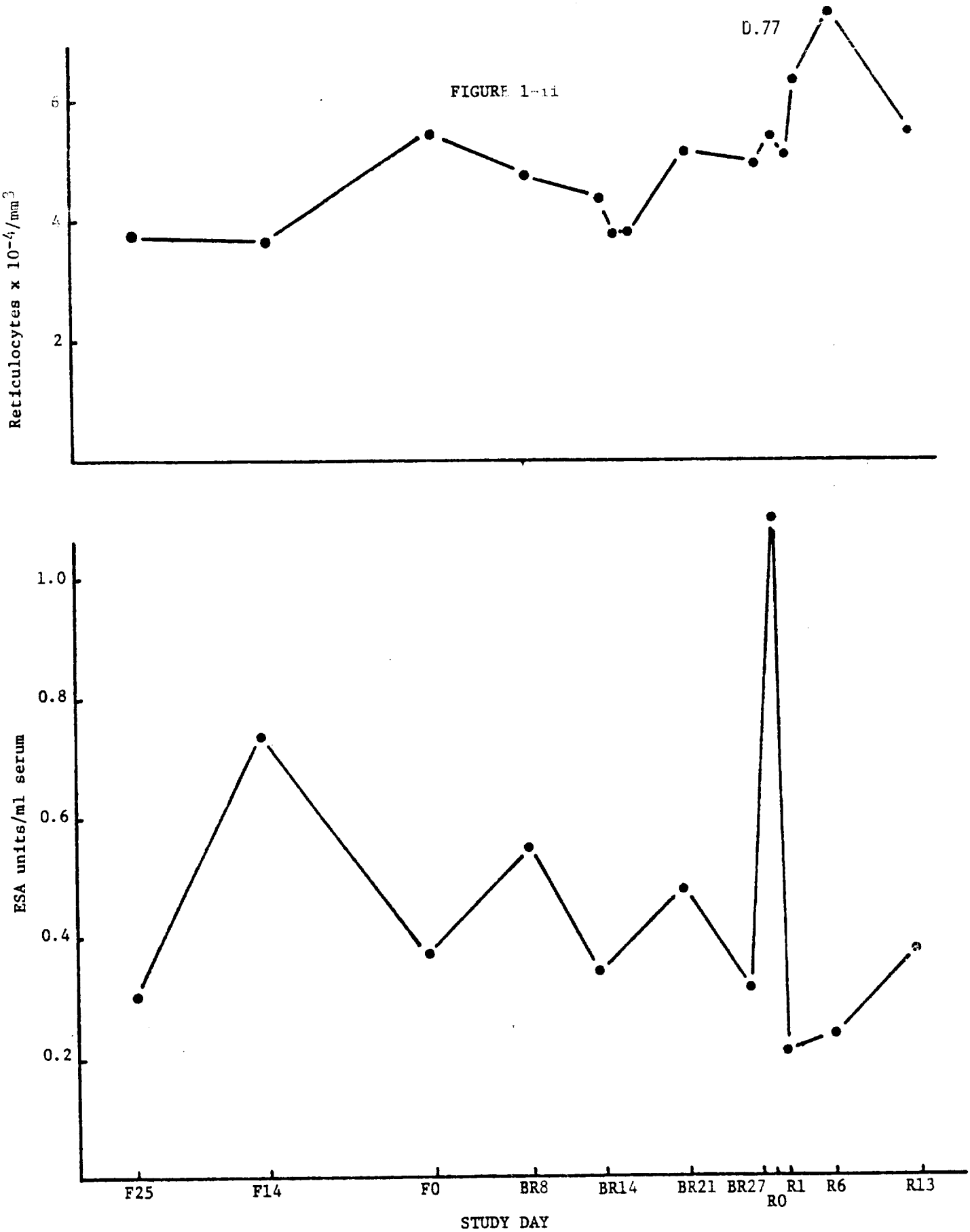

0.77
6
4
2
Reticulocytes x $10^{-4}/mm^3$
1.0
0.8
0.6
0.4
0.2
ESA units/ml serum
F25
F14
F0
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY

FIGURE 1-iii

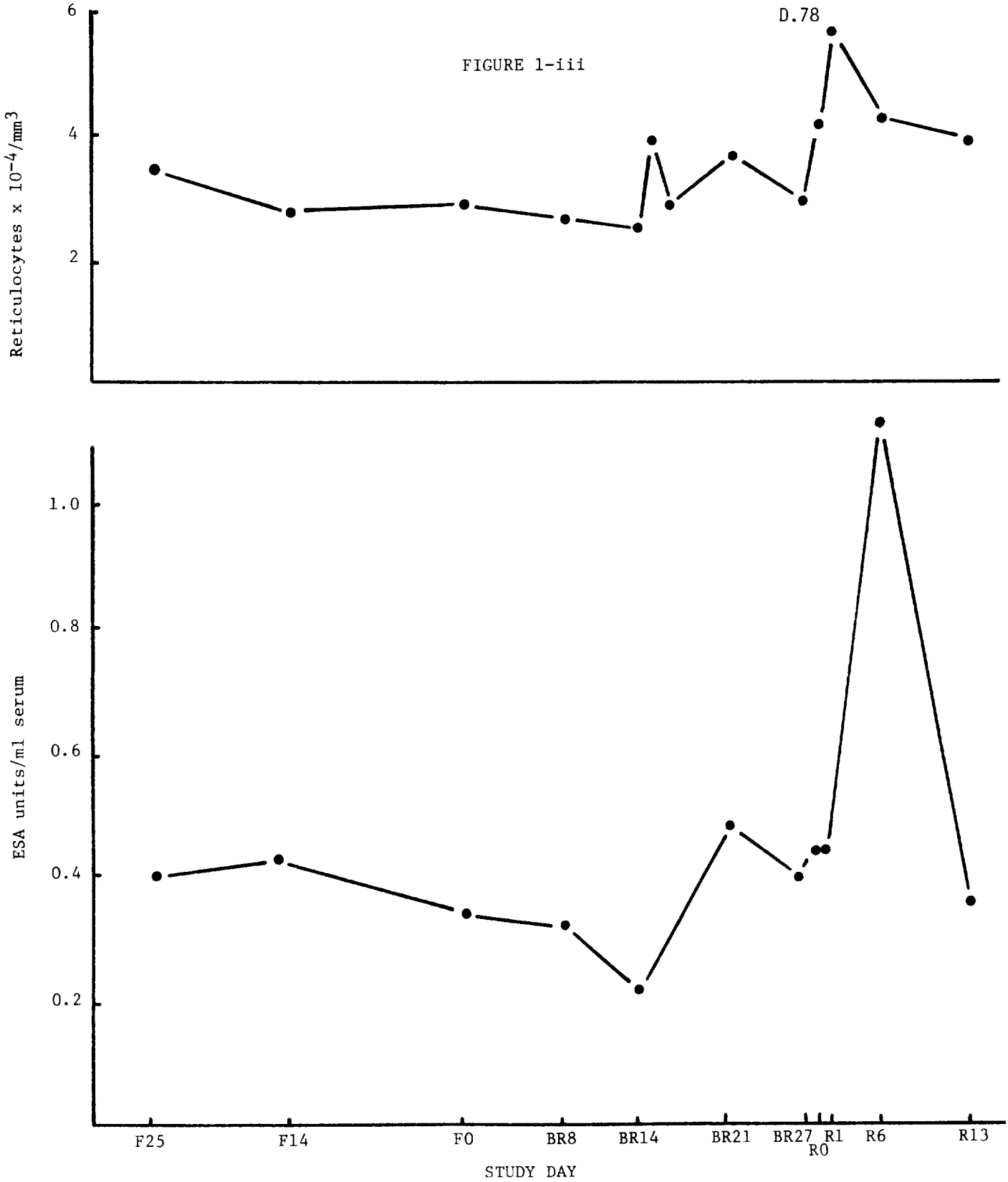

D.78
Reticulocytes x $10^{-4}/mm^3$
6
4
2
ESA units/ml serum
1.0
0.8
0.6
0.4
0.2
F25
F14
F0
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY

FIGURE 1-iv

D.79

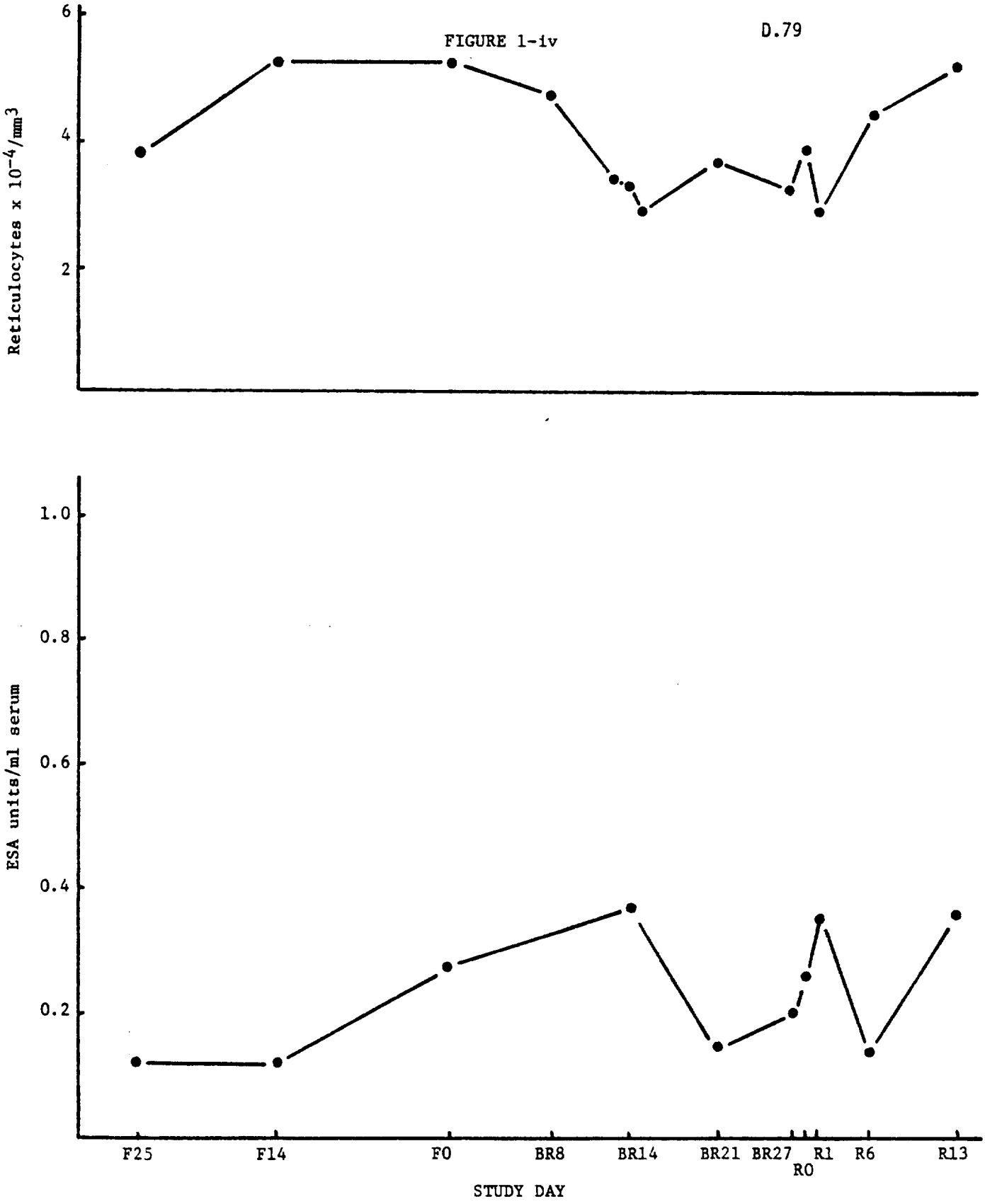


FIGURE 1-v

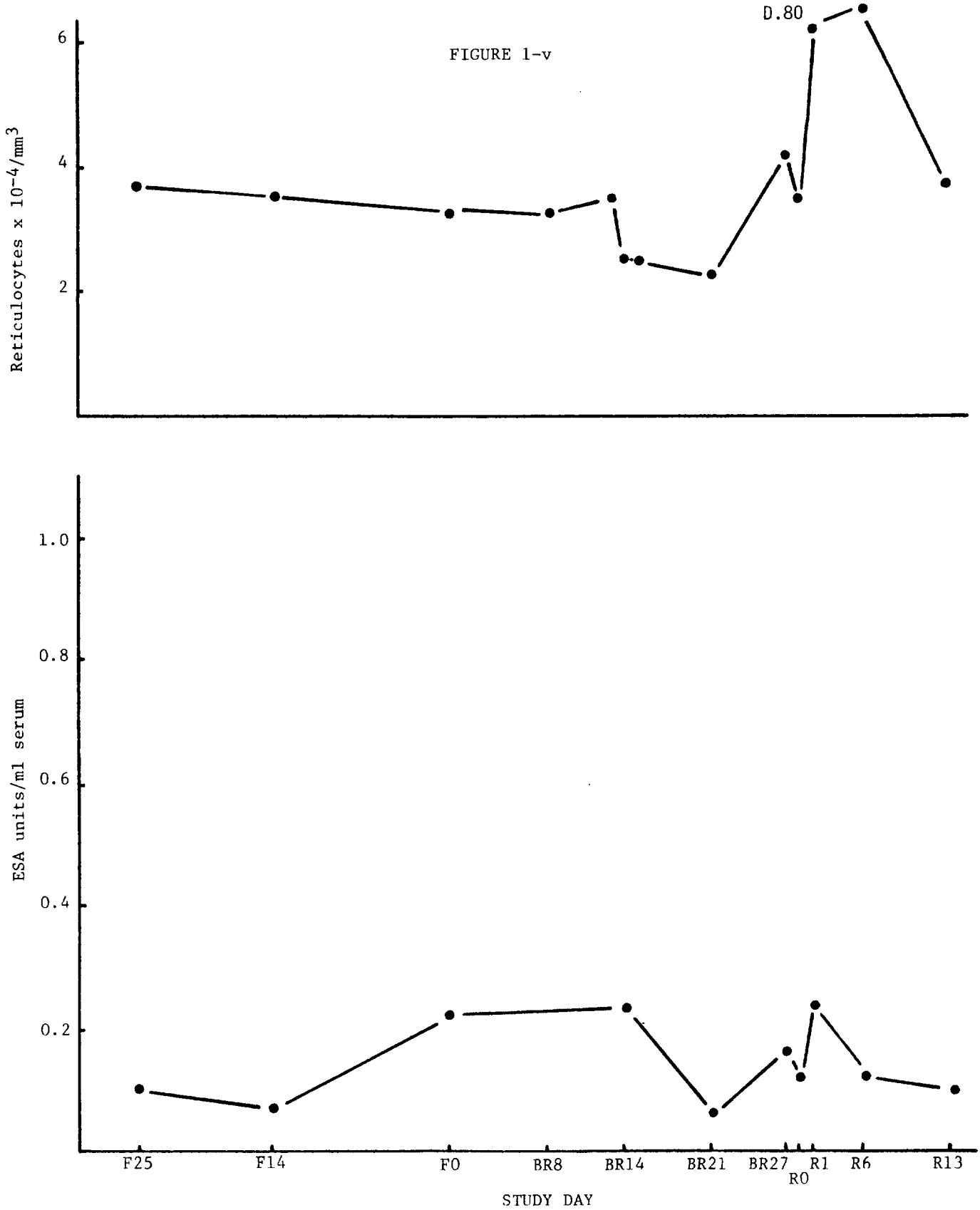
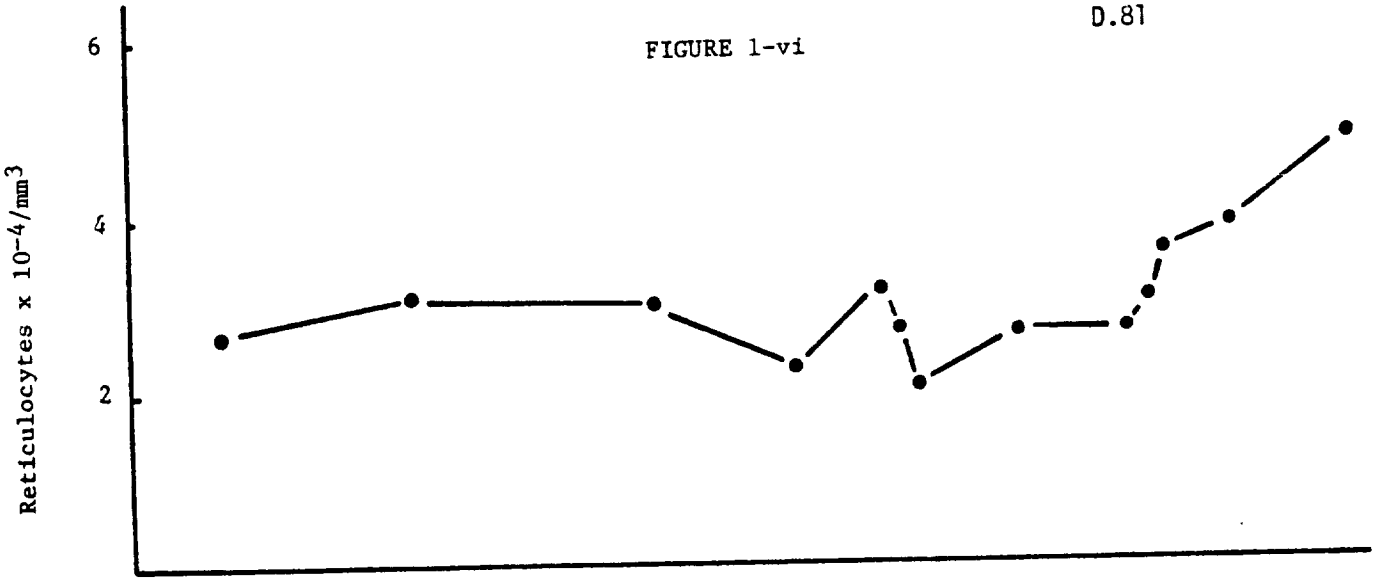
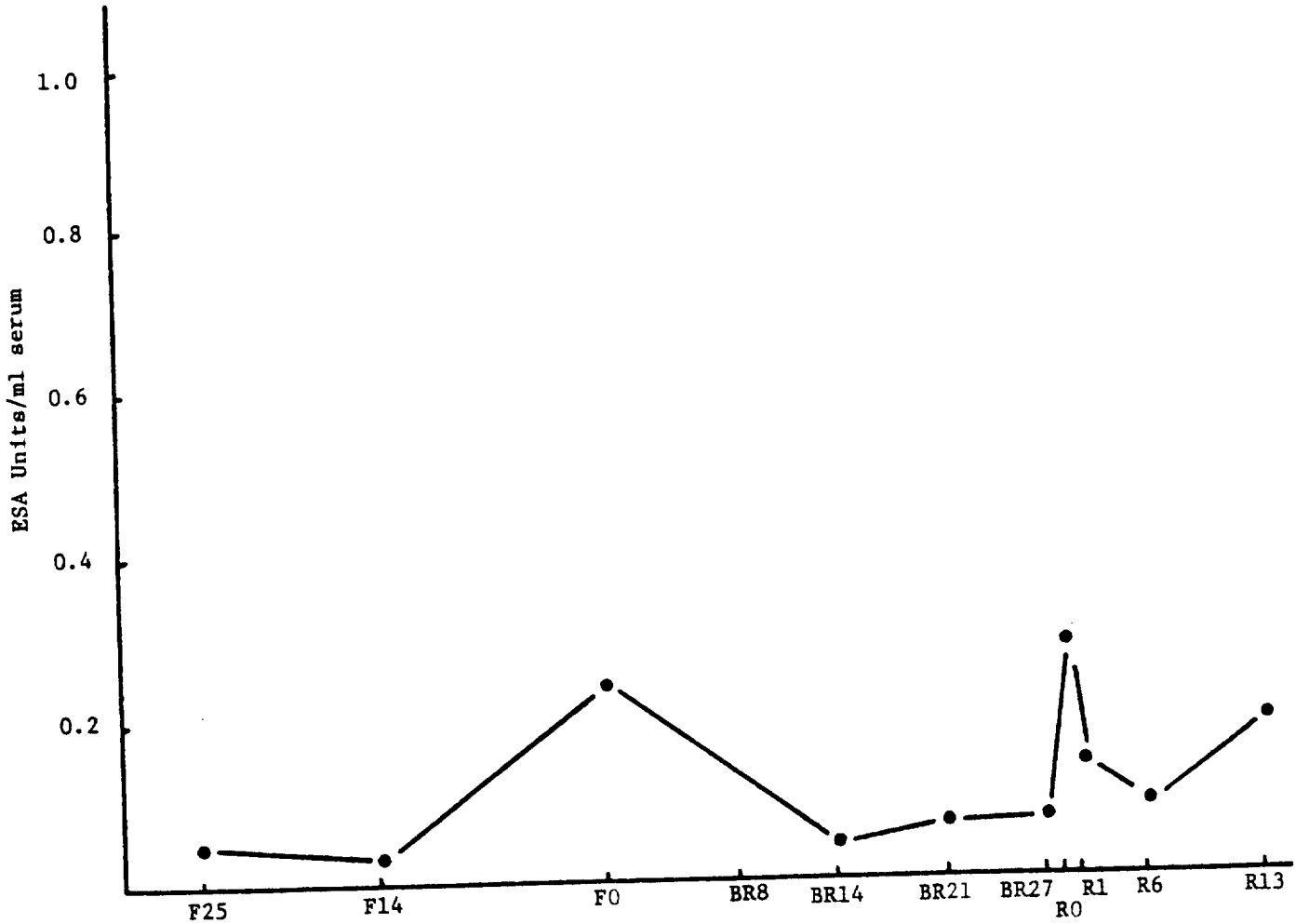
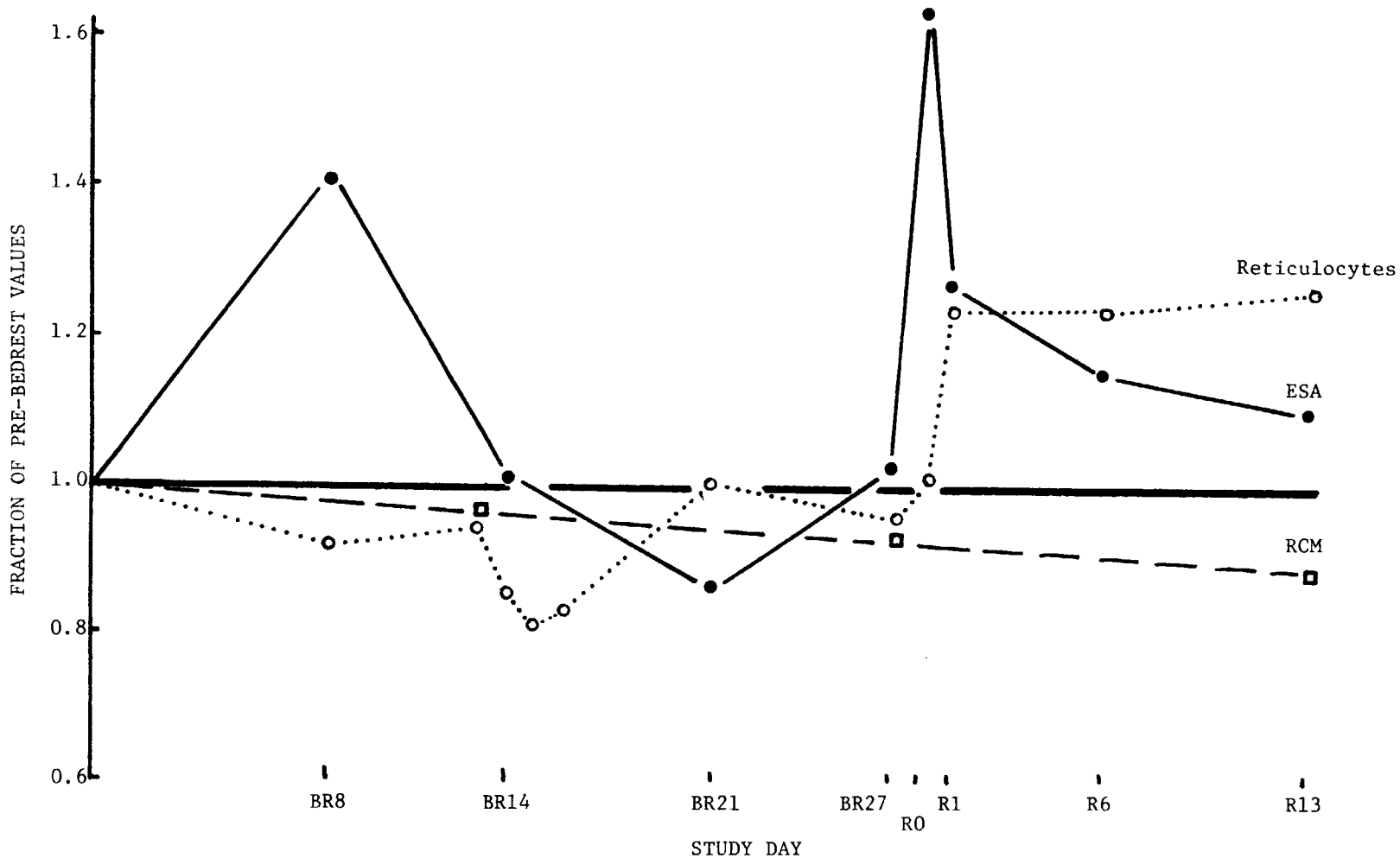

D.80
6
4
2
Reticulocytes x $10^{-4}/mm^3$
1.0
0.8
0.6
0.4
0.2
ESA units/ml serum
F25
F14
F0
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY

FIGURE 1-vi


6
4
2
Reticulocytes x $10^{-4}/mm^3$


1.0
0.8
0.6
0.4
0.2
ESA Units/ml serum
F25
F14
F0
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY


1.6
1.4
1.2
1.0
0.8
0.6
FRACTION OF PRE-BEDREST VALUES
Reticulocytes
ESA
RCM
BR8
BR14
BR21
BR27
R0
R1
R6
R13
STUDY DAY

The Influence of Bedrest on the Lymphocytic Response of Man

B. Sue Criswell and S. L. Kimzey
Baylor College of Medicine and JSC-NASA
Houston, Texas 77030

The cellular immune response of astronauts participating in the Apollo-Soyuz Test Project (ASTP) and in Skylab 3 and 4 was studied to determine what effects spaceflight and its weightlessness have on the human immune system. Kimzey et al. (1976) found that in Skylab the functional capacity of the astronauts' lymphocytes to respond to phytohemagglutinin (PHA) was depressed, and this laboratory noted a suppression in T-lymphocyte numbers. In the ASTP, a shorter flight, functional suppression was again noted, but no quantitative changes in lymphocytes occurred.

To date there have been few opportunities to study this unique environment. Conflicting demands on the astronaut's time plus practical limitations on the biological specimens which can be obtained make the studies less refined than desired. However, bedrest has proved to be a useful model for simulating many of the physiological effects of weightlessness (Wunder et al., 1968).

According to Wunder et al. (1968) two components of bedrest make it a valuable technique in simulating weightlessness: (1) less work is required for postural support and a diminished load is applied to the

body's supporting structure; and (2) the length of the major fluid columns is reduced.

As part of a two-phase bedrest follow-up to Skylab (that included ten medical experiments), we examined the lymphocytes of twelve volunteers, six who bedrested for two weeks and six for four weeks. The project was designed to proximate, as closely as possible, the medical testing and dietary control of Skylab.

Contrary to the functional suppression and quantitative changes of lymphocytes that occurred during the Skylab and Apollo-Soyuz flights, we found no suppression of lymphocyte function or number during the bedrest study. In fact, during the 28-day phase we observed a stimulation in the response of lymphocytes to three mitogens; and in both phases we found an increase in WBC's the day the subjects got out of bed.

Materials and Methods

Subjects

Twelve paid male volunteers, between the ages of 26 and 36, participated in the two-phase bedrest project. The subjects, similar to the Skylab astronaut population in terms of height, weight, intelligence, personality, physical fitness and general health, were studied 30 days

before and 14 days after each bedrest period. They ate only Skylab food and drank Skylab water for 49 days (first phase) and 63 days (second phase). During bedrest at the Methodist Hospital in Houston, the participants had to remain in the horizontal position, never raising their feet above the head. During the pre- and post-control period they lived in a special housing facility.

WBC Counts

Samples of heparinized peripheral venous blood (10 cubic centimeters) were obtained and were processed within one to 24 hours after collection. Before separation, total leukocyte (white blood cell, WBC) counts were performed using a hemacytometer and/or a Coulter counter; differential counts were determined using slide preparations stained with Wright's stain.

Lymphocyte Preparation

Lymphocytes were also separated by Ficoll-Hypaque gradient centrifugation according to Boyum's method (1968) or by using a Technicon lymphocyte separator. Cells in the resulting suspension of mononuclear cells were washed three times in minimum essential medium (MEM); they were then adjusted to a final concentration of 1×10^6 cells/ml.

Lymphocyte Classification

The B-lymphocyte distributions were determined by enumerating the percent of 200 mononuclear cells with surface immunoglobulins detected by the immunofluorescent antibody technique described by DeFazio et al. (1975).

The E-rosette-forming lymphocytes (T-cells) were determined by the method of Jondahl et al. (1972). A concentration of 1×10^6 lymphocytes was mixed in 0.25 ml of MEM and added to 0.25 ml of a 0.5 percent sheep red blood cell (SRBC) suspension. After mixing, the tubes were incubated at 310 K (37^0C) for 5 minutes, centrifuged at 500 g for 3 minutes, and incubated in ice water for 2 hours. Approximately half the supernatant was removed and the top layer of cells was gently resuspended; 200 lymphocytes were counted with three or more adhering SRBC used as the criterium for an E-rosetted lymphocyte.

Lymphocyte Responsiveness in Microculture to PHA, PWM and Con A.

Purified lymphocytes (1×10^5 cells) in MEM containing 40 percent fetal calf serum (FCS) were placed in culture plates, and the antigens were diluted in MEM (containing Pen-Strep and L-glutamine) in the following concentrations: 0.01 ml phytohemagglutinin (PHA)/ml MEM; 0.01 and 0.05 ml pokeweed mitogen (PWM)/ml MEM; and 25 and 50 μg Concanavalin A (Con A)/ml MEM. The diluted antigens in

0.1 ml aliquots (in duplicate) were placed in the appropriate well. The cultures were incubated in a humidified carbon dioxide atmosphere at 310 K (37°C) for the following periods: three days for PHA and five days for Con A and PWM. On the day of harvest, samples were pulsed for two hours with 1 microcurie of methyl ^{3}H-thymidine and then harvested with an automated harvester, onto glass-fiber strips; they were then counted in a liquid scintillation counter. Data were expressed as counts per minute (CPM/1 x 10^6 lymphocytes), and the stimulation index (SI) was calculated by dividing the mean result for stimulated cultures by that for the unstimulated cultures.

Results

White Blood Cell Quantitation

Table I gives the mean and one standard deviation of the WBC count and the lymphocyte count for pre-bedrest, bedrest and post-bedrest for both the 14- and 28-day periods. In both phases there were significant increases in WBC numbers on BR+0, the counterpart to day of splashdown in the space flights.

Table II shows the numbers of T-lymphocytes, B-lymphocytes and nonreactive lymphocytes. There are value fluctuations, but they remain within the one SD for normal laboratory values.

Lymphocyte Responsiveness in Culture to PHA, PWM and Con A.

The nonspecific mitogen culture results are shown in Table III. There was no suppression of response to the mitogens in either bedrest study. In fact, on BR+0 and BR+1 in the 28-day bedrest, the subjects showed a stimulated response to PHA, PWM and Con A.

Discussion

In this study, bedrest did not mimic the spaceflight environments of Skylab 3 and 4, or the ASTP. A significant increase in WBC number and an increased responsiveness to PHA, PWM and Con A was noted on bedrest "splashdown day," BR+0.

It has been postulated that lymphocyte changes might occur during spaceflight because crew members would not be exposed to antigenic stresses from foreign bacteria and viruses. On the other hand, the bedrest subjects unless left in isolation, would be exposed to the microbes.

In our study bedrest actually enhanced the immune system and, if WBC number and lymphocyte responsiveness are indicators, resulted in healthier individuals. Traditionally, bedrest is part of recommended therapy for various viral and bacterial infections, especially the common cold and influenza. But only within the last few years have there been any well controlled studies of the physiological changes that take place during bedrest. This study seems to substantiate reasons why bedrest could be beneficial to individuals with an infection.

In summary, our data suggest that the response of man's cellular immune system to bedrest is not consistent with the changes observed following extended spaceflight missions.

Acknowledgments

The excellent technical assistance of Ms. Kathy Cobb is acknowledged. Ms. Susan Elliott provided excellent assistance as a Scientific Editor. This work was conducted under the NASA Contract NAS 9 14322.

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Table I

Leukocyte Response to Bedrest

	Sample day(a)	WBC/mm^3 Mean ± 1SD	Lymphocyte Count/mm^3 Mean ± 1SD
14 Days of Bedrest			
Pre	BR-30	6728 ± 2339	2688 ± 896
Pre	BR-21	6087 ± 1112	2877 ± 830
Pre	BR-01	4494 ± 2354	3010 ± 1400
Post	BR+0	6223 ± 1684	2755 ± 1053
Post	BR+3	6930 ± 2250	3156 ± 1636
Post	BR+6	6123 ± 1470	2940 ± 845
28 Days of Bedrest			
Pre	BR-25	5800 ± 2143	1931 ± 521
Pre	BR-14	5283 ± 511	1838 ± 374
Pre	BR-0	5683 ± 560	2016 ± 376
	BR+27	6183 ± 790	2353 ± 523
Post	BR+0	7466 ± 677	2913 ± 507
Post	BR+1	6016 ± 818	1898 ± 427
Post	BR+6	4516 ± 691	1565 ± 294

Table II

Lymphocyte Response to Bedrest

	Sample day(a)	T-lymphocytes 1×10^5/ml (Mean ± 1SD)	B-lymphocytes 1×10^5/ml (Mean ± 1SD)	Non-reactive lymphocytes 1×10^5 (Mean ± 1SD)
14 Days of Bedrest				
Pre	BR-30	18.9 ± 6.6	3.4 ± 1.5	4.6 ± 2.4
Pre	BR-21	18.1 ± 5.4	2.6 ± 1.2	8.1 ± 3.7
Pre	BR-01	17.7 ± 11.3	7.2 ± 4.5	5.2 ± 4.2
Post	BR+0	17.7 ± 6.7	7.3 ± 3.2	2.6 ± 2.4
Post	BR+3	20.4 ± 8.4	8.3 ± 4.4	3.3 ± 4.2
Post	BR+6	19.4 ± 6.6	7.4 ± 2.5	2.6 ± 1.6
28 Days of Bedrest				
Pre	BR-25	13.8 ± 3.6	3.1 ± 0.8	2.4 ± 2.6
Pre	BR-14	13.8 ± 2.4	3.1 ± 0.6	1.5 ± 1.2
Pre	BR-0	13.6 ± 1.7	3.4 ± 1.2	3.8 ± 2.8
	BR+27	17.3 ± 4.0	5.0 ± 1.4	1.3 ± 1.3
Post	BR+0	20.0 ± 4.1	6.5 ± 2.1	3.0 ± 2.6
Post	BR+1	12.7 ± 3.0	4.0 ± 1.8	2.3 ± 1.4
Post	BR+6	11.5 ± 2.2	2.8 ± 0.7	1.4 ± 1.3

RED CELL MASS AND BODY VOLUME CHANGES AFTER 28 DAYS OF BEDREST

Philip C. Johnson, M.D. and Theda Driscoll

Baylor College of Medicine
Houston, Texas

INTRODUCTION

The 28 day bedrest study began as a simulation of Skylab so that comparative ground based data could be accumulated, using the same methodology. It gradually evolved into a more problem oriented study as tests were added which had been precluded by the spaceflight constraints. Weekly plasma volumes and a midpoint red cell mass were performed so that the time course of changes in these parameters could be documented. Additionally a countermeasure involving saline ingestion during -30 mmHg LBNP was evaluated in terms of its ability to restore plasma volume and exercise and orthostatic tolerance. The role of plasma volume (PV) in cardiovascular deconditioning is still open to debate as are the roles of the other fluid compartments such as extra and intracellular fluid. Although bedrest fluid volume changes are relatively well documented, there are still areas of non-agreement and the magnitude of change is different from that of spaceflight. Information about plasma volume change with 14 days of bedrest is copious. At that interval plasma volume has decreased a mean 11-12% with approximately three quarters of that occurring in the first 3 days. After two weeks the literature gets scantier, but the mean obtained showed a slight additional decrease to 16-17%. Although few red cell mass determinations have been performed during bedrest the literature would predict a decrease of approximately 7.8% in 28 days. The literature concerning extracellular fluid (ECF) is not so clear cut. One investigator has found extracellular fluid changes greater than plasma volume changes and postulated extravascular dehydration as being contributory to the cardiovascular deconditioning. Intuitively both ECF and total body water (TBW) would be predicted to decrease since PV and

RBC mass go down and muscle tissue of the legs should decrease to be replaced by fat, a non water containing tissue. However, we found no such changes in an earlier 14 day study.

METHODS

The subjects who participated were healthy male volunteers between the ages of 26 and 37 who were physically active although they were not athletes.

The counter measure study, performed on days 13, 14, and 15, utilized a three way crossover design. Plasma volume and response to lower body negative pressure (LBNP) and exercise testing were determined pre and post the following treatment:

(1) ingestion of approximately 1 liter of saline during four hours of LBNP at -30 mmHg (the exact amount was determined by body weight).

(2) ingestion of the same amount of saline at the same rate as treatment #1.

(3) water ad libitum for four hours.

Morning plasma volumes were performed before the subjects arose after an overnight fast. During the crossover study the PM plasma volume was done during the last half hour of the treatment before the second LBNP test and four hours after eating. Plasma volumes utilizing RIHSA ^{125}I were performed at BR-40, BR+0, approximately once weekly during the bedrest period, except during the crossover study, and on R+14. Red cell masses utilizing ^{51}Cr were performed on BR-40, BR+0, BR+13, BR+27 and R+14. Extracellular fluid volume was measured using $^{35}SO_4$ space at 30 minutes and by extrapolations to zero time of the $^{35}SO_4$ activity from the least squares fit of 30, 60, 90 and 120 minute samples. This was done

to compare the two ECF estimates. ECF was measured at BR-40, BR+0, and BR+27. Each time ECF was determined TBW was measured using specific activity of urine specimens collected 3-8 hours post dose. For a complete protocol and methods please consult "JSC/Methodist Hospital 28 Day Bedrest Study, Vol. 1".

An additional short study was performed to investigate the diurnal variation of plasma volume. Five males who had approximately the same anthropomorphic characteristics as the bedrest subjects were tested twice daily at 7 AM and 2 PM for plasma volume changes. Morning plasma volumes were performed before the subjects arose and after an 8 hour fast. The afternoon plasma volumes were performed 4 hours post prandial and after a 30 minute recumbency period. The first two days they ate a moderately high sodium intake diet and on the third day a low sodium diet; on days 1 and 3 they were ambulatory while on day 2 they remained in bed.

RESULTS

The results of the plasma volume data are summarized in Table 1. (Complete data for all measured parameters are presented in the Appendices). Mean control plasma volumes performed forty days apart, forty days before the beginning of bedrest and on the day the subjects went to bed, were not significantly different, varying only 32 ml. At the time of the BR-40 plasma volumes, the subjects were not eating a controlled diet. These data therefore, indicate that neither the high sodium content of the Skylab diet nor climate changes in Houston between April and June produced a significant change in plasma volume.

Tests were performed in both instances at about 7 AM before the subjects arose. Because of a flood of the Methodist Hospital only one group of subjects were tested on BR+7. They demonstrated a significant decrease at BR+7 which was equal to the decrease on BR+13. The mean plasma volume for all six subjects was 88.6% of the prebedrest control at day 13, 83.6% at day 21, and 85.8% at day 27. The plasma volumes thus showed the expected decrease predictable from a review of other bedrest studies. The maximum decrease was seen at three weeks, with plasma volume increasing 2.2% during the fourth week. It had returned to normal by two weeks post bedrest. In comparison, astronauts of Skylab II, the 28 day mission, showed only a -3% change in plasma volume.

Table II shows the plasma volume results during the crossover study on days 13, 14 and 15 of bedrest. When the subjects received no treatment but were allowed breakfast and water ad libitum, the plasma volume increased 81±74 ml between AM and PM. When the subjects received saline, the plasma volume increased 416±111 ml and when the subjects received saline while in the LBNP, the plasma volume increased 186±62 ml. Using the Friedman two-way analysis of variance by ranks, control vs LBNP and saline and control vs saline were statistically different ($p<0.05$). It should be noted that there was a relatively large carry over effect and the plasma volume remained elevated on the next morning post treatment. On bedrest day 13 the mean plasma volume, as mentioned earlier, was 88.6% of the control while on day 14 it had risen to 94.0% of the control and remained at 92.9% of the control on day 15. The largest carry over effect appeared to be with LBNP + Saline where the plasma volume was 218±93 ml larger the AM following the treatment than the AM of the treatment; with saline it was 69±138 ml

larger and with no treatment it was 66±87 ml smaller. However none of these differences was of significance statistically ($p>.05$). These data would be affected though by the order of treatments.

Because we saw a mean 88 ml increase in plasma volume when no treatment was given, and 356 and 223 ml increases in the two subjects who received no treatment on day 13, the first day of the crossover study, we decided to determine the diurnal variation of plasma volume in five control subjects who approximated the bedrest subjects with regard to age and build. These data are shown in Table III. An approximate 200 ml diurnal increase in plasma volume persisted between AM and PM plasma volumes, whether the subjects remained upright or supine during the interim and whether they consumed a high or low sodium diet. A Friedman two way analysis of variance by ranks showed no statistical difference among the treatments ($p=0.75$).

Table IV shows a summary % change between BR-0 and BR+27 of extracellular fluid, total body water and lean body mass data. No statistically significant change was seen in any of these parameters.

Table V shows the red cell mass data and the ferrokinetic studies. Red cell mass decreased to a mean 96.9% of the control value by day 13 of bedrest and to 93.3% by 27 days of bedrest. There was no significant drop between BR-40 and BR+0 indicating, as our earlier studies have indicated, that blood withdrawal was not great enough to cause red cell mass loss. The ferrokinetic studies showed no significant change and did not offer any insight into the cause for losses in red cell mass during bedrest. The mean RBC mass loss was greater than the mean of the two week bedrest study performed last year and also consistent with the red cell mass loss during bedrest reported in the literature. Figure 1 is a composite of literature studies reporting red cell mass changes with % loss of RBC mass plotted against the duration of bedrest. As can be seen

the decrease appears to be linear with time (% change = 0.9 + 0.24 x days of bedrest) and our findings in this study are consistent with this estimate of red cell mass loss. After both our two and four week studies, red cell mass continued to decrease upon ambulation, such that two weeks post bedrest after the two week study, the red cell mass loss equalled the loss found after 28 days of bedrest. Skylab II astronauts showed a 15.1% decrease in red cell mass which is greater than two standard deviations of the predicted bedrest value; however, unlike bedrest, the red cell mass did not continue to decrease postflight.

DISCUSSION

Through the correlation of our findings with those of other investigators involved in this study, we have been able to analyze several of the popular theories for the cardiovascular deconditioning seen after bedrest. Hyatt et al. have postulated that the deconditioning might be caused by extravascular dehydration, which is defined by them as a decrease in the interstitial fluid. Their evidence was derived from water balance data and later from a 5% measured decrease obtained from direct measurements using radioactive bromide space as a measure of ECF (1,2). They thought that increased extravasation of plasma during orthostasis at a time when plasma volume was already lowered could explain the increased heart rates of bedrested subjects during tilt or LBNP testing. We, however, have not found a significant ECF decrease. In our 1975 14-day bedrest study we saw an insignificant 1% decrease, but thought that the decrease could have been masked, because the control values were obtained three weeks prior to bedrest and prior to the subjects' beginning the relatively high salt content Skylab diet. This year we measured ECF both 40 days prior to the beginning of bedrest and the day the subjects went to bed; and calculated the ECF not only from a 30 minute sample but also from an extrapolation of a die-away curve. Although the extrapolated value differed from the 30 minute value, the relationship remained constant, showing that the reproducibility of the 30 minute value which was used for Apollo and Skylab studies is as good as that of the extrapolated value which requires multiple blood samples. Using the 30 minute sample, we found a mean 3.1% change ($P>0.05$) decrease in ECF which amounts to 8 ml/kg BW change during 27 days of bedrest. The plasma volume decrease of 6.8 ml/kg BW nearly completely accounts for this change. ECF decreases were also small (-0.8%) after the 28 day Skylab II and were

generally small after all spaceflights. The greatest mean decrease, which was still small (-2.6%) was noted after Apollo 15. The reason for the lower decrease in these studies than Hyatt's study is unclear. Feasibly since Hyatt estimates ECF with a bromide dilution space, and we estimate ECF with sulfate, the bromide space estimate might be measuring a volume more sensitive to bedrest than the sulfate space estimate of ECF.

Intuitively, one might assume that ECF would change since plasma volume, which constitutes a portion of ECF, decreases; but our evidence seems to point to a shift in location of ECF rather than a plasma volume unrelated decrease. The relatively rapid changes in leg volume noted in this study without a significant decrease in ECF would be consistent with a transfer of ECF from the lower extremities. Within a week of the start of bedrest the leg volume showed a significant decrease, too large to be accounted for by a plasma volume change only. Although we were able to perform plasma volumes for only one group of subjects at day 7 because of the flooding of The Methodist Hospital, they showed a decrease on day 7 identical to that on day 13. The mean decrease on day 13 for all six subjects was 373 ml and could be assumed to be approximately that on day 7. The mean measured left leg volume decrease at that time was 189 ml or approximately 378 for both legs. Since it is illogical to assume that the total plasma volume decrease would be from the legs, ECF appears to have been lost from the legs. This could mean a movement of ECF to the dependent portions of the back muscles away from the weight supporting areas of the upright body. The leg volume continued to decrease another 100 ml from 13 to 25 days presumably as a result of calf muscle atrophy. Conversely, early recovery data seem to indicate a fluid shift into the legs either intra or extravascular. When the resting supine leg volume was measured

by Hoffler on BR+27 and remeasured on R+0 after the subjects had been out of bed for approximately 2-3 hours, sitting and walking, it showed a 100 ml increase. Upright biostereometric measurements performed earlier in the day or one hour after arising from bedrest registered this shift between BR+27 and R+0. On R+0 a 3.7% decrease in calf size compared to pre bedrest was calculated from photos which returned to -2% by R+1 and remained decreased on R+7, the last time photos were taken. Biostereometric photos showed a concommitant increase in the midsection of the body, although no weight gain was seen, further indicating a shift rather than an overall fluid loss. Spaceflight differs from bedrest in that most astronauts lose weight during the earlier flight days nonetheless the ECF changes are minimal and the decrease in calf size is approximately 8%, twice as large as the bedrest changes.

Whether these shifts indicate that increased extravasation of fluid would occur post bedrest and what the significance of a shift would be in the complex of other changes are undetermined. Several investigators including Menninger, Bartok and Hoffler, in this study, have attempted to measure postbedrest increases in % change in leg volume during LBNP or tilt, to no avail (3,4). Hoffler consistently found about a 3% increase in leg volume during -50 LBNP regardless of the bedrest duration or treatment. Even during the crossover study when the plasma volume was expanded, the leg volume increase during LBNP remained constant. An increase could have indicated either venous pooling or increased fluid extravasation. No change may actually occur or the measurement may not be sensitive enough to measure the magnitude of change which would be expected. If the plasma volume is reduced and a normal amount of blood is pooled in the legs, central blood volume would be reduced and even a small increase in pooling or extravasation could produce a physiologically

significant decrease in central volume. Since the leg volume is about 8 liters a 3% increase would indicate that about 500 ml are pooled in the legs during LBNP and an additional 200 ml increase, which would be within the noise level of the measurement, would go undetected and could be significant to the cardiovascular system. The studies of Van Beaumont et al., however, have pointed away from plasma extravasation as a major factor for syncope, at least in their centrifuge studies (5). After both dehydration and bedrest they found that loss of plasma through extravasation during centrifugation was smaller the greater the plasma volume decrease. They found a twofold greater loss of plasma volume following centrifugation pre bedrest than post bedrest although acceleration tolerance was reduced post bedrest. Their studies would indicate that the initial plasma or blood volume rather than extravasation of the blood volume was more important.

Plasma volume has long been known to decrease with bedrest, and has been incorporated into several theories of the cardiovascular deconditioning seen post bedrest and postflight. Postflight, Hoffler has found a correlation of statistical significance (r=.54) between blood volume decrease and orthostatically stressed change in heart rate (6). Stevens et al. found a similar correlation between plasma volume change and change in stressed heart rate when hypoxia and bedrest were combined (7). Chobanian, on the other hand, who studied the time course of changes in plasma volume and orthostatically stressed heart rate, found his greatest plasma volume change at one week, but found that the orthostatically stressed heart change increased progressively (8). In our 28 day bedrest study we found no correlation between stressed heart rate and blood or plasma volume change at 13 or 27 days. The weekly decline in orthostatic tolerance as assessed by a change in heart rate at -50 LBNP was linear (r=.94), while blood volume change decreased 10%

during the first two weeks and only an additional 1.5% during the last two weeks. Although the decrease in red cell mass appears linear when various bedrest studies are reviewed, the plasma volume decreases most rapidly within the first few days. In the present study plasma volume decreased 11.4% in 13 days and an additional 2.8% in the next 14. There was actually a slight increase in plasma volume between the third and fourth week.

To evaluate the role of plasma volume changes in orthostatic tolerance, the special crossover study was performed. There was no correlation, however, between the plasma volume increase and the lowering of the heart rate during LBNP stress. Plasma volume increase was greatest with saline alone (+416 ml), while LBNP + saline had the greatest protective effect during the LBNP testing. This treatment also produced a 4% increase in resting leg size after both 2 and 4 weeks of bedrest, while saline alone did not increase leg volume. The increase in leg volume after the LNBP and saline treatment is presumably due to increased interstitial fluid rather than increased vascular volume in that the plasma volume increased only 186 ml. The LBNP + Saline plasma volume determinations may have been artificially low because the determination was made during the last 30 minutes of the four hour LBNP. By the following morning, the largest residual increase was in the saline + LBNP group (218), suggesting a slow return of the fluid from the interstitial space. Leg volumes and heart rates returned to pretreatment levels by the following morning and did not reflect this carryover effect. Since aldosterone levels were found to be elevated on the days when LBNP treatment was used, the increased plasma volumes the following morning could have also resulted from the increased aldosterone.

Although neither plasma volume nor blood volume changes correlated well with LBNP induced heart rate changes, it is nonetheless true that all techniques which have been used to increase orthostatic tolerance are

directed at increasing or changing the distribution of plasma volume and extracellular fluid. For example, in the previously mentioned hypoxic bedrest study, LBNP was used for 10 hours a day for two consecutive days to restore plasma volume (7). In response to a given exercise load the heart rate was much higher if the plasma volume was decreased but unchanged from control levels if the plasma volume was re-expanded by LBNP. Maximum oxygen consumption was decreased in all subjects following bedrest regardless of their blood volumes indicating that maximum cardiac output was still below the prebedrest levels even after correction of the blood volume. Bohnn et al. have also used 9- alpha flurohydrocortisone to correct bedrest induced plasma volume decreases and to prevent the orthostatic instability of bedrest (9). Stevens et al. used the same drugs in addition to occlusive cuffs in their hypoxic bedrest study but found that while this treatment restored plasma volume it had no significant effect on the heart rate response to orthostatic intolerance (10). In our study a treatment using LBNP and saline ingestion reduced the heart rate response to LBNP stress and also increased plasma volume and ECF in the legs.

The reason for these inconsistencies is not clear. It is clear that both LBNP and 9-alpha flurohydrocortisone must have physiological effects other than plasma volume reexpansion; the "reconditioning" capabilities of these treatments therefore might stem from factors unrelated to plasma volume, and the plasma volume reconstitution could be totally circumstantial. Plasma volume increases might remove some of the symptomology of "deconditioning" without plasma volume decreases actually being the cause of the improved cardiac functions, just as nitroglycerine relieves the pain of angina pectoris without increasing coronary blood flow. The decrease in plasma volume could also relate to the prior physical conditioning of the subjects,

in that blood volume is known to increase with physical conditioning. The influence of the diurnal variation of plasma volume has not been taken into consideration in all studies. It has been assumed generally in the medical literature that plasma volume of a normal subject who is up and about is greatest in the AM (control period) and that the plasma volume decreases during the day due to shifts of fluids out of the vascular tree as a result of the increased hydrostatic pressure in the legs. The results of the two studies reported here seem to refute this. These data indicate that bedrest decreases but does not ameliorate the normal AM to PM increase in plasma volume. Therefore, if treatments which produce changes in plasma volume are to be studied it will be necessary to compare them at similar times of the day to remove this variable from the treatment effect. The results suggest again that the most reproducible plasma volume is obtained when the subject first awakes in the AM and before he gets out of bed or eats. The small number of subjects in this present study and other studies naturally makes it difficult to intelligently weigh the importance of these various factors.

Besides extravascular dehydration and plasma volume decrease, Saltin has mentioned the possibility of a "cardiac effect" in the cardiovascular deconditioning of bedrest (11). He and Hyatt have both found increases in heart rates during submaximum supine bicycle exercise post bedrest (1,9,11). In this position venous return should be facilitated theoretically removing the effect of the decreased plasma volume. Bedrested subjects differ from subjects whose plasma volumes are reduced by thermal dehydration. Thermally dehydrated subjects with plasma volume deficits of up to 25% showed increased heart rates only when they were exercised in the upright position (12). Sawin in this study found intolerance to supine exercise during bedrest and intolerance to supine and upright exercise post bedrest, although the supine exercise deficit did not become statistically significant until the

third week and did not correlate with plasma volume decrease. Hoffler also found decreased cardiac sizes post bedrest. Although the cardiac size in this study was determined from standard upright chest films, an earlier study by Saltin showed decreases even in the supine position after 4 weeks of bedrest (11). These results suggest that bedrest causes a change in cardiac dynamics unrelated to the total plasma volume deficit. While plasma volume deficit may explain many of the early changes, there are probably other factors which become important later as bedrest is prolonged beyond the first week.

Another finding of bedrest and space flight has been a red cell mass decrease. Although not as significant as the red cell mass decrease after 28 days of spaceflight (15.1%), the bedrest decrease was 6.7%. We had in fact predicted this decrease from a formula which equates days of bedrest to % decrease in red cell mass (% decrease=0.90 + 0.24 x days of bedrest) which we derived from a review of bedrest studies in the literature. The observed relationship was thus reconfirmed, indicating that the red cell mass decrease is a linear function with time at least for 28 days. Plasma volume, on the other hand, decreases rapidly during the first few days of bedrest followed by only small changes for up to 28 days.

A linear decrease could most easily be produced by a decrease in bone marrow production. A 25% decrease in red cell production rate could account for the changes found. It seems less likely that the lowering of the red cell mass is a result of increased random loss as is found in hemolytic anemia since this would produce an exponential decrease and there was no ancillary evidence of hemolysis. A shortened life span seems unlikely since fragile cells appear maintained in the circulation only to be lost in a short period following ambulation. After both the 14 and 28

day studies as well as after a study by Morse, red cell mass was seen to additionally decrease upon ambulation (13). No additional decrease has been seen after spaceflight, although the inflight changes were larger, narrowing total overall difference in the two experimental conditions. In bedrest the mean red cell age may actually increase during bedrest if production slows and red cells remain in the peripheral circulation for longer periods of time.

Unfortunately we find ourselves unable to prove this possibility and at the same time rule out other explanations. The unchanged reticulocyte counts during bedrest are evidence against this theory; however, a 25% decrease in reticulocytes might be too small a change to be measured since the number of reticulocytes actually counted has a coefficient of variation equal to this. Iron turnover did not change but would be expected to change if the production rate decreased. Ineffective erythropoiesis does not seem likely, since the percent reappearance of the radio-iron labeled cells was normal.

If aging red cells are allowed to remain in the circulation of a bedrest subject and the red cell shape changes are minimal, we can assume that vascular endothelium remained intact and that the red cells are not subjected to increased fibrous strands as is seen during intravascular red cell fragmentation. On the other hand, if a decrease in bone marrow function was to occur, it would by necessity require a hormone messenger. Where the messenger arises and how it performs is still unknown. Bedrest might prove to be a convenient model to study the phenomenon of inhibited red cell function.

Changes in endocrine function occur during prolonged bedrest, but none that would explain the red cell mass changes. Both the 14 and 28 day study

period produced increased cortisol excretion, and increased serum T-4, T-3 and increased aldosterone excretion. Cortisol is a known stimulator of erythropoiesis which presumably could counteract any red cell mass loss. The increase in thyroid hormone levels without a concurrent change in TSH indicates increased thyroid function which would stimulate erythropoiesis. Testosterone levels and ketosteroids were not measured but are not known to decrease during bedrest.

These bedrest studies were designed as a simulation of the 28 day Skylab II mission. In the bedrest studies the space and volume determinations were performed by techniques identical to those used for the Skylab experiment M0113 and the biochemistry studies. A comparison of the two test series indicates:

	Mean % Change			
Measurement	BR ml	SL II ml	BR ml/kg	SL II ml/kg
Red Cell Mass	- 6.7	-15.1	- 6.7	- 9.5
Plasma Volume	-14.6	- 3.0	-14.6	+ 1.9
Extracellular Fluid	- 3.1	- 0.8	- 3.1	+ 4.3
Total Body Water	+ 0.7	- 2.5	+ 0.7	+ 1.7

This bedrest study showed a lower percentage decrease in the red cell mass with the bedrest value about one half of that seen after spaceflight. The red cell mass change constrasts sharply with the plasma volume change, which is about five times greater following the bedrest study. In neither the extracellular fluid nor the body water determination was a significant difference found.

To the present the greater decrease in red cell mass found during spaceflight is unexplained. However during bedrest fragile red cells seem to remain in the circulation until the subject is up and about, when these red cells leave the circulation. It is possible that these fragile cells

disappeared from the Skylab astronauts circulating blood volume during the reentry and recovery sequence. If this did not happen then the environment of spaceflight causes a continuous loss of these cells which seems to be preserved during bedrest.

The lesser plasma volume decrease found after the recovery of the Skylab crewmembers may be a reflection of normal diurnal change noted in plasma volume. A diurnal change continues for at least 15 days during bedrest. Since the crewmembers had been awake and active for about six hours prior to recovery, they would be expected to show a lesser decrease in plasma volume if spaceflight affects plasma volume in a fashion quantitatively similar to that of bedrest and a diurnal change continues. At this time there is no information as to whether diurnal plasma volume changes occur.

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TABLE 1

Date (AM)	Mean Plasma Volume 28 Day Bedrest Study ml	% of Mean Control	ml/kg	14 Day Bedrest Study % of Control
BR-40	3420		49.2	
BR-0	3388		48.8	
BR+13	3015	88.6	43.2	
BR+14	3205	94.0	42.7	93.1
BR+15	3204	92.9	45.0	
BR+21	2844	83.6	40.9	
BR+27	2918	85.8	42.0	
R+13	3434	100.7	49.1	107.4

TABLE 2

CROSSOVER STUDY AT DAYS 13, 14, & 15 of 28 DAY BEDREST

AM to PM Plasma Volume Change

Δml ± SE

N = 6

Control	Saline	LBNP + Saline
+81 ± 74	+416 ± 111	+186 ± 62

Friedman Two-Way Analysis of Variance by Ranks

Control vs LBNP + Saline	$p < 0.05$
Control vs Saline	$p < 0.05$
Saline vs LBNP + Saline	$p = 0.10$

AM to AM Plasma Volume Change

Δml ± SE

N = 4

Control	Saline	LBNP + Saline
-66 ± 87	+69 ± 138	+218 ± 93

Mann Whitney U Test

Control vs LBNP + Saline	$p = .057$
Control vs Saline	$p = .343$
Saline vs LBNP + Saline	$p = .243$

TABLE 3

CONTROL SUBJECTS AM TO PM PLASMA VOLUME CHANGE

Δml ± SE

Up and About*	Supine Throughout** the Study Day	Up and About* Low Sodium Diet
+226 ± 41	+194 ± 84	+224 ± 40

*Supine 8 hours prior to and until the 30 minute AM plasma volume sample was withdrawn.
Supine 30 minutes prior to and until the 30 minute PM plasma volume sample was withdrawn.

**Supine 8 hours prior to the AM plasma volume and throughout the day until the 30 minute PM plasma volume sample was withdrawn.

Friedman Two-Way Analysis of Variance by Ranks $p = 0.75$

TABLE 4

FLUID SPACES

MEAN

	ECF Ext. ml/kg		ECF ml/kg		TBW ml/kg		LBM		%LBM		PV ml/kg	
BR Days	14	28	14	28	14	28	14	28	14	28	14	28
PRE		201		235		654		62.5		89.5	43.3	49.2
BR-0		203	234	234	611	654	58.3	62.4	83.7	89.6	42.8	48.8
BR END		195	229	226	607	658	58.2	62.8	83.0	90.1	39.9	42.0

28 Day Bedrest Study

% of Control Value of BR+27 Days

	MEAN	1	2	3	4	5	6
ECF* (liters)	96.9	99.4	99.7	92.3	91.0	100.6	98.5
ECF** (liters)	97.6	100.0	101.4	96.3	88.5	100.0	99.6
TBW (liters)	100.7	97.8	100.6	105.4	100.7	99.6	100.0
LBM (kg)	100.7	97.9	100.7	105.4	100.7	99.6	99.9
LBM (%BW)	100.6	101.5	102.6	103.6	100.7	96.8	98.4
ECF* (ml/kg)	96.3	100.5	100.0	91.3	91.2	97.7	96.9
ECF** (ml/kg)	96.9	101.0	101.6	95.6	88.4	97.2	97.8
TBW (ml/kg)	100.6	101.4	102.5	103.8	100.7	96.8	98.5

* ECF using ^{35}S concentration of 30 minute plasma sample

** ECF using extrapolated 0 time ^{35}S concentration

TABLE 5

Mean Red Cell Mass

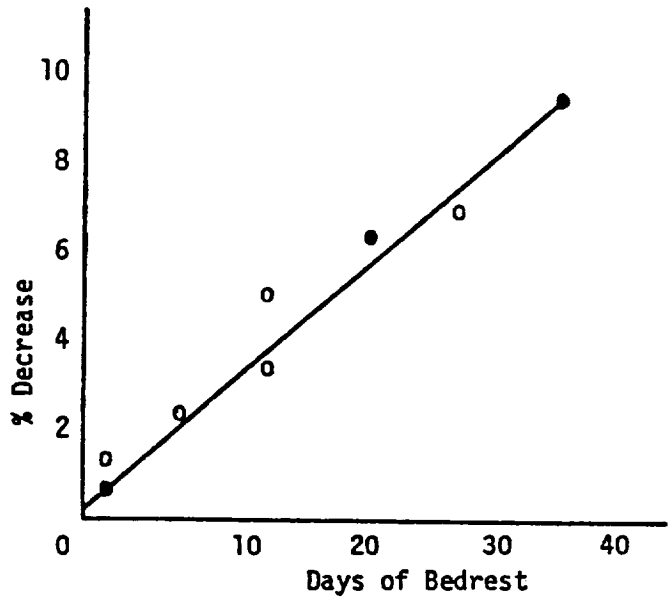
Day	28 Day Bedrest Study ml	ml/kg	% of Mean Control	14 Day Bedrest Study % of Mean Control
BR-40	2162	31.1		
BR-0	2165	31.2		
BR+13/14	2098	30.0	96.9	95.1
BR+27	2020	29.1	93.3	
R+13	1908	27.4	87.9	93.5
R+48				105.2

Control 14 Day Study = 26.5 ml/kg
28 Day Study = 31.2 ml/kg

Mean Values

BR Days	^{59}Fe T½ (min) 14	28	Serum Iron 14	28	^{59}Fe Turnover 14	28	^{59}Fe % Reappearance 14	28
Pre		96.7		84.2		0.46		95
Post	113.2	97.6	107	96	0.41	0.42		103

FIGURE 1



Relationship between red cell mass decrease and days of bedrest.

O = Bedrest studies conducted by PI

● = Bedrest studies in the literature

$r^2 = 0.96$

28 Day Bedrest Study
Plasma Volume (ml)

DAY	MEAN	1	2	3	4	5	6
BR-40	3420	3457	3612	3278	3311	3668	3197
BR-0	3388	3469	3577	3304	3230	3656	3095
BR+7					2938	3357	2841
BR+13 AM	3015	2849	3112	2900	3010	3376	2841
BR+13 PM		3034 **	3554*	3256	3110**	4323*	3064
BR+14 AM	3205	3279	3269	3017	3087	3797	2781
BR+14 PM		3528 *	3132	3483**	3456*	3774	3011**
BR+15 AM	3204	3111	2967	3064	2953	3776	3097
BR+15 PM		3205	3019**	3317*	2928	3859**	3333*
BR+21	2844	2871	2791	2832	2659	3199	2713
BR+27	2918	2827	2894	2989	2767	3241	2787
R+13	3434	3641	3285	3559	2822	4128	3169

Red Cell Mass (ml)

BR-40	2162	2247	2428	2135	2007	2322	1856
BR-0	2165	2245	2471	2126	2014	2315	1822
BR+13	2098	2134	2423	2072	2016	2164	1782
BR+27	2020	2135	2343	2047	2022	1969	1605
R+13	1908	1967	2335	1961	1772	1898	1514

* Saline

** Saline + LBNP

28 Day Bedrest Study
Plasma Volume (ml/kg)

DAY	MEAN	1	2	3	4	5	6
BR-40	49.2	44.9	52.0	45.2	54.0	49.6	49.8
BR-0	48.8	45.8	51.7	45.5	52.4	48.9	48.5
BR+7					47.3	44.8	44.2
BR+13	43.2	37.7	45.0	39.6	48.5	44.4	44.0
BR+14	42.7	40.3	44.3	38.6	46.4	46.3	40.4
BR+15	45.0	41.3	43.3	41.8	47.6	49.2	46.9
BR+21	40.9	38.5	41.2	38.6	43.3	42.0	42.0
BR+27	42.0	38.4	2.5	40.5	45.0	42.4	42.9
R+13	49.1	49.8	58.2	48.0	46.3	53.3	49.1

Red Cell Mass (ml/kg)

BR-40	31.1	29.2	34.9	29.4	32.7	31.4	28.9
BR-0	31.2	29.6	35.7	29.3	32.7	31.0	28.6
BR+13	30.0	28.3	35.0	28.3	32.5	28.5	27.6
BR+27	29.1	29.0	34.4	27.7	32.9	25.7	24.7
R+13	27.4	26.9	34.3	26.4	29.1	24.5	23.5

Plasma Volume (% of Pre Bedrest Mean)

BR+7	90.6				89.8	91.7	90.3
BR+13 AM	88.6	82.3	86.6	88.1	92.0	92.2	90.3
BR+13 PM	99.3	87.6**	98.9*	98.9	95.1**	118.0*	97.4
BR+14 AM	94.0	94.7	90.9	91.7	94.4	103.7	88.4
BR+14 PM	100.0	101.9 *	87.1	105.8**	105.7 *	103.0	95.7**
BR+15 AM	92.9	89.8	82.5	93.1	90.3	103.1	98.4
BR+15 PM	96.4	92.5	84.0 **	100.8 *	89.5	105.4**	105.9 *
BR+21	83.6	82.9	77.6	86.0	81.3	87.4	86.2
BR+27	85.8	81.6	80.5	90.8	84.6	88.5	88.6
R+13	100.7	105.1	91.4	108.1	86.3	112.7	100.7

Red Cell Mass (% of Pre Bedrest Mean)

BR+13	96.9	95.0	98.9	97.2	100.3	93.3	96.9
BR+27	93.3	95.0	95.6	96.1	100.6	84.9	87.3
R+13	87.9	87.6	95.5	92.0	88.1	81.9	82.3

28 Day Bedrest Study

Blood Volume (ml)

DAY	MEAN	1	2	3	4	5	6
BR-40	5586	5704	6040	5413	5318	5990	5053
BR-0	5554	5714	6048	5430	5244	5971	4917
BR+13	5113	4983	5535	4972	5026	5540	4623
BR+27	4938	4962	5237	5036	4789	5210	4392
R+13	5488	5578	5624	5520	4594	6026	4683

Blood Volume (ml/kg)

BR-40	80.3	74.1	86.9	74.6	86.8	80.9	78.7
BR-0	80.0	75.5	87.4	74.8	85.1	79.8	77.1
BR+13	73.2	66.0	80.0	67.9	81.1	72.9	71.6
BR+27	71.0	67.4	76.9	68.2	77.9	68.1	67.6
R+13	76.5	76.3	82.6	74.4	75.4	77.8	72.6

Intracellular Fluid (liters)

BR-40	29.2	31.8	28.9	30.4	26.0	31.1	26.7
BR-0	29.3	31.5	29.1	31.1	25.3	31.1	27.5
BR+27	30.0	30.7	29.5	34.7	27.3	30.8	27.2

Interstitial Fluid (liters)

BR-40	13.0	13.1	13.5	14.4	11.5	14.5	10.8
BR-0	12.9	12.7	14.0	14.1	12.1	14.3	10.1
BR+27	12.9	13.5	14.4	13.2	10.9	15.0	10.6

Blood Volume (ml)
% of Pre Bedrest Mean

BR+13	90.2	87.3	91.6	91.7	95.2	92.6	92.7
BR+27	88.7	86.9	86.6	92.9	90.7	87.1	88.1
R+13	95.7	97.7	93.0	101.8	87.0	100.8	93.9

28 Day Bedrest Study

DAY	Mean	1	2	3	4	5	6
Subject Weight (kg)							
BR-40	69.8	77.0	69.5	72.6	61.3	74.0	64.2
BR-0	69.6	75.7	69.2	72.6	61.6	74.8	63.8
BR+7					62.1	74.9	64.3
BR+13	70.1	75.0	69.3	73.2	62.2	76.2	64.7
BR+14	70.3	76.1	69.1	73.1	62.2	76.7	64.5
BR+15	70.3	75.3	68.6	73.2	62.0	76.7	66.0
BR+21	69.6	74.5	67.8	73.4	61.4	76.1	64.6
BR+27	69.8	73.6	68.1	73.8	61.5	76.5	65.0
R+13	69.7	73.1	68.1	74.2	60.9	77.5	64.5
30 Min Extracellular Fluid (liters)							
BR-40	16.4	16.6	17.1	17.7	14.8	18.2	14.0
BR-0	16.3	16.2	17.6	17.4	15.3	18.0	13.2
BR+27	15.8	16.3	17.3	16.2	13.7	18.2	13.4
Extrapolated Extracellular Fluid (ECF) (liters)							
BR-40	14.0	14.0	14.8	14.8	12.5	15.8	12.0
BR-0	14.1	13.8	14.8	15.1	13.5	16.2	11.3
BR+27	13.7	13.9	15.0	14.4	11.5	16.0	11.6
Total Body Water (TBW) (liters)							
BR-40	45.6	48.4	46.3	48.1	40.8	49.3	40.7
BR-0	45.5	47.7	46.7	48.5	40.6	49.1	40.5
BR+27	45.9	47.0	46.8	50.9	41.0	49.0	40.6
Lean Body Mass (LBM) (Kg)							
BR-40	62.5	66.3	63.3	65.9	56.0	67.5	55.8
BR-0	62.4	65.3	64.0	66.4	55.6	67.3	55.5
BR+27	62.8	64.4	64.1	69.7	56.2	67.1	55.6
Lean Body Mass (% BW)							
BR-40	89.5	86.1	91.0	90.8	91.3	91.2	86.8
BR-0	89.6	86.3	92.4	91.5	90.3	89.9	87.0
BR+27	90.1	87.5	94.1	94.4	91.4	87.7	85.5

28 Day Bedrest Study

DAY	MEAN	1	2	3	4	5	6
			30 Min ECF (ml/kg)				
BR-40	235	216	246	244	241	246	218
BR-0	234	214	254	240	248	241	207
BR+27	226	216	250	221	223	238	206
			Extrapolated ECF (ml/kg)				
BR-40	201	182	213	204	204	214	187
BR-0	203	182	214	208	219	216	177
BR+27	195	184	217	197	187	209	178
			TBW (ml/kg)				
BR-40	654	628	665	662	666	666	634
BR-0	654	630	675	668	659	656	635
BR+27	658	638	687	690	667	640	625

28 Day Bedrest Study
HEMATOLOGY DATA

DATE	MEAN	1	2	3	4	5	6
			^{59}Fe Turnover				
BR-40	0.46	0.39	0.72	0.41	0.55	0.38	0.29
R+27	0.42	0.47	0.61	0.34	0.35	0.39	0.36
			Serum Iron				
BR-40	84.2	77.6	107.4	72.6	73.6	84.7	89.0
R+27	95.6	97.2	114.6	112.5	86.1	81.9	81.2
			^{59}Fe T½ (min)				
BR-40	96.7	89.6	77.0	79.2	72.0	109.4	153.1
R+27	97.6	78.2	79.9	131.6	109.6	88.7	97.3
			^{59}Fe % Reappearance				
Pre	95	100	91	100	96	93	91
Post	103	104	105	100	103	100	105
			^{51}Cr Survival T½ in Days				
Pre	23	23.5	21.0	22.0	23.0	25.0	24.0
			Peripheral Hematocrit (Per Hct)				
BR-40	.43	.445	.445	.445	.420	.435	.410
BR-0	.43	.435	.445	.440	.415	.430	.395
BR+7					.450	.430	.430
BR+13 AM	.45	.490	.480	.470	.440	.425	.415
BR+13 PM		.470	.440	.440	.430	.390	.400
BR+14 AM		.450	.460	.460	.435	.370	.410
BR+14 PM		.440	.460	.430	.415	.400	.410
BR+15 AM		.470	.475	.440	.435	.395	.387
BR+15 PM		.470	.465	.420	.440	.400	.370
BR+21	.45	.480	.500	.465	.460	.415	.410
BR+27	.45	.470	.490	.455	.460	.412	.400
R+13	.39	.390	.450	.400	.420	.350	.350

28 Day Bedrest Study
HEMATOLOGY DATA

Total Body Hematocrit (T.B. Hct)

DAY	MEAN	1	2	3	4	5	6
BR-40	.39	.395	.406	.394	.377	.388	.367
BR-0	.39	.393	.409	.392	.384	.388	.370
BR+13	.41	.428	.438	.417	.400	.392	.385
BR+27	.41	.430	.447	.406	.422	.378	.365
R+13	.36	.351	.416	.355	.386	.315	.323

TB Hct to Per Hct Ratio

BR-40	.90	.89	.91	.88	.90	.89	.90
BR-0	.91	.90	.92	.89	.92	.90	.94
BR+13	.90	.87	.91	.89	.91	.92	.93
BR+27	.91	.91	.91	.89	.92	.92	.91
R+14	.91	.90	.92	.89	.92	.90	.92

Mean Peripheral Hematocrit

	1975	1976
BR-40		.43
BR-21	.43	
BR-0		.43
BR+13/14	.44	.45
BR+21		.45
BR+27		.45
R+13	.41	.39
R+48	.45	

NASA JSC - BAYLOR BED REST II

CARDIOVASCULAR STUDIES

LOWER BODY NEGATIVE PRESSURE

G. W. Hoffler
J. T. Baker
R. L. Johnson
W. Crosier

INTRODUCTION: This bed rest study was designed to simulate many aspects of the 28-day Skylab mission. For the Lower Body Negative Pressure (LBNP) studies this included use of the Skylab LBNP protocol and Skylab equivalent hardware. The objective was to assess alterations in subject orthostatic responses to LBNP during the course of the hypodynamic (bed rest) period when subjects continuously maintained the horizontal position with respect to the long axis of their body. This provided a ground based study for comparison of results with those from the first manned Skylab mission.

In addition, a second objective sought to explore the potential of using LBNP as a countermeasure to decreased orthostatic tolerance consequent to prolonged exposure to hypodynamia. This was performed by oral intake of isotonic saline to provide hypothesized substrate in conjunction with the action of LBNP. Preliminary work by Hyatt (1) had already shown promise of advantage from the combination of these two procedures both by improved response to LBNP stress tests and by augmented intravascular volume.

For the first objective, standard Skylab LBNP tests were performed on each of the six crewmen several times before, during and after the bed rest interval. The second objective employed a special 3-day cross over procedure allowing each subject to be his own control with responses to early morning standard LBNP tests being compared to similar afternoon tests for assessing the efficacy of the countermeasures. Both tests

flanked a 4-hour period of the designated treatment condition. During this 3-day period about the middle of the 28-day bed rest interval, each subject experienced in different order all three therapeutic conditions.

METHODS: The Skylab Experiment M092 (Lower Body Negative Pressure) was followed as exactly as feasible in terms of hardware employed, protocol of test conditions, frequency and sequencing, level of stress, and data reduction (2,3). Certain Skylab conditions and circumstances, such as the physical and psychological stresses of launch, the ambient atmosphere and sleep/wake/work cycles could not be realistically incorporated into the bed rest study design.

All basic Skylab cardiovascular measurements were included (heart rate, blood pressure, calf circumference, percentage change in calf size, temperature and the vectorcardiogram) as well as recordings of leg volume and systolic time intervals (STI) throughout all phases of the study and the addition of arm circumference and arm blood flow determinations.

Six normal, healthy, male subjects ranging in age from 27 to 36 years, volunteered for the study. For expediency, two groups of three subjects each underwent identical (but staggered by five days) pre-, in-, and post bed rest periods of testing.

Five baseline tests on each subject were performed at 24, 20, 14, 7 and one days prior to beginning of bed rest. Due to uncontrollable events following local flooding at the Houston medical center, early in bed rest tests were preluded, the first occurring at 11 days and

7 days of bed rest for the two groups, respectively.

For the question of countermeasures, the special 3-day cross over study on bed rest days 13, 14, and 15 provided one of three treatment conditions for each subject each day according to the following matrix:

Group	I	II	Bed Rest Day 13	14	15
Subjects	1	4	Saline + LBNP	Saline	Nothing
	2	5	Saline	Nothing	Saline + LBNP
	3	6	Nothing	Saline + LBNP	Saline

Thus, each of the six subjects experienced all three treatment conditions over the 3-day interval in varying sequences. The treatment condition spanned 4 hours during which either (a) 1.60% of body weight in isotonic saline (as beef bouillon) was ingested over the first 3 hours while continuous LBNP was applied at -30mmHg for the full 4 hours; (b) the same amount and rate of isotonic saline was ingested without concomitant application of LBNP; or (c) the subject simply returned to bed rest for 4 hours. Before and after each treatment condition standard LBNP stress tests were performed; these became labelled respectively as morning (AM) and afternoon (PM) tests.

Besides this special 3-day cross over study about the middle of the 28-day bed rest interval, all subjects were tested on recovery day (R+0) by standard LBNP before and after a 4 hour therapeutic interval employing only the combined saline and LBNP exactly as used at mid bed rest. In all other test days only diagnostic LBNP tests were performed.

RESULTS:

A. Basic LBNP Studies

Heart rate, blood pressure, and leg volume changes at rest and during the highest level of LBNP (-50mmHg) are summarized by means for the 6-subject group in Table I. Thus HR both at rest and during -50mmHg LBNP increased during bed rest and afterward. A gradual return toward pre- bed rest values occurred over the first week post bed rest. Systolic and diastolic blood pressure showed lesser corresponding increases, with small changes in pulse pressure and modest elevation in mean blood pressure. Percentage change in calf size during LBNP was slightly increased during bed rest and a like amount decreased afterwards. Total leg volume was only moderately decreased during bed rest and barely altered afterwards.

RESULTS:

A. Basic LBNP Studies - Appendix A tabulates all LBNP test data except that of the vectorcardiograms by subject and test. Variables 1-11 are one item, single value descriptors concerning each test time and conditions, subject status and anthropometry. The remaining values give individual, five-minute mean values for each of the five designated LBNP periods (the -30mmHg LBNP level includes -8mmHg and -16mmHg periods). The Grand means with standard deviations from all six subjects are also listed under each test date with respect to the bed rest phase.

Heart rate, blood pressure, and leg volume changes at rest and during the highest level of LBNP (-50mmHg) are summarized by means for the 6-subject group in Table I. Thus HR both at rest and during -50mmHg LBNP increased during bed rest and afterward. A gradual return toward pre- bed rest values occurred over the first week post bed rest. Systolic and diastolic blood pressure showed lesser corresponding increases, with small changes in pulse pressure and modest elevation in mean blood pressure. Percentage change in calf size during LBNP was slightly increased during bed rest and a like amount decreased afterwards. Total leg volume was only moderately decreased during bed rest and barely altered afterwards.

These summary data have not been subjected to statistical analysis for significance, but overall responses are easily viewed and changes are not comparable in magnitude to those observed in Skylab crewmen, particularly for the leg volumes.

Table II presents cardiothoracic ratios from standard erect 6-foot postero-anterior chest X-rays taken on BR -1 and R+0. A definite decrease in size of the cardiac silhouette is evident, but not statistically significant. One pre- bed rest film was lost.

In order to analyze this mass of data for a more readily interpretable presentation, selected measurements and test dates have been tabulated in Appendix B. Heart rate; systolic, diastolic, mean, and pulse pressures; percentage change in calf (leg) volume; arm blood flow; and the pre-ejection period/left ventricular ejection period ratio (PEP/LVET) are given in tables B1-B8. Results of one pre- bed rest test (BR -1) are compared with those of the initial recovery day (R+0) test, both before and after the saline + LBNP treatment. This allows assessment of the effect of bed rest per se and of the special countermeasure procedure.

Percentage change between the highest (-50mmHg) LBNP stress values and control (supine resting) values were computed to provide a normalized method of comparing all variables.

Grand (n+6) means of percentage change due to LBNP orthostatic stress were then compared by Student's t-test for pre- and post bed rest tests. Bed rest produced elevated percentage change in heart rate from 22% to 52% ($p < 0.05$). Saline and LBNP instituted as

a countermeasure on recovery day (R+0) evoked a statistically significant ($p < 0.05$) reduction in the same measurement back to 26%; this latter value is not different statistically from the pre- bed rest datum.

Among all the other seven variables analyzed in this manner, the only significant difference occurred between PEP/LVET ratios on BR -1 and R+0 after countermeasure treatment ($p < 0.02$). The percentage change was greater for the latter test; that initially on R+0 (before treatment) was only modestly elevated (not significant). Trends in the other measurements are similar to those of previous reports (i.e., elevated systolic, diastolic, and mean blood pressures, reduced pulse pressures and arm blood flow, and no evident pattern for percentage change in calf volume on recovery day compared to pre- bed rest).

No significant change in average weight occurred throughout the whole study. Averaged maximal forearm and calf circumferences showed absolute decrease after bed rest ($P < 0.020$ and $p < 0.25$, respectively). But after the countermeasure therapy on R+0 the calf regained circumference approaching the pre- bed rest value (no significant difference), while the arm remained at its recovery morning decreased circumference value (Tables B9 - B11).

Averaged total leg volume (Table B12) decreased on R+0 by an average of only 173ml (NS). On the other hand, the effect of saline and LBNP therapy on R+0 was almost double that of bed rest and opposite in direction, producing a 322ml increase in left leg volume ($p < 0.001$). This latter volume, though greater than the pre- bed rest value, did not differ significantly from it.

B. Special Countermeasure Studies - The special countermeasure, cross over study results can be considered from several points of view, but one useful total perspective is a comparison of post treatment versus pre-treatment responses to the highest level of LBNP (-50mmHg) referenced(%Δ)to resting control values for the corresponding test. Six-subject group means are given in Tables C1-C7, and summarized in Table III.

Two basic comparisons are considered: (a) the before (AM) versus after (PM) treatment response of each cardiovascular measurement both at control rest and during the highest (-50mmHg) level of LBNP, and (b) the orthostatic stress response (control rest versus -50mmHg LBNP) both before (AM) and after (PM) treatment. In each case mean values of all six subjects are used to calculate percentage change from the designated reference. Finally, the sequential order of treatment is examined for assessing the duration of evoked effect.

Resting supine heart rates showed no significant change due to any treatment condition either during the bed rest phase or on R+0. Orthostatically stressed heart rates were reduced 11% and 18%,

respectively, by saline and saline plus LBNP. In the same fashion the orthostatic heart rate response remained virtually identical on each morning of the therapeutic trials (around 50 + % more than the resting rate) while saline reduced the stressed augmentation to 38% and saline plus LBNP to 30% greater than resting rates. Saline plus LBNP on R+O yielded only 26% increase, not statistically different from that at 2 weeks of bed rest.

Blood pressure measurements in all forms showed much less percentage changes with any treatment and no indicated trends. The same held for percentage change in calf volume during LBNP but resting total leg volume was greatly augmented by saline plus LBNP.

By virtue of an add-on saline therapy on bed rest day 16 for Group II subject 183 (special Table of Appendix A), five of the six subjects underwent saline plus LBNP treatment followed the next day by saline alone (Tables C8 - C14 and Table IV). Again, using percentage change in the orthostatic response (-50mmHg LBNP versus control rest) as the indicator, the average of all five subjects revealed significantly ($p < 0.05$) decreased heart rate response after saline + LBNP (53% to 24%). The morning response the next day, however, was already elevated to pretreatment level (54%) while the effect of saline alone that day reduced the response only to 43% (NS).

On the other hand, blood pressure responses were slightly less in magnitude after saline + LBNP therapy than after saline therapy alone the following day. This seems not logically interpretable in view of

the fact that percentage change in calf size during LBNP was less after saline + LBNP therapy, presenting a converse, if not inconsistent, picture. Total leg volume at rest, however, increased only following saline + LBNP therapy. This augmented leg volume had fully subsided by the next morning ($<$ 18 hours after treatment) and did not recur after saline therapy alone.

It is clearly evident that both saline and LBNP have positive countering effects to LBNP test responses produced by bed rest and that their effects are additive. Optimal combination treatment cannot be adduced however.

C. Correlations - The best overall cardiovascular indicator of orthostatic response has proven to be heart rate. In a recent summarization of space flight related test data (4), a significant correlation of change in orthostatically stressed heart rate with blood volume changes post flight has been shown (Figure 1). The same handling of these bed rest data is presented in Figure 2. That a like correlation has not become evident from this study may in part be due to the small number of subjects and to the fact that blood volumes were performed one day removed from the corresponding days of orthostatic testing.

Perhaps more meaningful physiologically, absolute blood volumes corresponding in near time with heart rate response to LBNP stress tests show excellent individual consistency as well as an acceptable group pattern (Table V and Figure 3).

No other interrelationships have been attempted in this analysis, though the data as presented will allow nearly any manipulation deemed suitable or potentially profitable.

SUMMARY:

A. This bed rest study, while unique in employing many aspects of protocol, physiological measurements, and hardware identical to an actual space mission (Skylab 2), has yielded essentially nothing new in basic cardiovascular findings. The decrements in orthostatic tolerance assessed by LBNP stress tests are in keeping with observations and findings from other bed rest subjects and from space crews. Of course, magnitudes vary between subjects and among types of hypodynamic exposure.

B. Perhaps chief among magnitude variations are the modest leg volume decrements (< 5%) measured in these bed rest subjects compared to the relatively large (> 10%) leg mass losses experienced by the Skylab crews.

C. A thorough evaluation of oral intake of isotonic saline in conjunction with LBNP as countermeasures to decreased post hypodynamic orthostatic tolerance (previously propounded by Hyatt, et.al) has yielded interesting and potentially useful results. The use of saline plus LBNP or saline alone are salutary for the adverse responses to LBNP stress testing after bed rest. The combined treatment (saline plus LBNP) provides the greater effect, which is, however, quite short-lived (<18 hours), and primarily manifest by filling of

leg interstitial tissue, probably reducing its attendant blood pooling and consequences. In any case, the overall complex seems tied to absolute and/or effective blood volume operative in the cardiovascular system.

The ultimate efficacy of this countermeasure will probably be determined by resolving an optimal amount and time/rate of applying these therapies, weighing these data with the potential gain versus lost or compromised of crew time, and future Shuttle and Space Station experience for assessing the operational need for orthostatic countermeasures.

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The authors are grateful to Fern Deans (JSC) and Dorothy Carr, John Donaldson, Kathy Tamer, and Mary Taylor (all of Technology, Inc.) for analytical and clerical assistance in the preparation of this report.

APPENDICES

APPENDIX A - contains all cardiovascular data from first level of analysis with explanatory, scheduling, and auxiliary tables and notes. Basic data are reduced copies of computer line printer outputs.

APPENDIX B - contains eight tables (B1-B8) of data from -50mmHg LBNP versus control rest (except % Δ leg volume, B6) for difference response to this stress testing for days BR -1, R+0 before and R+0 after saline plus LBNP countermeasure treatment; and four tables of unique data (control) for each of those same designated test times--by individual subject and group mean with standard deviation and t-test values as appropriate.

APPENDIX C - contains seven tables (C1-C7) of percentage changes produced by the several countermeasure studies, both for resting and LBNP stressed values and for orthostatic (LBNP) stress response, as a function of countermeasure employed; and seven tables (C8-C14) of percentage changes produced by orthostatic (LBNP) stress testing as a function of countermeasure employed and sequence of application.

TABLE I Group mean (n=6) summary of LBNP cardiovascular measurements by condition of test and phase of study.

TABLE II Cardiothoracic ratio data from pre- and post bed rest chest X-rays for evaluating cardiac size.

TABLE III Group mean (n=6) percentage changes between orthostatically stressed and rest measurements from the countermeasure studies.

TABLE IV Group mean (n=5) percentage changes between orthostatically stressed and at rest measurements from the countermeasure studies as a function of sequence of treatment.

TABLE V Percentage change in heart rate (-50mmHg LBNP versus rest) and absolute associated blood volume on three discrete days of the bed rest study (BR -1/0, BR +13, and R+0/BR +27)

FIGURE 1 Percentage change in immediate post flight orthostatically stressed heart rate (from mean post flight reference values) as a function of corresponding percentage change in total blood volume measured by radioisotope dilution methods--from U.S. space crews (Reference

FIGURE 2 The same presentation of data from the six subjects of this bed rest study as for Figure 1.

FIGURE 3 Percentage augmentation of heart rate (by LBNP stress) as a function of absolute blood volume (ml/Kg) for three discrete dates of the bed rest study.

TABLE B1

HEART RATE (bpm)

Subject No.	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	60	53	+ 7	+13.2	102	62	+40	+64.5	74	61	+13	+21.3
184	85	55	+30	+54.5	105	67	+38	+56.7	113	77	+36	+46.8
186	59	56	+ 3	+ 5.4	88	68	+20	+29.4	95	76	+19	+25.0
182	61	58	+ 3	+ 5.2	115	67	+48	+71.6	78	62	+16	+25.8
183	87	63	+24	+38.1	122	73	+49	+67.1	85	64	+21	+32.8
185	62	54	+ 8	+14.8	89	72	+17	+23.6	70	66	+ 4	+ 6.1
Mean	69.0	56.5		+21.87	103.5	68.2		+52.17	85.8	67.7		+26.29
S.D.	13.2	3.6		20.04	13.6	4.0		20.54	15.97	7.06		13.40

t ind = 2.59

t ind = 2.59

t ind = 0.44

TABLE B2

SYSTOLIC BLOOD PRESSURE (mmHg)

	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
Subject no.	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	123	116	+ 7	+ 6.03	115	127	-12	-9.4	119	127	- 8	- 6.3
184	107	115	- 8	- 6.96	101	108	- 7	-6.5	107	121	-14	-11.6
186	85	85	0	0	104	106	- 2	-1.9	104	108	- 4	- 3.7
182	95	96	- 1	- 1.04	96	91	+ 5	+5.5	95	100	- 5	- 5.0
183	99	114	-15	-13.2	111	120	- 9	-7.5	110	113	- 3	- 2.7
185	87	94	- 7	- 7.4	93	103	-10	-9.7	90	95	- 5	- 5.3
Mean	99.3	103.3		- 3.76	103.2	109.1		-4.92	104.3	110.7		-5.75
S.D.	14.1	13.3		6.78	8.5	12.7		5.83	10.5	12.3		3.12

t ind = 0.32

t ind = -0.31

t ind = 0.65

TABLE B3

DIASTOLIC BLOOD PRESSURE (mmHg)

	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
Subject No.	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	66	64	2	+ 3.1	76	76	- 0	0.0	74	69	5	+7.24
184	44	49	-5	-10.2	57	63	- 6	- 9.5	57	54	3	+5.6
186	57	56	1	+ 1.8	63	61	2	+ 3.3	63	59	4	+6.8
182	59	56	3	+ 5.4	67	57	10	+17.5	64	62	2	+3.2
183	75	68	7	+10.3	83	78	5	+ 6.4	89	81	8	+9.9
185	51	51	-0	0.0	63	60	3	+ 5.0	64	60	4	+6.7
Mean	58.7	57.3		+1.72	68.2	65.8		+3.78	68.3	64.0		+6.55
S.D.	10.9	7.4		6.83	9.8	8.9		8.82	11.4	9.5		2.17

t ind = -0.4516

t ind = 0.74

t ind = 1.64

TABLE B4

MEAN BLOOD PRESSURE (mmHg)

Subject No.	BR-1 -50	BR-1 Control	BR-1 Δ	BR-1 %Δ	R+0 -50	R+0 Control	R+0 Δ	R+0 %Δ	R+0 p̄ Rx (Saline + LBNP) -50	R+0 p̄ Rx (Saline + LBNP) Control	R+0 p̄ Rx (Saline + LBNP) Δ	R+0 p̄ Rx (Saline + LBNP) %Δ
181	85	81	+4	+4.9	89	93	-4	- 4.3	89	88	+1	+1.1
184	65	71	-6	-8.5	72	78	-6	- 7.7	74	76	-2	-2.6
186	66	66	0	0	77	76	+1	+ 1.3	77	75	+2	+2.7
182	71	70	+1	+1.4	77	68	+9	+13.2	74	75	-1	-1.3
183	83	83	0	0	92	92	0	0	96	92	+4	+4.3
185	63	65	-2	-3.1	73	74	-1	- 1.4	73	72	+1	+1.4
Mean	72.2	72.7		-0.86	80.0	80.2		- 0.20	80.5	79.7		0.92
S.D.	9.6	7.6		4.53	8.4	10.1		7.15	9.7	8.2		2.55

t ind = -0.30

t ind = 0.23

t ind = 0.85

TABLE B5

PULSE PRESSURE (mmHg)

Subject No.	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	57	52	5	+ 9.6	39	51	-12	-23.52	45	58	-13	-22.4
184	63	66	- 3	- 4.5	44	45	- 1	- 2.2	50	67	-17	-25.4
186	28	29	- 1	- 3.4	41	45	- 4	- 8.9	41	49	- 8	-16.3
182	36	40	- 4	-10.0	29	34	- 5	-14.7	38	38	0	0
183	24	46	-22	-47.8	28	42	-14	-33.3	21	32	-11	-34.4
185	36	43	- 7	-16.3	30	43	-13	-30.2	26	35	- 9	-25.7
Mean	40.7	46.0		-12.08	35.2	43.3		-18.81	36.8	46.5		-20.70
S.D.	15.8	12.4		19.50	7.0	5.5		12.28	11.2	14.0		11.70

t ind = 0.71

t ind = 0.27

t ind = -0.93

TABLE B6

LEG VOLUME (% Change)

Subject No.	BR-1		R+0		R+0 p̄ Rx (Saline + LBNP)	
	-50	Control	-50	Control	-50	Control
181	1.9		3.9		1.9	
184	2.3		2.3		3.0	
186	2.1		1.4		1.4	
182	2.6		2.6		2.9	
183	2.7		2.2		2.2	
185	2.1		1.7		1.6	
Mean	2.28		2.35		2.17	
S.D.	0.31		0.87		0.67	

t ind = -0.044

t ind = -0.40

t ind = -0.38

TABLE B7

FOREARM BLOOD FLOW (ml/dl)

Subject No.	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	3.28	4.36	-1.08	-24.8	3.01	5.04	-2.03	-40.3	0.30	1.56	-1.26	-80.8
184	0.56	2.13	-1.57	-73.7	2.38	1.33	+1.05	+78.9	0.54	1.54	-1.00	-64.9
186	0.75	2.25	-1.50	-66.7	1.58	3.92	-2.34	-59.7	1.12	2.99	-1.87	-62.5
182	2.70	5.22	-2.52	-48.3	0.17	2.28	-2.11	-92.5	1.97	2.13	-0.16	- 7.5
183	1.42	7.18	-5.76	-80.2	1.40	3.95	-2.55	-64.6	0.10	3.03	-2.93	-96.7
185	0.95	2.21	-1.26	-57.0	1.86	3.25	-1.39	-42.8	0.63	1.12	-0.49	-43.8
Mean	1.61	3.89		-58.44	1.73	3.30		-36.82	0.78	2.06		-59.37
S.D.	1.12	2.07		20.07	0.96	1.32		59.74	0.68	0.80		31.07

t ind = -0.84

t ind = -0.82

t ind = -0.06

TABLE B8

PEP/LVET Ratio

Subject No.	BR-1				R+0				R+0 p̄ Rx (Saline + LBNP)			
	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ	-50	Control	Δ	%Δ
181	0.56	0.36	0.20	+55.6	0.75	0.48	0.27	+56.3	0.71	0.42	0.29	+69.0
184	0.54	0.31	0.20	+64.5	0.77	0.43	0.34	+79.1	0.66	0.39	0.27	+69.2
186	0.53	0.35	0.18	+51.4	0.62	0.44	0.18	+40.9	0.63	0.33	0.30	+90.9
182	0.53	0.35	0.18	+51.4	0.74	0.37	0.37	+100.0	0.62	0.33	0.29	+87.9
183	0.56	0.34	0.21	+60.0	0.70	0.43	0.27	+62.8	0.63	0.38	0.25	+65.8
185	0.55	0.32	0.23	+71.9	0.63	0.38	0.25	+65.8	0.66	0.38	0.28	+73.7
Mean	0.55	0.34		+59.13	0.70	0.42		+67.47	0.65	0.37		+76.09
S.D.	0.014	0.019		8.04	0.063	0.041		20.24	0.033	0.035		10.65

t ind = -0.93

t ind = 0.92

t ind = 3.11

TABLE B9

WEIGHT (Kg)

Subject No.	BR-1 -50	BR-1 Control	R+0 -50	R+0 Control	R+0 p̄ Rx (Saline + LBNP) -50	R+0 p̄ Rx (Saline + LBNP) Control
181		76.7		73.4		73.4
184		69.4		67.4		67.4
186		72.6		73.9		73.9
			-SAME-			
182		61.7		61.7		61.7
183		73.9		77.1		77.1
185		64.4		65.3		65.3
Mean		69.8		69.8		69.8
S.D.		5.78		5.91		5.91

t dep = -0.017

TABLE B10

RIGHT FOREARM CIRCUMFERENCE (cm)

Subject No.	BR-1		R+0		R+0 p̄ Rx (Saline + LBNP)	
	-50	Control	-50	Control	-50	Control
181		28.1		27.6		28.0
184		28.5		27.7		27.7
186		28.4		28.4		28.3
182		27.1		26.5		26.5
183		28.5		28.3		28.2
185		27.0		26.5		26.5
Mean		27.9		27.5		27.5
S.D.		0.70		0.84		0.83

t dep = 3.69

t dep = 0.43

t dep = 3.46

TABLE B11

LEFT LEG (CALF) CIRCUMFERENCE (cm)

Subject No.	BR-1 -50	BR-1 Control	R+0 -50	R+0 Control	R+0 p̄ Rx (Saline + LBNP) -50	R+0 p̄ Rx (Saline + LBNP) Control
181		37.3		35.5		36.0
184		34.3		33.8		34.2
186		37.0		36.2		36.6
182		34.5		33.4		33.6
183		36.3		36.0		36.9
185		32.7		32.5		32.8
Mean		35.4		34.6		35.0
S.D.		1.80		1.54		1.71

t dep = 3.20

t dep = -4.53

t dep = 1.18

TABLE B12

LEG VOLUME (% Change)

Subject No.	BR-1 -50	BR-1 Control	R+0 -50	R+0 Control	R+0 $\bar{p}$ Rx (Saline + LBNP) -50	R+0 $\bar{p}$ Rx (Saline + LBNP) Control
181		8287		8004		8291
184		8000		7476		7919
186		8797		8631		8876
182		7402		7051		7316
183		7589		7895		8231
185		6688		6666		7025
Mean		7794		7621		7943
S.D.		736		707		680

t dep = 1.46

t dep = 10.82

t dep = -1.27

TABLE: C1

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: HEART RATE

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	-1	-3	-0.+	-1
	-50mmHg LBNP	-1	-11	-18	-18
CONTROL REST vs. -50mmHg	AM	+57	+53	+57	+52
	PM	+56	+38	+30	+26

TABLE: C2

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: SYSTOLIC BLOOD PRESSURE

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	-6.4	-2.4	-0.5	+1.8
	-50mmHg LBNP	-1.4	+1.8	+0.7	+0.1
CONTROL REST vs. -50mmHg	AM	-13.1	-11.4	-6.8	+5.0
	PM	- 8.4	- 7.5	-6.1	-5.7

TABLE: C3

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: DIASTOLIC BLOOD PRESSURE

COMPARISON \ Rx		CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	-2.1	-3.3	-2.6	-2.5
	-50mmHg LBNP	-2.3	+1.2	+0.5	+0.+
CONTROL REST vs. -50mmHg	AM	+3.5	+0.1	+3.2	+3.8
	PM	+3.2	+4.7	+6.1	+6.5

TABLE: C4

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: MEAN BLOOD PRESSURE

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	-3.9	-3.3	-1.7	-0.3
	-50mmHg LBNP	-2.6	+1.3	+0.6	+0.5
CONTROL REST vs. -50mmHg	AM	-4.4	-5.2	-1.4	+0.2
	PM	-3.1	-0.7	+0.5	+1.0

TABLE: C5

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: PULSE PRESSURE

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	-12.3	+0.4	+2.4	+6.8
	-50mmHg LBNP	+3.6	+7.9	+0.8	-0.4
CONTROL REST vs. -50mmHg	AM	-35.2	-29.4	-19.9	-18.8
	PM	-23.9	-25.0	-22.4	-23.8

TABLE: C6

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: CALF VOLUME DURING LBNP

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+O @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
	CONTROL REST	-	-	-	-
AM vs. PM					
	-50mmHg LBNP	+14.2	+8.3	-6.1	-3.3
CONTROL REST vs.	AM	+ 2.8	+2.7	+3.1	+2.1
-50mmHg	PM	+ 3.2	+3.0	+2.9	+2.2

— * Not Applicable

TABLE: C7

SPECIAL PREVENTATIVE THERAPIES STUDY

PERCENTAGE CHANGE IN: LEG VOLUME - TOTAL RESTING

COMPARISON	Rx	CROSS OVER @ 2 WEEKS			R+0 @ 4 WKS
		NIL	SALINE	SALINE + LBNP	SALINE + LBNP
AM vs. PM	CONTROL REST	+0.5	+0.3	+4.5	+4.2
	-50mmHg LBNP	—	—	—	—
CONTROL REST vs. -50mmHg	AM	—	—	—	—
	PM	—	—	—	—

— = Not Applicable

TABLE: C8

PERCENTAGE CHANGE IN: HEART RATE

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	+58.8	+41.2	+70.0	+51.0
J. HORWITZ				
R. THORSON	+45.8	+17.6	+31.3	+25.4
J. McGREER	+41.8	+18.9	+38.8	+53.8
M. ANDERSON	+72.3	+32.2	+96.8	+58.3
J. HUDSON	+47.7	+11.3	+34.8	+26.7
MEAN	53.3	24.2	54.3	43.0
S.D.	12.46	12.16	28.29	15.73

$t_d = 2.70$, $p < 0.05$

$t_d = 2.32$ NS

$t_d = 1.29$ NS

$t_d = -0.14$ NS

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C9

PERCENTAGE CHANGE IN: SYSTOLIC BLOOD PRESSURE

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	-0.5	-3.3	-7.6	-3.6
J. HORWITZ				
R. THORSON	-12.4	-9.2	-9.0	-8.3
J. McGREER	+ 4.3	-3.4	-5.7	-1.4
M. ANDERSON	-11.7	-6.2	-13.5	-4.4
J. HUDSON	- 8.7	-4.1	- 8.2	-3.4
MEAN	- 5.8	-5.2	- 8.8	-4.2
S.D.	7.36	2.50	2.90	2.53

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C10

PERCENTAGE CHANGE IN: DIASTOLIC BLOOD PRESSURE

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	+14.8	+13.8	-2.7	+3.7
J. HORWITZ				
R. THORSON	- 5.0	+ 4.9	+3.6	+3.4
J. McGREER	+ 2.1	+ 6.2	+9.5	+13.1
M. ANDERSON	+ 7.6	+ 2.4	-1.2	+ 8.9
J. HUDSON	+ 5.0	+ 9.3	+2.0	+11.8
MEAN	+ 4.9	+ 7.3	+2.2	+ 8.2
S.D.	7.27	4.39	4.77	4.49

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C11

PERCENTAGE CHANGE IN: MEAN BLOOD PRESSURE

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	+8.0	+5.2	-5.5	+1.2
J. HORWITZ				
R. THORSON	-8.6	-1.4	-1.4	-1.4
J. McGREER	+2.8	+2.8	+2.8	+7.1
M. ANDERSON	0	-1.1	-5.2	+3.3
J. HUDSON	-3.0	+3.0	-3.1	+3.1
MEAN	-0.16	+2.40	-2.48	+2.66
S.D.	6.21	2.75	3.38	3.12

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C12

PERCENTAGE CHANGE IN: PULSE PRESSURE

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	-22.0	-21.1	-16.0	-13.4
J. HORWITZ				
R. THORSON	-19.2	-26.7	-27.8	-23.3
J. McGREER	+ 8.1	-17.5	-33.3	-25.0
M. ANDERSON	-46.5	-29.0	-48.5	-34.2
J. HUDSON	-21.3	-16.7	-18.8	-25.0
MEAN	-20.2	-22.2	-28.9	-24.2
S.D.	19.35	5.48	12.97	7.39

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C13

PERCENTAGE CHANGE IN: LEG VOLUME (DURING LBNP)

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	+3.2	+2.6	+2.7	+3.7
J. HORWITZ				
R. THORSON	+2.9	+1.7	+2.7	+1.9
J. McGREER	+3.7	+3.5	+2.9	+3.9
M. ANDERSON	+3.5	+2.4	+2.5	+3.5
J. HUDSON	+2.3	+2.1	+2.6	+2.8
MEAN	+3.1	+2.5	+2.7	+3.2
S.D.	0.55	0.67	0.15	0.82

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE: C14

LEG VOLUME (RESTING SUPINE, LITERS)

	Iso-Saline + LBNP		Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
H. LEE	8081	8682	8153	8153
J. HORWITZ				
R. THORSON	8598	8864	8542	8397
J. McGREER	7181	7505	7204	7343
M. ANDERSON	7735	8120	7699	7768
J. HUDSON	6600	6944	6681	6698
MEAN	7639	8023	7656	7672
S.D.	777	804	740	675

$t_d = -6.67$, $p < 0.005$

$t_d = -0.34$, NS

$t_d = -0.53$, NS

Tables C8-14 compare the orthostatic response (-50mmHg LBNP vs. resting values) for Isotonic Saline plus LBNP followed by Isotonic Saline (next day) alone.

The Pre Rx Isotonic Saline value should evidence duration of the Isotonic Saline + LBNP effect.

The two Post treatment values should compare the two treatments/countermeasures.

TABLE I

SELECTED MEASUREMENTS AVERAGED (± SD) FOR EACH BED REST PHASE

	REST			-50		
	Pre	In Bed-Rest	Post	Pre	In Bed-Rest	Post
HR (bpm)	58 ± 2	63 ± 3	67 ± 3	74 ± 7	100 ± 9	91 ± 9
SBP (mmHg)	100 ± 11	107 ± 1	106 ± 4	94 ± 7	96 ± 1	98 ± 5
DBP (mmHg)	57 ± 8	61 ± 2	64 ± 2	58 ± 9	65 ± 2	67 ± 1
MBP (mmHg)	72 ± 7	76 ± 2	78 ± 2	70 ± 7	76 ± 2	78 ± 2
PP (mmHg)	43 ± 10	46 ± 2	42 ± 4	36 ± 8	32 ± 2	32 ± 4
% LV	-	-	-	2.4 ± 0.5	2.6 ± 0.5	2.2 ± 0.2
Leg Vol (Litres)	7.80 ± 0.73	7.56 ± 0.05	7.75 ± 0.12			

TABLE II

CARDIO-THORACIC RATIO

Subject		BR-1			R+0		
No.	Name	Cardiac Diameter	Thoracic Diameter	C/T Ratio	Cardiac Diameter	Thoracic Diameter	C/T Ratio
181	Lee	14.0	31.2	0.448	10.0	31.6	0.316
184	Horwitz	N/A	N/A	N/A	10.4	29.6	0.351
186	Thorson	12.9	32.2	0.400	12.0	32.2	0.372
182	McGreer	12.8	29.7	0.430	12.3	29.4	0.418
183	Anderson	13.3	32.2	0.413	13.7	33.0	0.415
185	Hudson	12.0	32.8	0.365	11.2	32.9	0.340
	Mean			0.411			0.372
	S.D.			0.031			0.045

t dep = 1.64
n = 5

TABLE III

PERCENT CHANGE BETWEEN ORTHO STRESS AND REST

	SPECIAL CROSS-OVER STUDY						R+0	
	No Rx		Iso-Saline		Iso-Saline + LBNP		Iso-Saline + LBNP	
	Pre Rx	Post	Pre Rx	Post	Pre Rx	Post	Pre Rx	Post
HR	+57 ± 19	+55 ± 13	+53 ± 13	+38 ± 13	+57 ± 14	+30 ± 17	+52 ± 21	+26 ± 13
SBP	-13 ± 4	- 8 ± 9	-11 ± 6	- 8 ± 7	- 7 ± 7	- 6 ± 3	- 5 ± 5	- 6 ± 4
DBP	+ 4 ± 6	+ 3 ± 5	+ 0 ± 6	+ 5 ± 6	+ 3 ± 8	+ 6 ± 5	+ 4 ± 9	+ 6 ± 2
MBP	- 4 ± 5	- 3 ± 7	- 5 ± 6	- 1 ± 6	- 1 ± 6	+ 1 ± 4	+ 0 ± 7	+ 1 ± 3
PP	-35 ± 7	-24 ± 18	-29 ± 13	-25 ± 10	-20 ± 17	-22 ± 5	-19 ± 12	-24 ± 6
%ΔLV	+2.8 ± 0.70	+3.2 ± 1.0	+2.7 ± 0.1	+3.0 ± 0.7	+3.1 ± 0.5	+2.9 ± 1.2	+2.1 ± 0.9	+2.2 ± 0.7
Leg Vol*	7.62 ± 0.70	7.66 ± 0.75	7.67 ± 0.66	7.70 ± 0.61	7.65 ± 0.70	7.99 ± 0.72	7.62 ± 0.71	7.94 ± 0.68

*Absolute values in Litres

TABLE IV

CV DATA ACCORDING TO SEQUENCE OF CROSS-OVER THERAPY

Group (n=5) Mean Values

	Preceding Day Iso-Saline + LBNP		Following Day Iso-Saline	
	Pre Rx	Post Rx	Pre Rx	Post Rx
HR	+53 ± 12	+24 ± 12	+54 ± 28	+43 ± 16
SBP	- 6 ± 7	- 5 ± 3	- 9 ± 3	- 4 ± 3
DBP	+ 5 ± 7	+ 7 ± 4	+ 2 ± 5	+ 8 ± 5
MBP	- 0 ± 6	+ 2 ± 3	- 2 ± 3	+ 3 ± 3
PP	-22 ± 19	-22 ± 5	-29 ± 13	-24 ± 7
%ΔLV	+3.1 ± 0.6	+2.5 ± 0.7	+2.7 ± 0.2	+3.2 ± 0.8
Leg Vol*	7.64 ± 0.78	8.02 ± 0.80	7.66 ± 0.74	7.67 ± 0.68

*Absolute values; all others percentage change between ortho stress and rest

TABLE V

HEART RATE (AND PERCENTAGE CHANGE) AND BLOOD VOLUME

	BR-1/0			BR+13 (AM)			R+0/BR+27 (AM)		
	-50/Rest	%ΔHR	Blood Vol ml/Kg	-50/Rest	%ΔHR	Blood Vol ml/Kg	-50/Rest	%ΔHR	Blood Vol ml/Kg
Lee	60/53	13	75.5	81/51	59	66.0	102/62	65	67.4
Horwitz	85/55	55	87.4	107/65	65	80.0	105/67	57	76.9
Thorson	59/56	5	74.8	95/72	32	67.9	88/68	29	68.2
McGreer	61/58	5	85.1	78/55	42	81.1	115/67	72	77.9
Anderson	87/63	38	79.8	118/67	61	72.9	122/73	67	68.1
Hudson	62/54	15	77.1	90/64	41	71.6	89/72	24	67.6

NASA-S-75-12450

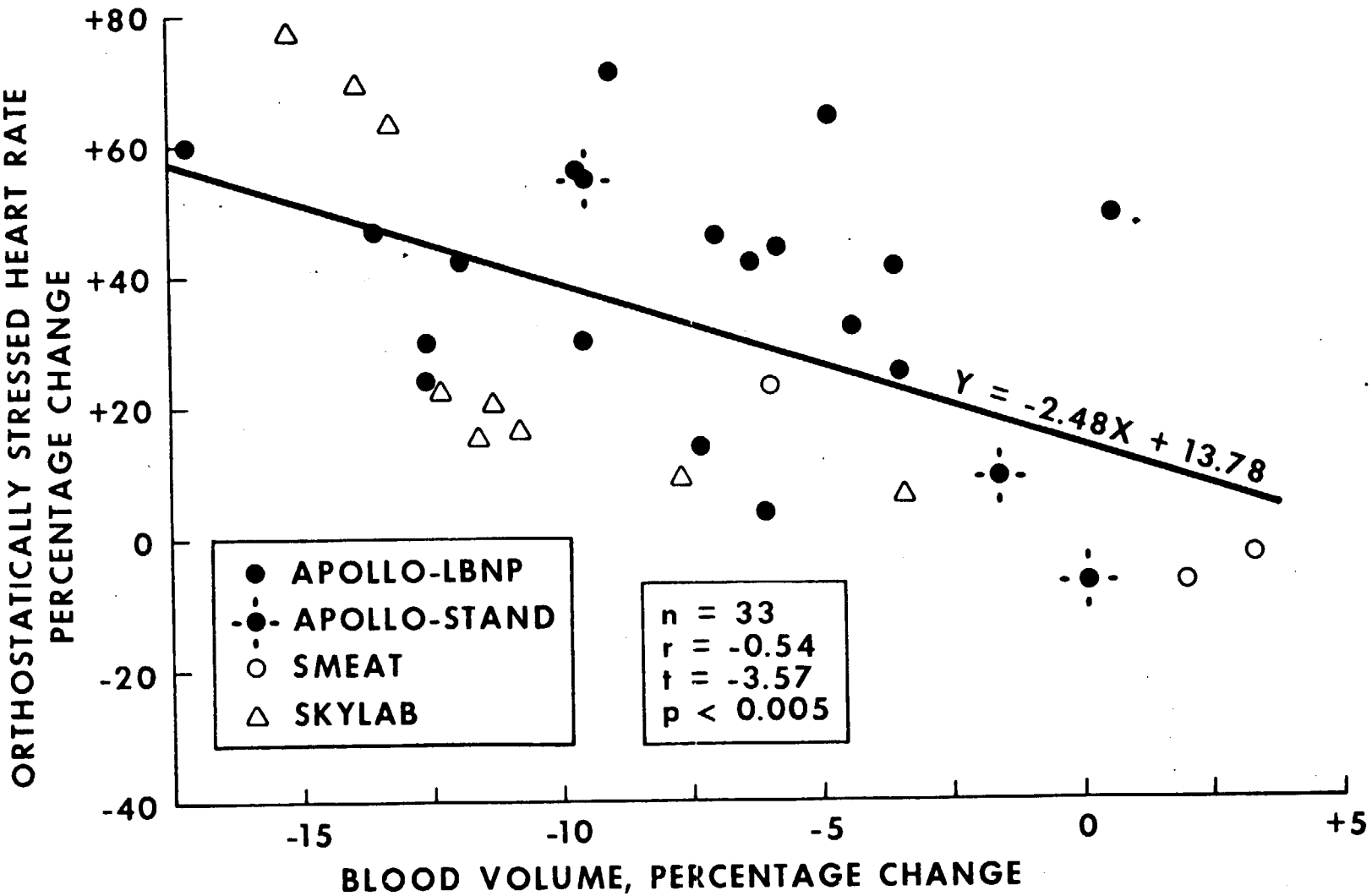

FIGURE 1

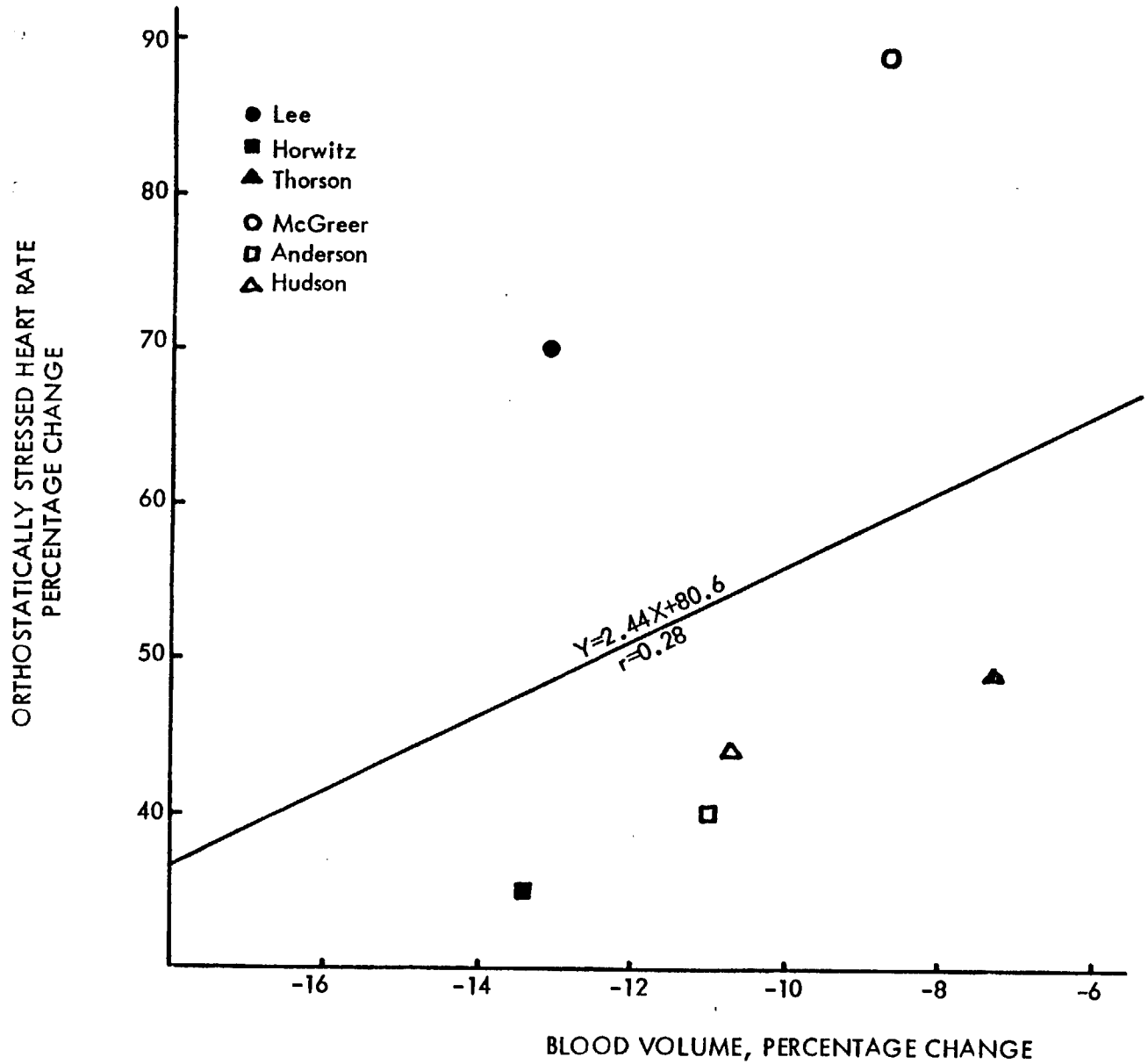
90
80
70
60
50
40
ORTHOSTATICALLY STRESSED HEART RATE
PERCENTAGE CHANGE
Lee
Horwitz
Thorson
McGreer
Anderson
Hudson
Y=2.44X+80.6
r=0.28
-16
-14
-12
-10
-8
-6
BLOOD VOLUME, PERCENTAGE CHANGE

FIGURE 2

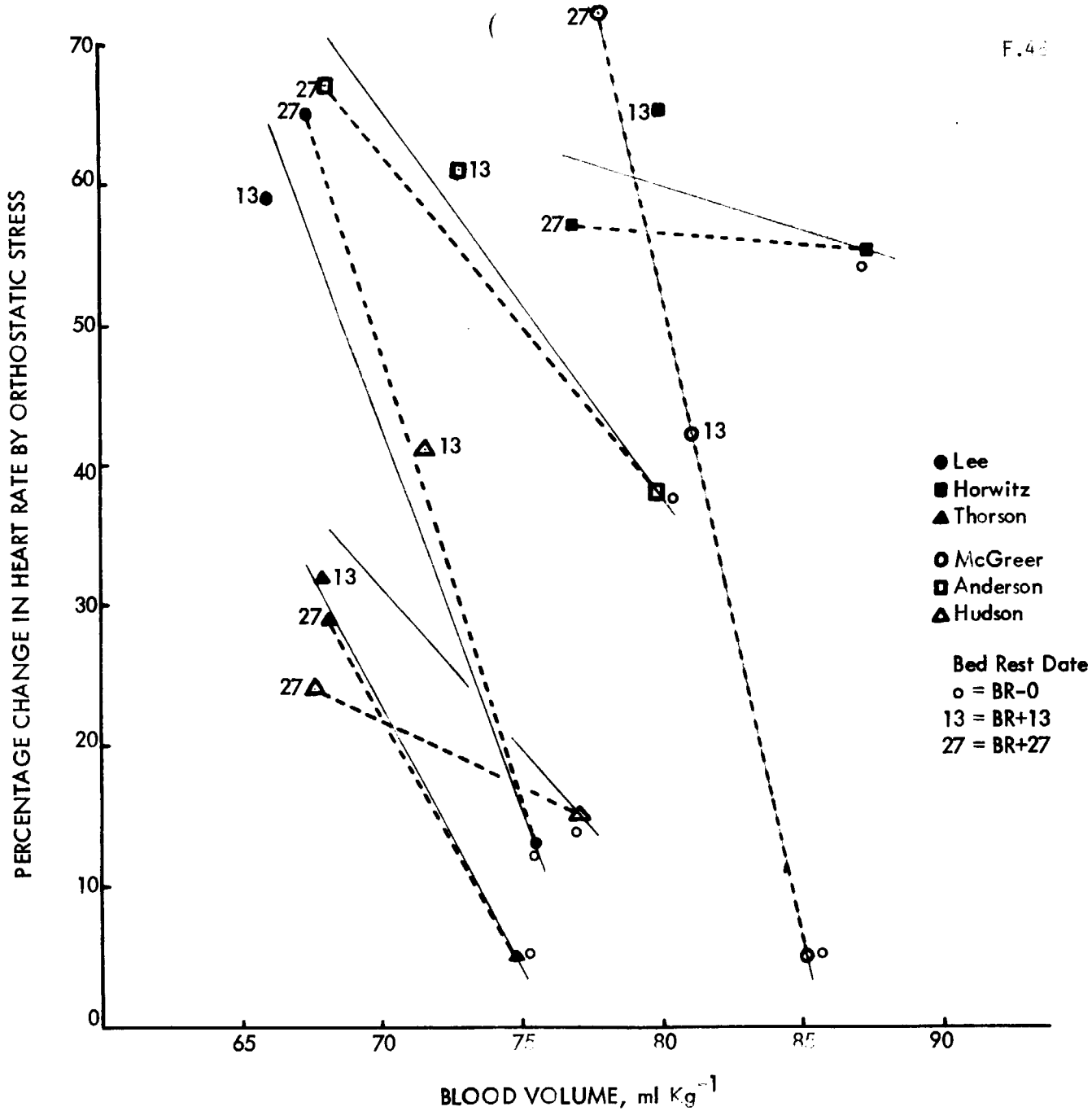

FIGURE 3 · Heart Rate/Blood Volume Relationship

CARDIOVASCULAR BED REST DATA VARIABLES

Variable Number	Variable Name	Description	Units
1	TIME	Time of test (GMT)	Hours
2	HRSE	Hours since eating	Hours
3	HROS	Hours of sleep	Hours
4	HRSV	Hours since venipuncture	Hours
5	OTMP	Oral Temperature	°F
6	CSBP	Clinical Systolic BP	mmHg
7	CDBP	Clinical Diastolic BP	mmHg
8	WT	Body weight	kg
9	ACIR	Right arm circumference	cm
10	LCIR	Left leg circumference	cm
11	LVOL	Left leg volume	cm^3
12	HR	Heart rate	beats/min
13	SBP	Systolic Blood Pressure	mmHg
14	DBP	Diastolic Blood Pressure	mmHg
15	MBP	Mean Blood Pressure	mmHg
16	PP	Pulse Pressure	mmHg
17	% LV	% change in leg volume	percent
18	ATMP	Ambient (room) temperature	°F
19	CTMP	Chamber (LBNP) temperature	°F
20	ABFR	Arm Blood Flow Rate	ml/100 ml tissue / minute
21	STHR	STI Heart rate	beats/min
22	Not used		
23	Not used		
24	Not used		
25	PEPT	Pre-ejection period ÷ Ejection Time	units
26	ETI	Corrected * Ejection Time	msec
27	QS2I	Corrected* Q-S_2 Period	msec
28	PEPI	Corrected* Pre-Ejection Period	msec

*Corrected for heart rate-

NOTES:

1. Variables 1-11 were recorded once per subject, per run—immediately before testing.

2. Variables 12-28 were recorded during LBNP for each LBNP level. Five levels were used in the data analysis—control, -30 mmHg, -40 mmHg, -50 mmHg, and recovery.

3. Variables 12-19 constitute the basic LBNP data. Variable 20 is from a separate analysis of arm blood flow. Variables 21-28 are from a separate analysis of Systolic Time Intervals.

4. Data in the attached tables for variables 12-19 at -30 mmHg are actually the averages from a 5-minute period consisting of 1 minute at -8 mmHg, 1 minute at -16 mmHg, and 3 minutes at -30 mmHg.

5. Data for variables 20-28 at -30 mmHg are only from the 3 minute period at -30 mmHg.

6. Data for each of the other pressure levels is the average from a five-minute period at that pressure level.

VARIABLE NUMBER 1 TIME
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	14.0	13.5	14.0	14.5	13.7	14.3	6.6	13.7	6.6	13.0	6.8	12.9	8.3	10.2	8.2	16.0	9.9	9.1	8.8
184	15.0	14.5	15.0	15.2	15.0	15.7	7.9	14.7	7.4	13.8	7.8	15.4	9.3	11.2	9.4	17.0	10.8	10.2	9.8
186	16.0	15.7	15.8	16.0	16.0	16.8	8.7	15.5	8.3	15.0	8.5	16.2	10.2	12.0	10.3	18.0	11.7	11.2	10.8
182	14.0	13.7	14.0	13.5	13.7	14.0	6.8	13.8	6.7	13.3	6.8	13.4	8.5	10.2	8.3	16.3	9.5	9.2	9.2
183	14.3	14.5	15.0	14.7	14.5	15.2	7.8	14.7	7.5	14.2	7.7	14.8	9.7	11.0	9.3	17.2	10.5	11.0	11.2
185	16.5	15.5	16.0	15.7	15.7	16.2	8.8	15.4	8.5	15.0	8.9	15.5	11.0	12.0	10.3	18.2	11.5	10.2	10.2
MEAN	15.0	14.6	15.0	14.9	14.8	15.4	7.7	14.6	7.5	14.0	7.7	14.7	9.5	11.1	9.3	17.1	10.7	10.1	10.0
S.D.	1.07	0.90	0.86	0.90	0.99	1.08	0.92	0.77	0.80	0.85	0.89	1.28	1.01	0.82	0.93	0.87	0.86	0.88	0.91
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 2 HRSE
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	12.0	2.0	10.0	2.0	1.5	2.0	12.0	5.0	10.5	4.5	10.5	4.0	1.0	2.0	1.5	4.5	13.0	2.0	2.0
184	1.0	1.0	1.0	1.0	3.0	1.0	1.0	4.5	0.5	5.0	11.5	5.0	1.0	1.0	2.5	4.5	0.5	2.5	2.0
186	2.0	1.0	3.0	3.0	4.0	4.0	2.0	5.0	1.0	5.0	10.5	8.0	2.0	3.0	3.0	7.0	3.0	3.0	3.5
182	12.0	1.0	10.0	1.5	1.5	1.0	11.0	4.0	10.5	3.5	12.0	4.0	1.0	2.0	1.5	5.0	13.5	1.5	2.0
183	1.0	2.5	0.5	2.5	2.0	2.0	1.0	6.0	1.0	4.0	0.5	5.0	1.5	3.0	3.0	5.0	1.0	3.5	4.0
185	3.0	3.5	1.0	3.0	3.0	3.0	1.5	4.5	1.0	4.5	1.0	5.0	3.0	4.0	1.5	9.5	2.0	2.0	2.0
MEAN	5.2	1.8	4.2	2.2	2.5	2.2	4.7	4.8	4.1	4.4	7.7	5.2	1.6	2.5	2.2	5.9	5.5	2.4	2.6
S.D.	5.34	1.03	4.54	0.82	1.00	1.17	5.25	0.68	4.97	0.58	5.39	1.47	0.80	1.05	0.75	1.99	6.07	0.74	0.92
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 3 HROS
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
									SPECIAL						SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	6.0	6.0	6.0	7.0	6.5	7.0	6.5	6.5	6.0	6.0	7.0	7.0	6.5	5.5	5.5	5.5	5.5	7.5	6.0
184	7.0	7.0	7.0	8.0	3.0	7.5	7.0	7.0	5.0	5.0	4.0	4.0	5.5	4.0	6.0	6.0	6.5	7.0	6.0
186	8.0	6.0	8.0	8.0	4.0	7.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	7.0	7.0	7.0	7.0	7.0	8.0
182	6.0	6.5	6.0	7.0	6.0	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.5	6.0	6.0	6.0	6.0	6.0	6.0
183	6.0	6.5	6.5	7.0	6.5	7.0	7.0	7.0	8.0	8.0	7.0	7.0	7.0	7.0	6.0	6.0	7.0	7.0	7.0
185	7.0	6.0	6.0	8.0	7.0	8.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	7.0	7.0	7.0	7.0	6.0	7.0
MEAN	6.7	6.3	6.6	7.5	5.5	7.2	6.7	6.7	6.5	6.5	6.2	6.2	6.3	6.1	6.2	6.2	6.5	6.7	6.7
S.D.	0.82	0.41	0.80	0.55	1.61	0.52	0.42	0.42	1.05	1.05	1.17	1.17	0.52	1.20	0.61	0.61	0.63	0.61	0.82
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 4 HRSV
CONTROL

	PRE-BEDREST					IN BEDREST								POST-BEDREST				
							SPECIAL							- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	1.0	-99.0	0.2	-99.0	-99.0	-99.0	0.5	0.5	0.5	0.2	0.2	0.2	-99.0	3.0	-99.0	-99.0	0.3	-99.0	-99.0
184	3.0	-99.0	3.0	-99.0	-99.0	-99.0	1.5	0.2	1.5	0.2	1.0	0.2	-99.0	3.5	-99.0	-99.0	1.5	-99.0	-99.0
186	0.2	-99.0	0.5	-99.0	-99.0	-99.0	2.5	0.5	1.5	0.5	2.5	0.5	-99.0	1.5	-99.0	-99.0	3.0	-99.0	-99.0
182	2.0	-99.0	2.0	-99.0	-99.0	2.0	0.5	0.2	0.2	0.2	0.2	0.2	1.0	1.0	-99.0	-99.0	1.0	-99.0	-99.0
183	3.5	-99.0	2.5	-99.0	-99.0	3.0	2.0	0.2	1.0	0.2	1.0	0.2	2.0	4.0	-99.0	-99.0	2.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	3.5	2.0	0.2	2.0	0.2	1.5	0.2	3.5	5.0	-99.0	-99.0	3.5	-99.0	-99.0
MEAN	1.9	0.0	1.6	0.0	0.0	2.8	1.5	0.3	1.1	0.3	1.1	0.3	2.2	3.0	0.0	0.0	1.9	0.0	0.0
S.D.	1.35	0.00	1.22	0.00	0.00	0.76	0.84	0.13	0.67	0.12	0.85	0.10	1.26	1.52	0.00	0.00	1.21	0.00	0.00
N	5	0	5	0	0	3	6	6	6	6	6	6	3	6	0	0	6	0	0

VARIABLE NUMBER 5 OTMP
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	97.6	98.2	96.8	97.6	98.2	99.0	98.6	97.8	97.2	98.2	97.8	97.8	97.2	98.0	97.8	97.6	98.2	97.8	97.4
184	96.6	97.4	97.4	97.6	97.2	98.4	97.2	98.6	97.1	98.2	96.8	97.8	96.8	98.2	98.4	98.4	97.4	97.2	97.6
186	99.0	98.0	98.6	98.4	97.6	99.0	98.4	98.4	98.4	98.4	98.2	98.6	98.6	98.6	98.2	98.2	98.2	98.4	97.8
182	97.4	96.8	98.5	98.4	97.2	97.8	97.2	97.2	97.0	98.2	97.2	98.6	97.2	97.4	97.2	97.6	97.4	97.4	97.2
183	97.8	97.2	97.6	97.8	97.6	97.2	97.2	97.7	97.8	97.8	97.8	97.8	98.2	98.2	98.4	97.4	97.6	97.6	97.6
185	98.0	98.8	98.2	97.8	97.2	98.2	98.0	98.7	98.0	97.8	98.6	98.4	98.4	98.8	98.2	97.8	97.8	97.8	97.6
MEAN	97.5	97.7	97.9	97.9	97.5	98.3	97.8	98.1	97.6	98.1	97.7	98.2	97.7	98.2	98.0	97.8	97.8	97.7	97.5
S.D.	0.54	0.73	0.70	0.37	0.40	0.71	0.66	0.60	0.57	0.24	0.65	0.41	0.76	0.49	0.47	0.39	0.36	0.41	0.19
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 6 CSBP
CONTROL

	PRE-BEDREST					IN BEDREST								POST-BEDREST				
							SPECIAL							SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	110.0	123.0	125.0	130.0	118.0	118.0	110.0	114.0	120.0	123.0	128.0	125.0	113.0	122.0	124.0	115.0	114.0	108.0	112.0
184	106.0	102.0	95.0	98.0	100.0	119.0	108.0	108.0	114.0	110.0	108.0	102.0	110.0	106.0	106.0	106.0	112.0	103.0	94.0
186	98.0	100.0	90.0	88.0	96.0	97.0	103.0	98.0	110.0	100.0	98.0	100.0	100.0	100.0	100.0	106.0	93.0	88.0	88.0
182	88.0	100.0	84.0	88.0	102.0	100.0	90.0	97.0	96.0	96.0	88.0	91.0	106.0	94.0	90.0	92.0	90.0	94.0	90.0
183	115.0	100.0	112.0	100.0	100.0	110.0	123.0	106.0	118.0	118.0	115.0	116.0	117.0	114.0	123.0	114.0	110.0	119.0	104.0
185	102.0	90.0	92.0	93.0	92.0	97.0	108.0	81.0	90.0	99.0	93.0	94.0	100.0	90.0	101.0	98.0	103.0	88.0	97.0
MEAN	103.2	102.5	99.7	99.5	101.3	106.8	107.0	100.7	108.0	107.7	105.0	104.7	107.7	104.3	107.7	105.2	103.7	100.0	97.5
S.D.	9.52	10.91	15.58	15.74	8.91	10.23	10.70	11.55	12.26	11.11	14.97	13.20	6.95	12.16	13.54	8.95	10.17	12.31	9.07
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 7 CDBP
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	52.0	68.0	62.0	64.0	72.0	72.0	80.0	60.0	74.0	64.0	85.0	73.0	73.0	81.0	76.0	68.0	70.0	64.0	72.0
184	52.0	52.0	63.0	62.0	52.0	57.0	64.0	64.0	63.0	54.0	58.0	63.0	60.0	52.0	68.0	56.0	50.0	50.0	66.0
186	52.0	70.0	64.0	60.0	64.0	60.0	58.0	70.0	60.0	57.0	60.0	62.0	64.0	70.0	58.0	66.0	60.0	58.0	62.0
182	58.0	46.0	54.0	46.0	55.0	54.0	56.0	70.0	64.0	60.0	63.0	64.0	55.0	54.0	56.0	64.0	60.0	58.0	52.0
183	75.0	63.0	78.0	74.0	69.0	70.0	78.0	68.0	78.0	68.0	74.0	77.0	84.0	84.0	78.0	85.0	70.0	88.0	68.0
185	62.0	54.0	54.0	50.0	50.0	52.0	68.0	60.0	50.0	40.0	54.0	52.0	57.0	58.0	56.0	60.0	52.0	54.0	59.0
MEAN	58.5	58.8	62.5	59.3	60.3	60.8	67.3	65.3	64.8	57.2	65.7	65.2	65.5	66.5	65.3	66.5	60.3	62.0	63.2
S.D.	9.07	9.60	8.80	10.09	9.27	8.35	10.01	4.68	10.05	9.77	11.64	8.84	11.08	13.91	10.09	10.03	8.52	13.56	7.11
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 8 WT
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	78.0	77.1	76.2	77.6	76.7	79.4	75.0	75.0	73.1	76.1	75.3	75.3	75.2	73.3	73.4	73.4	75.2	75.0	73.9
184	70.8	69.9	69.8	69.4	69.4	69.1	69.3	69.3	69.1	69.1	68.6	68.6	67.6	68.0	67.4	67.4	69.2	68.5	68.0
186	72.6	72.6	72.1	72.1	72.6	72.1	73.1	73.1	76.1	76.1	73.2	73.2	73.3	73.6	73.9	73.9	74.6	74.0	75.3
182	62.1	62.6	61.2	61.2	61.7	62.4	62.2	62.2	62.2	62.2	62.0	62.0	61.6	61.4	61.7	61.7	61.7	61.2	61.7
183	73.9	74.8	74.8	74.8	73.9	74.8	76.2	76.2	76.7	76.7	76.7	76.7	76.2	76.2	77.1	77.1	77.6	76.7	76.7
185	64.0	64.4	64.9	64.9	64.4	64.2	64.7	64.7	64.5	64.5	66.2	66.2	64.7	65.1	65.3	65.3	65.8	65.3	65.3
MEAN	70.2	70.2	69.8	70.0	69.8	70.3	70.1	70.1	70.3	70.8	70.3	70.3	69.8	69.6	69.8	69.8	70.7	70.1	70.2
S.D.	6.08	5.76	5.82	6.15	5.78	6.44	5.70	5.70	6.05	6.44	5.71	5.71	6.01	5.71	5.91	5.91	6.17	6.13	6.05
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 9 ACIR
CONTROL

SUBJ	PRE-BEDREST 1	2	3	4	5	6	IN BEDREST SPECIAL 7	8	9	10	11	12	13	14	POST-BEDREST - SPECIAL - 15	16	17	18	19
1 181	28.0	27.9	28.3	27.9	28.1	27.9	28.2	28.2	28.1	28.3	28.3	27.8	27.8	27.6	27.6	28.0	27.8	27.6	27.5
2 184	27.9	27.7	27.5	28.1	28.5	27.9	27.7	28.0	27.6	28.0	28.4	27.7	27.6	27.9	27.7	27.7	27.6	27.4	27.6
3 186	27.8	28.0	27.5	28.0	28.4	28.2	28.3	28.1	28.4	28.8	28.3	28.5	28.4	28.4	28.4	28.3	28.6	28.3	28.5
4 182	26.5	27.0	26.9	27.0	27.1	26.9	27.2	26.8	27.1	27.3	26.9	26.8	27.1	27.1	26.5	26.5	26.6	26.5	26.7
5 183	28.3	28.7	28.2	28.6	28.5	28.5	28.6	28.7	29.8	28.3	28.6	28.0	28.3	28.5	28.3	28.2	28.1	28.1	28.2
6 185	26.3	27.8	27.1	26.9	27.0	26.8	26.9	27.0	27.0	26.8	27.3	26.5	26.8	26.8	26.5	26.5	26.5	26.5	26.7
MEAN	27.5	27.9	27.6	27.7	27.9	27.7	27.8	27.8	28.0	27.9	28.0	27.6	27.7	27.7	27.5	27.5	27.5	27.4	27.5
S.D.	0.85	0.55	0.57	0.67	0.70	0.70	0.67	0.74	1.04	0.74	0.69	0.76	0.64	0.69	0.84	0.83	0.83	0.77	0.74
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 10 LCIR
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	36.7	37.6	37.4	37.4	37.3	36.0	36.2	36.7	35.9	36.0	35.7	35.9	35.3	34.9	35.5	36.0	36.1	36.4	35.6
184	35.4	35.1	34.4	35.0	34.3	34.2	33.9	34.2	34.0	34.2	34.0	34.3	33.7	33.3	33.8	34.2	34.0	34.0	34.3
186	35.6	36.8	35.4	36.8	37.0	36.1	36.0	36.0	36.1	36.5	36.1	35.8	35.6	35.4	36.2	36.6	36.2	36.1	36.4
182	34.1	34.6	34.4	34.6	34.5	33.9	33.6	34.0	33.2	33.6	33.5	33.3	33.1	32.9	33.4	33.6	33.3	33.3	33.8
183	36.4	36.0	36.5	36.4	36.3	35.9	35.7	35.8	35.8	35.8	35.7	36.3	35.6	35.3	36.0	36.9	36.3	36.4	36.5
185	32.0	33.4	32.9	32.6	32.7	32.0	32.0	32.1	31.8	32.4	31.9	32.1	31.7	31.4	32.5	32.8	32.3	32.2	32.5
MEAN	35.0	35.6	35.2	35.5	35.4	34.7	34.6	34.8	34.5	34.7	34.5	34.6	34.2	33.9	34.6	35.0	34.7	34.7	34.9
S.D.	1.74	1.53	1.62	1.76	1.80	1.63	1.67	1.69	1.76	1.60	1.64	1.68	1.60	1.60	1.54	1.71	1.73	1.81	1.59
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 11 LVOL
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.	8507.	8530.	8490.	8287.	8084.	8081.	8682.	8153.	8153.	8108.	8196.	8021.	7854.	8004.	8291.	8282.	8423.	8262.
184	-99.	8078.	7854.	7938.	8000.	7588.	7748.	7811.	7692.	7615.	7679.	7828.	7462.	7251.	7476.	7919.	7693.	7641.	7716.
186	-99.	8797.	8700.	8395.	8797.	8521.	8529.	8731.	8598.	8868.	8542.	8397.	8588.	8673.	8631.	8876.	8813.	8749.	8916.
182	7416.	7522.	7364.	7409.	7402.	7235.	7181.	7505.	7204.	7343.	7036.	7029.	7115.	7015.	7051.	7316.	6821.	7058.	7168.
183	7492.	7511.	7690.	7650.	7559.	7705.	7740.	7694.	7735.	8120.	7676.	7830.	7659.	7707.	7895.	8231.	7760.	7981.	7646.
185	6580.	6730.	6759.	6655.	6688.	6469.	6681.	6698.	6594.	6682.	6600.	6944.	6514.	6528.	6666.	7025.	6602.	6735.	6779.
MEAN	7163.	7857.	7816.	7756.	7789.	7600.	7660.	7853.	7863.	7797.	7607.	7704.	7560.	7505.	7620.	7943.	7662.	7764.	7748.
S.D.	506.0	755.9	725.3	681.8	738.0	708.0	653.4	766.8	703.4	756.4	703.6	597.8	718.5	746.4	707.1	679.9	842.7	777.7	763.6
N	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

189
189
378

7756
7789
7772 —

7560
7505
7532 = 240

34/K6

VARIABLE NUMBER 12 HR
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	52.0	61.0	56.0	54.0	53.0	52.0	51.0	51.0	50.0	49.0	49.0	51.0	53.0	63.0	62.0	61.0	62.0	56.0	63.0
184	67.0	59.0	58.0	53.0	55.0	64.0	65.0	60.0	57.0	62.0	60.0	59.0	70.0	62.0	67.0	77.0	79.0	66.0	62.0
186	67.0	65.0	62.0	54.0	56.0	61.0	72.0	63.0	72.0	68.0	67.0	67.0	79.0	68.0	68.0	76.0	82.0	73.0	60.0
182	55.0	62.0	49.0	60.0	58.0	64.0	55.0	58.0	49.0	52.0	48.0	54.0	57.0	61.0	67.0	62.0	54.0	73.0	66.0
183	57.0	49.0	62.0	58.0	63.0	57.0	67.0	67.0	60.0	56.0	65.0	59.0	70.0	62.0	73.0	64.0	67.0	61.0	50.0
185	61.0	59.0	58.0	56.0	54.0	60.0	64.0	57.0	65.0	71.0	69.0	60.0	62.0	66.0	72.0	66.0	72.0	68.0	65.0
MEAN	59.8	59.0	57.2	55.8	56.5	59.7	62.3	59.3	58.8	59.7	59.7	58.3	65.2	63.7	68.2	67.7	69.3	66.2	61.0
S.D.	6.27	5.33	5.00	2.71	3.62	4.59	7.84	5.47	8.84	8.82	9.16	5.50	9.62	2.73	3.97	7.06	10.54	6.74	5.80
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 12 HR
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	56.0	63.0	63.0	62.0	55.0	61.0	60.0	60.0	61.0	61.0	61.0	68.0	67.0	78.0	73.0	68.0	68.0	65.0	67.0
184	69.0	62.0	64.0	65.0	54.0	80.0	81.0	68.0	72.0	72.0	77.0	66.0	92.0	68.0	79.0	76.0	85.0	86.0	68.0
186	68.0	63.0	57.0	58.0	60.0	64.0	88.0	66.0	80.0	74.0	73.0	73.0	89.0	94.0	74.0	80.0	87.0	85.0	64.0
182	55.0	68.0	70.0	62.0	63.0	75.0	60.0	64.0	54.0	59.0	52.0	70.0	72.0	87.0	86.0	63.0	66.0	81.0	65.0
183	59.0	49.0	70.0	69.0	65.0	63.0	78.0	69.0	69.0	63.0	77.0	63.0	83.0	71.0	82.0	65.0	72.0	74.0	60.0
185	62.0	60.0	58.0	59.0	55.0	66.0	72.0	62.0	73.0	70.0	71.0	61.0	69.0	69.0	75.0	66.0	70.0	69.0	67.0
MEAN	61.7	60.4	63.7	62.5	58.7	68.3	73.2	64.8	68.2	66.5	68.5	66.8	78.7	77.8	78.2	69.7	74.7	76.7	65.2
S.D.	5.75	6.37	5.61	4.04	4.68	7.57	11.43	3.49	9.28	6.28	9.99	4.45	10.75	10.65	5.12	5.77	9.03	8.69	2.93
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 12 HR
-40 MM HG

SUBJ	PRE-BEDREST 1	2	3	4	5	IN BEDREST 6	7	8	9	10	11	12	13	14	POST-BEDREST 15	16	17	18	19
							SPECIAL								- SPECIAL -				
181	66.0	70.0	74.0	69.0	60.0	70.0	69.0	68.0	72.0	65.0	71.0	79.0	72.0	90.0	90.0	73.0	75.0	71.0	70.0
184	79.0	65.0	74.0	72.0	67.0	98.0	98.0	74.0	92.0	91.0	91.0	85.0	-99.0	84.0	99.0	91.0	100.0	86.0	72.0
186	73.0	70.0	69.0	62.0	58.0	74.0	100.0	73.0	96.0	75.0	78.0	77.0	103.0	97.0	78.0	85.0	99.0	91.0	66.0
182	70.0	64.0	62.0	72.0	64.0	90.0	65.0	65.0	60.0	70.0	60.0	68.0	89.0	100.0	104.0	69.0	68.0	84.0	77.0
183	73.0	55.0	78.0	75.0	72.0	76.0	92.0	83.0	91.0	75.0	94.0	68.0	101.0	94.0	101.0	74.0	90.0	84.0	70.0
185	71.0	62.0	62.0	63.0	58.0	77.0	80.0	70.0	87.0	76.0	83.0	67.0	79.0	80.0	83.0	68.0	72.0	73.0	71.0
MEAN	72.0	64.3	69.8	68.8	63.2	80.8	84.0	72.2	83.0	75.3	79.5	74.0	88.8	90.8	92.5	76.7	84.0	81.5	71.0
S.D.	4.29	5.61	6.71	5.27	5.60	10.78	14.95	6.24	14.00	8.73	12.72	7.83	13.50	7.70	10.52	9.27	14.13	7.82	3.58
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 12 HR
-50 MM HG

SUBJ	PRE-BEDREST 1	2	3	4	5	IN BEDREST 6	7	8	9	10	11	12	13	14	POST-BEDREST 15	16	17	18	19
							SPECIAL								- SPECIAL -				
181	69.0	73.0	86.0	68.0	60.0	75.0	81.0	72.0	85.0	74.0	79.0	90.0	81.0	95.0	102.0	74.0	85.0	76.0	78.0
184	83.0	73.0	82.0	79.0	85.0	102.0	107.0	75.0	98.0	101.0	105.0	93.0	-99.0	120.0	105.0	113.0	119.0	103.0	84.0
186	75.0	82.0	68.0	70.0	59.0	91.0	95.0	92.0	105.0	80.0	88.0	84.0	121.0	110.0	88.0	95.0	106.0	95.0	70.0
182	72.0	75.0	68.0	72.0	61.0	91.0	78.0	69.0	69.0	80.0	74.0	83.0	99.0	115.0	115.0	78.0	82.0	95.0	85.0
183	85.0	68.0	92.0	96.0	87.0	98.0	118.0	96.0	110.0	87.0	112.0	78.0	120.0	110.0	122.0	85.0	102.0	95.0	81.0
185	74.0	68.0	66.0	66.0	62.0	87.0	90.0	79.0	96.0	79.0	93.0	76.0	89.0	91.0	89.0	70.0	77.0	77.0	74.0
MEAN	76.3	71.8	76.3	75.2	69.0	90.0	94.8	80.5	93.7	83.5	91.8	84.0	102.0	106.8	103.5	85.8	95.2	90.2	78.7
S.D.	6.31	6.91	11.83	11.14	13.22	8.90	15.38	11.08	15.19	9.52	14.69	6.60	18.06	11.81	13.63	15.97	16.36	11.03	5.85
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 12 HR
RECOVERY

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	52.0	55.0	52.0	47.0	45.0	49.0	47.0	51.0	44.0	46.0	46.0	46.0	44.0	58.0	52.0	55.0	54.0	50.0	55.0
184	63.0	55.0	52.0	50.0	52.0	60.0	51.0	55.0	48.0	60.0	51.0	62.0	71.0	61.0	70.0	77.0	76.0	60.0	58.0
186	61.0	65.0	58.0	59.0	51.0	61.0	61.0	64.0	68.0	67.0	63.0	65.0	76.0	70.0	69.0	73.0	75.0	75.0	58.0
182	-99.0	57.0	49.0	55.0	62.0	63.0	51.0	59.0	47.0	50.0	48.0	49.0	63.0	66.0	71.0	61.0	57.0	63.0	55.0
183	64.0	53.0	59.0	64.0	56.0	56.0	71.0	63.0	67.0	58.0	72.0	57.0	74.0	67.0	82.0	64.0	70.0	66.0	55.0
185	58.0	56.0	56.0	54.0	51.0	56.0	56.0	55.0	60.0	67.0	65.0	62.0	57.0	60.0	69.0	66.0	67.0	68.0	65.0
MEAN	59.6	56.8	54.3	54.8	52.8	57.5	56.2	57.8	55.7	58.0	57.5	56.8	64.2	63.7	68.8	66.0	66.5	63.7	57.7
S.D.	4.83	4.22	3.93	6.11	5.71	5.01	8.73	5.08	10.67	8.65	10.60	7.73	12.19	4.68	9.62	8.00	9.18	8.41	3.88
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 13 SBP
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	108.0	126.0	111.0	118.0	116.0	117.3	121.0	115.0	124.0	119.0	125.0	119.0	118.9	123.0	126.6	127.2	120.7	114.5	116.0
184	99.0	103.0	105.0	103.0	115.0	110.2	111.0	102.0	114.0	104.0	107.0	106.0	115.0	108.2	108.3	121.4	119.0	111.0	104.3
186	93.0	96.0	88.0	94.0	85.0	96.8	104.0	101.0	101.0	102.0	94.0	100.0	103.6	101.8	105.6	107.9	108.8	92.5	93.6
182	83.0	94.0	99.0	86.0	96.0	104.1	96.0	98.0	95.0	94.0	99.0	92.0	97.0	95.0	91.2	100.3	88.0	94.1	88.7
183	105.0	95.0	113.0	104.0	114.0	110.4	114.0	112.0	114.0	106.0	116.0	111.0	116.6	117.6	120.1	112.7	106.4	110.9	100.9
185	97.0	88.0	95.0	84.0	94.0	93.1	101.0	93.0	97.0	102.0	97.0	92.0	95.1	96.3	102.6	94.8	97.0	93.8	98.8
MEAN	97.5	100.3	100.3	98.2	103.3	105.3	107.8	103.5	107.5	104.5	106.3	103.3	107.7	107.0	109.1	110.7	106.6	102.8	100.4
S.D.	8.94	13.46	10.80	12.78	13.32	9.13	9.20	8.41	11.59	8.19	12.13	10.76	10.47	11.45	12.67	12.33	12.61	10.32	9.43
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 13 SBP
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	102.0	117.0	98.0	111.0	118.0	114.0	111.0	110.0	118.0	116.0	117.0	109.0	114.0	116.0	121.0	128.0	119.0	117.0	111.0
184	99.0	101.0	100.0	99.0	109.0	103.0	102.0	97.0	106.0	92.0	96.0	102.0	102.0	101.0	102.0	112.0	112.0	103.0	98.0
186	90.0	94.0	90.0	91.0	81.0	93.0	92.0	94.0	97.0	98.0	91.0	96.0	98.0	90.0	104.0	107.0	107.0	93.0	90.0
182	82.0	92.0	95.0	87.0	97.0	106.0	99.0	97.0	98.0	92.0	98.0	94.0	93.0	93.0	90.0	100.0	86.0	92.0	88.0
183	104.0	89.0	110.0	103.0	110.0	105.0	111.0	109.0	110.0	100.0	107.0	106.0	115.0	110.0	115.0	111.0	101.0	105.0	97.0
185	96.0	87.0	91.0	82.0	92.0	91.0	97.0	90.0	91.0	100.0	95.0	87.0	92.0	93.0	108.0	96.0	97.0	92.0	93.0
MEAN	95.5	96.7	97.3	95.5	101.2	102.0	102.0	99.5	102.7	99.7	100.7	99.0	102.3	100.5	106.7	108.3	103.7	100.3	96.2
S.D.	8.24	11.08	7.31	10.80	13.64	8.63	7.69	8.17	10.42	8.80	9.61	8.20	10.09	10.52	10.80	9.89	11.66	9.99	8.23
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 13 SBP
=40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	97.0	106.0	100.0	105.0	115.0	113.0	113.0	111.0	118.0	112.0	116.0	112.0	111.0	118.0	118.0	124.0	124.0	111.0	112.0
184	95.0	103.0	94.0	97.0	108.0	104.0	100.0	93.0	98.0	90.0	102.0	97.0	-99.0	99.0	97.0	110.0	118.0	102.0	98.0
186	85.0	92.0	88.0	89.0	80.0	88.0	91.0	92.0	95.0	96.0	87.0	93.0	96.0	92.0	105.0	105.0	104.0	92.0	89.0
182	79.0	94.0	92.0	91.0	100.0	106.0	98.0	100.0	90.0	94.0	98.0	94.0	87.0	94.0	91.0	98.0	88.0	92.0	88.0
183	104.0	95.0	109.0	101.0	105.0	104.0	105.0	103.0	104.0	102.0	108.0	106.0	111.0	108.0	114.0	109.0	101.0	96.0	101.0
185	94.0	85.0	89.0	80.0	92.0	88.0	96.0	87.0	91.0	97.0	92.0	86.0	89.0	90.0	100.0	92.0	96.0	90.0	91.0
MEAN	92.2	96.2	95.3	93.8	100.0	100.5	100.5	97.7	99.3	98.5	100.5	98.0	98.8	100.2	104.2	106.3	105.2	97.5	96.5
S.D.	9.24	8.18	7.94	9.04	12.47	10.23	7.66	8.71	10.46	7.69	10.58	9.44	11.63	10.85	10.30	11.04	13.54	7.99	9.18
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 13 SBP
=50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
						SPECIAL									SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	87.0	106.0	89.0	106.0	123.0	110.9	121.0	111.0	114.0	115.0	111.0	110.0	107.3	116.2	114.8	119.3	115.6	114.1	107.4
184	93.0	104.0	87.0	96.0	107.0	95.3	94.0	93.0	96.0	83.0	95.0	95.0	-99.0	88.3	101.2	106.6	88.5	95.7	94.3
186	83.0	96.0	87.0	89.0	85.0	84.0	86.0	84.0	89.0	93.0	85.0	92.0	98.4	90.1	103.5	104.1	93.0	93.5	87.0
182	70.0	99.0	87.0	93.0	95.0	103.2	100.0	95.0	89.0	93.0	92.0	97.0	88.8	91.7	95.5	95.0	86.5	89.8	85.0
183	99.0	91.0	106.0	96.0	99.0	98.9	88.0	90.0	95.0	102.0	102.0	104.0	103.6	102.5	111.1	110.4	96.3	97.9	93.0
185	93.0	84.0	86.0	77.0	87.0	83.0	90.0	85.0	89.0	98.0	89.0	88.0	88.6	87.0	93.3	90.2	91.5	89.7	88.6
MEAN	87.5	97.0	90.3	92.8	99.3	95.9	96.5	93.0	95.3	97.3	95.8	97.7	97.3	96.0	103.2	104.3	95.2	96.8	92.6
S.D.	10.19	8.72	7.74	9.58	14.11	10.92	12.99	9.82	9.69	10.75	9.24	8.07	8.50	11.35	8.47	10.52	10.55	9.08	8.09
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 13 SBP
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	102.0	113.0	113.0	115.0	133.0	125.0	132.0	118.0	128.0	127.0	132.0	128.0	122.0	133.0	124.0	129.0	124.0	118.0	117.0
184	100.0	107.0	100.0	105.0	117.0	119.0	112.0	103.0	113.0	108.0	99.0	106.0	117.0	114.0	119.0	118.0	132.0	110.0	111.0
186	96.0	116.0	96.0	97.0	86.0	100.0	103.0	102.0	114.0	102.0	103.0	104.0	114.0	104.0	118.0	111.0	109.0	97.0	92.0
182	-99.0	96.0	86.0	82.0	95.0	100.0	100.0	97.0	94.0	95.0	98.0	99.0	100.0	103.0	94.0	96.0	93.0	95.0	87.0
183	107.0	97.0	115.0	105.0	108.0	109.0	110.0	106.0	111.0	106.0	115.0	110.0	118.0	115.0	120.0	113.0	113.0	108.0	104.0
185	103.0	89.0	96.0	86.0	92.0	101.0	101.0	101.0	105.0	100.0	103.0	92.0	99.0	103.0	104.0	99.0	98.0	92.0	97.0
MEAN	101.6	103.0	101.0	98.3	105.2	109.0	109.7	104.5	110.8	106.3	108.3	106.5	111.7	112.0	113.2	111.0	111.5	103.3	101.3
S.D.	4.04	10.64	11.10	12.55	17.70	10.79	11.98	7.23	11.20	11.11	13.08	12.23	9.77	11.66	11.60	12.21	14.90	10.19	11.47
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 14 DBP
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	49.0	66.0	63.0	65.0	64.0	66.1	71.0	58.0	74.0	67.0	73.0	67.0	66.1	73.5	75.6	68.5	69.4	69.4	70.4
184	41.0	53.0	52.0	54.0	49.0	54.1	63.0	62.0	60.0	57.0	64.0	59.0	59.4	58.3	62.6	53.9	55.6	60.7	62.6
186	48.0	61.0	62.0	62.0	56.0	60.2	58.0	59.0	54.0	57.0	58.0	57.0	60.9	61.8	60.6	59.0	52.7	63.4	64.4
182	55.0	57.0	53.0	49.0	56.0	53.4	59.0	58.0	59.0	58.0	57.0	60.0	51.1	52.4	57.3	61.5	64.7	64.4	54.6
183	72.0	64.0	75.0	74.0	68.0	74.4	73.0	66.0	72.0	72.0	73.0	80.0	77.1	79.0	78.3	80.9	67.6	78.6	65.6
185	41.0	52.0	56.0	46.0	51.0	47.1	58.0	54.0	50.0	48.0	49.0	52.0	54.6	53.7	60.3	60.4	56.4	56.2	55.8
MEAN	51.0	58.8	60.2	58.3	57.3	59.2	63.7	59.5	61.5	59.8	62.3	62.5	61.5	63.1	65.8	64.0	61.1	65.5	62.2
S.D.	11.58	5.78	8.57	10.60	7.37	9.86	6.74	4.09	9.63	8.47	9.54	9.85	9.22	10.85	6.65	9.51	7.03	7.77	6.04
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 14 DBP
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	46.0	66.0	68.0	65.0	65.0	67.0	71.0	65.0	77.0	70.0	74.0	71.0	68.0	72.0	76.0	71.0	68.0	72.0	73.0
184	42.0	55.0	53.0	54.0	47.0	52.0	60.0	62.0	56.0	58.0	62.0	62.0	56.0	60.0	61.0	55.0	53.0	61.0	63.0
186	45.0	56.0	57.0	56.0	55.0	61.0	57.0	59.0	55.0	58.0	58.0	58.0	60.0	64.0	61.0	63.0	60.0	64.0	62.0
182	53.0	58.0	52.0	53.0	56.0	57.0	56.0	58.0	60.0	60.0	55.0	63.0	57.0	57.0	61.0	60.0	68.0	67.0	60.0
183	75.0	67.0	75.0	78.0	68.0	77.0	76.0	70.0	75.0	73.0	76.0	79.0	80.0	82.0	82.0	84.0	66.0	72.0	77.0
185	54.0	50.0	56.0	48.0	52.0	50.0	59.0	54.0	53.0	48.0	51.0	51.0	54.0	56.0	66.0	62.0	59.0	57.0	54.0
MEAN	52.5	58.7	60.2	59.0	57.2	60.7	63.2	61.3	62.7	61.2	62.7	64.0	62.5	65.2	67.8	65.8	62.3	65.5	64.8
S.D.	11.98	6.62	9.24	10.84	7.94	10.09	8.28	5.65	10.60	9.09	10.23	9.84	9.87	10.09	9.06	10.30	6.02	6.02	8.57
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 14 DBP
-40 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	45.0	65.0	69.0	66.0	64.0	69.0	75.0	63.0	78.0	69.0	77.0	70.0	69.0	71.0	75.0	72.0	72.0	77.0	72.0
184	38.0	58.0	57.0	54.0	48.0	54.0	61.0	63.0	57.0	56.0	60.0	62.0	-99.0	60.0	62.0	58.0	55.0	61.0	62.0
186	43.0	59.0	54.0	63.0	56.0	64.0	57.0	63.0	52.0	60.0	59.0	57.0	60.0	65.0	62.0	62.0	57.0	66.0	65.0
182	53.0	59.0	54.0	48.0	57.0	61.0	58.0	61.0	63.0	66.0	60.0	62.0	61.0	57.0	63.0	62.0	64.0	66.0	60.0
183	74.0	68.0	79.0	70.0	70.0	77.0	75.0	71.0	79.0	74.0	77.0	79.0	80.0	84.0	85.0	86.0	78.0	74.0	77.0
185	55.0	49.0	56.0	50.0	52.0	51.0	60.0	58.0	53.0	50.0	48.0	57.0	56.0	57.0	63.0	63.0	62.0	57.0	60.0
MEAN	51.3	59.7	61.5	58.5	57.8	62.7	64.3	63.2	63.7	62.5	63.5	64.5	65.2	65.7	68.3	67.2	64.7	66.8	66.0
S.D.	12.79	6.56	10.25	9.07	8.01	9.61	8.38	4.31	12.13	8.85	11.40	8.55	9.52	10.46	9.58	10.32	8.85	7.57	7.01
N	6	6	6	5	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 14 DBP
-50 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	47.0	69.0	66.0	69.0	66.0	74.4	82.0	66.0	72.0	70.0	78.0	69.0	71.0	72.5	75.9	74.4	71.2	77.0	74.0
184	39.0	58.0	48.0	52.0	44.0	44.5	60.0	61.0	59.0	58.0	60.0	59.0	-99.0	56.4	56.7	56.5	58.0	60.7	62.4
186	44.0	57.0	59.0	60.0	57.0	62.1	58.0	55.0	51.0	60.0	60.0	59.0	60.9	64.2	63.3	62.8	61.2	65.1	62.5
182	47.0	59.0	53.0	55.0	59.0	63.4	60.0	62.0	65.0	66.0	65.0	63.0	59.0	55.9	67.1	64.1	70.3	66.9	60.6
183	75.0	70.0	80.0	66.0	75.0	76.6	68.0	64.0	72.0	74.0	79.0	82.0	84.2	89.5	83.3	88.5	73.0	75.1	76.0
185	56.0	49.0	55.0	50.0	51.0	50.2	57.0	59.0	52.0	53.0	50.0	58.0	56.6	54.2	62.7	63.6	60.7	56.1	60.4
MEAN	51.3	60.3	60.2	58.7	58.7	61.9	64.2	61.2	61.8	63.5	65.3	65.0	66.3	65.4	68.2	68.3	65.7	66.8	66.0
S.D.	12.85	7.94	11.44	7.69	10.93	12.76	9.56	3.87	9.37	7.89	11.31	9.27	11.39	13.63	9.75	11.44	6.47	8.09	7.07
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 14 DBP
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	42.0	64.0	68.0	63.0	63.0	73.0	79.0	64.0	79.0	68.0	78.0	76.0	71.0	82.0	81.0	71.0	71.0	75.0	71.0
184	41.0	58.0	44.0	53.0	45.0	58.0	60.0	59.0	60.0	60.0	59.0	60.0	61.0	65.0	66.0	59.0	56.0	63.0	65.0
186	53.0	64.0	62.0	59.0	58.0	67.0	63.0	67.0	71.0	59.0	61.0	62.0	64.0	68.0	67.0	65.0	60.0	69.0	60.0
182	-99.0	61.0	50.0	53.0	57.0	57.0	58.0	59.0	61.0	56.0	58.0	57.0	61.0	58.0	66.0	64.0	64.0	62.0	57.0
183	73.0	71.0	78.0	67.0	71.0	79.0	78.0	67.0	78.0	75.0	78.0	78.0	83.0	83.0	86.0	82.0	74.0	73.0	73.0
185	59.0	51.0	59.0	49.0	52.0	56.0	62.0	61.0	59.0	49.0	54.0	51.0	59.0	59.0	65.0	62.0	58.0	55.0	57.0
MEAN	53.6	61.5	60.2	57.3	57.7	65.0	66.7	62.8	68.0	61.2	64.7	64.0	66.5	69.2	71.8	67.2	63.8	66.2	64.5
S.D.	13.22	6.72	12.24	6.86	8.94	9.57	9.33	3.71	9.21	9.15	10.58	10.75	9.12	10.98	9.20	8.28	7.28	7.55	6.75
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 15 MBP
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	69.0	86.0	79.0	83.0	81.0	83.0	88.0	77.0	91.0	84.0	90.0	84.0	84.0	90.0	93.0	88.0	86.0	84.0	85.0
184	60.0	70.0	70.0	70.0	71.0	73.0	79.0	75.0	78.0	73.0	78.0	75.0	78.0	75.0	78.0	76.0	77.0	78.0	77.0
186	63.0	72.0	71.0	73.0	66.0	72.0	73.0	73.0	70.0	72.0	70.0	71.0	73.0	75.0	76.0	75.0	72.0	73.0	74.0
182	64.0	69.0	65.0	61.0	70.0	70.0	71.0	71.0	71.0	70.0	71.0	71.0	66.0	66.0	68.0	75.0	73.0	74.0	66.0
183	83.0	74.0	88.0	84.0	83.0	86.0	87.0	81.0	86.0	83.0	87.0	90.0	90.0	92.0	92.0	92.0	81.0	90.0	78.0
185	75.0	64.0	69.0	59.0	65.0	62.0	72.0	67.0	66.0	66.0	65.0	65.0	68.0	68.0	74.0	72.0	70.0	69.0	70.0
MEAN	69.0	72.5	73.7	71.7	72.7	74.3	78.3	74.0	77.0	74.7	76.8	76.0	76.5	77.7	80.2	79.7	76.5	78.0	75.0
S.D.	8.65	7.92	8.38	10.58	7.61	8.82	7.63	9.86	9.88	7.26	9.99	9.30	9.33	10.97	10.13	8.21	6.09	7.77	6.63
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 15 MBP
-30 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	65.0	83.0	78.0	80.0	83.0	83.0	84.0	80.0	91.0	85.0	88.0	84.0	83.0	87.0	91.0	89.0	85.0	87.0	86.0
184	61.0	70.0	69.0	69.0	68.0	69.0	74.0	74.0	73.0	69.0	73.0	75.0	71.0	74.0	75.0	74.0	73.0	75.0	75.0
186	69.0	69.0	68.0	68.0	64.0	72.0	69.0	71.0	69.0	71.0	69.0	71.0	73.0	73.0	75.0	78.0	76.0	74.0	71.0
182	63.0	69.0	67.0	64.0	70.0	73.0	70.0	70.0	71.0	71.0	69.0	73.0	69.0	69.0	71.0	73.0	74.0	75.0	69.0
183	85.0	74.0	87.0	86.0	82.0	86.0	88.0	83.0	07.0	82.0	86.0	88.0	92.0	91.0	93.0	93.0	78.0	83.0	84.0
185	68.0	62.0	68.0	59.0	65.0	64.0	72.0	66.0	66.0	65.0	66.0	63.0	67.0	68.0	80.0	73.0	72.0	69.0	67.0
MEAN	67.0	71.2	72.8	71.0	72.0	74.5	76.2	74.0	76.2	73.8	75.2	75.7	75.8	77.0	80.8	80.0	76.3	77.2	75.3
S.D.	9.27	6.97	8.04	10.12	8.41	8.41	7.91	6.42	10.28	7.86	9.45	9.07	9.68	9.65	9.13	8.81	4.76	6.59	7.97
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 15 MBP
=40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	62.0	79.0	79.0	79.0	81.0	84.0	88.0	79.0	91.0	83.0	90.0	84.0	83.0	87.0	89.0	89.0	89.0	88.0	85.0
184	57.0	73.0	69.0	54.0	68.0	71.0	74.0	73.0	71.0	67.0	74.0	74.0	-99.0	73.0	74.0	75.0	76.0	75.0	74.0
186	57.0	70.0	65.0	72.0	64.0	72.0	68.0	73.0	66.0	72.0	69.0	69.0	72.0	74.0	76.0	76.0	73.0	75.0	73.0
182	61.0	71.0	67.0	62.0	71.0	76.0	71.0	74.0	72.0	75.0	73.0	73.0	70.0	69.0	72.0	74.0	72.0	75.0	69.0
183	84.0	72.0	89.0	80.0	82.0	86.0	85.0	82.0	87.0	83.0	87.0	88.0	90.0	92.0	95.0	94.0	86.0	82.0	85.0
185	68.0	61.0	67.0	60.0	65.0	63.0	72.0	66.0	66.0	66.0	63.0	67.0	67.0	68.0	75.0	73.0	73.0	68.0	70.0
MEAN	64.8	71.0	72.7	67.8	71.8	75.3	76.3	74.8	75.5	74.3	76.0	75.8	76.4	77.2	80.2	80.2	78.2	77.2	76.0
S.D.	10.23	5.83	9.42	10.74	7.88	8.62	8.16	4.96	10.82	7.47	10.47	8.38	9.71	9.95	9.45	8.98	7.41	6.91	7.21
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 15 MBP
=50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	60.0	82.0	74.0	81.0	85.0	86.0	95.0	81.0	86.0	85.0	89.0	83.0	83.0	87.0	89.0	89.0	86.0	89.0	85.0
184	57.0	73.0	61.0	67.0	65.0	62.0	71.0	72.0	71.0	64.0	72.0	71.0	-99.0	67.0	72.0	74.0	68.0	73.0	73.0
186	57.0	70.0	68.0	70.0	66.0	69.0	67.0	65.0	64.0	71.0	69.0	70.0	73.0	73.0	77.0	77.0	73.0	75.0	71.0
182	55.0	76.0	64.0	68.0	71.0	77.0	73.0	73.0	73.0	75.0	74.0	74.0	69.0	68.0	77.0	74.0	76.0	75.0	69.0
183	83.0	77.0	89.0	76.0	83.0	84.0	75.0	73.0	80.0	83.0	87.0	89.0	91.0	101.0	92.0	96.0	81.0	83.0	82.0
185	68.0	61.0	65.0	59.0	63.0	61.0	68.0	68.0	64.0	68.0	63.0	67.0	68.0	65.0	73.0	73.0	71.0	67.0	70.0
MEAN	63.3	73.2	70.2	70.2	72.2	73.2	74.8	72.0	73.0	74.3	75.7	75.7	76.8	76.8	80.0	80.5	75.8	77.0	75.0
S.D.	10.67	7.19	10.23	7.63	9.56	10.83	10.32	5.44	8.76	8.33	10.27	8.52	9.91	14.26	8.44	9.65	6.68	7.80	6.78
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 15 MBP
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
									SPECIAL						SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	62.0	77.0	83.0	80.0	86.0	90.0	97.0	82.0	95.0	88.0	96.0	93.0	88.0	99.0	95.0	90.0	89.0	89.0	86.0
184	61.0	74.0	63.0	70.0	69.0	78.0	77.0	74.0	78.0	76.0	72.0	75.0	80.0	81.0	84.0	79.0	75.0	79.0	80.0
186	67.0	81.0	73.0	72.0	67.0	78.0	76.0	79.0	85.0	73.0	75.0	76.0	81.0	80.0	84.0	80.0	78.0	78.0	73.0
182	-99.0	73.0	67.0	63.0	70.0	71.0	72.0	72.0	72.0	69.0	71.0	71.0	74.0	73.0	75.0	75.0	74.0	73.0	67.0
183	84.0	80.0	91.0	80.0	83.0	89.0	89.0	80.0	89.0	85.0	90.0	89.0	95.0	94.0	97.0	92.0	87.0	85.0	81.0
185	74.0	64.0	71.0	61.0	65.0	71.0	75.0	74.0	74.0	66.0	70.0	65.0	72.0	74.0	78.0	74.0	71.0	67.0	70.0
MEAN	69.6	74.8	74.7	71.0	73.3	79.5	81.0	76.8	82.2	76.2	79.0	78.2	81.7	83.5	85.5	81.7	79.0	78.5	76.2
S.D.	9.56	6.18	10.46	8.10	8.87	8.36	9.78	4.02	9.02	8.75	11.14	10.74	8.64	10.67	8.87	7.61	7.35	7.94	7.31
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 16 PP
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	59.0	60.0	46.0	53.0	52.0	51.0	50.0	57.0	50.0	52.0	52.0	52.0	53.0	49.0	51.0	58.0	52.0	46.0	46.0
184	58.0	50.0	53.0	49.0	66.0	56.0	48.0	40.0	54.0	47.0	43.0	47.0	56.0	50.0	45.0	67.0	63.0	50.0	41.0
185	45.0	35.0	26.0	32.0	29.0	37.0	46.0	42.0	47.0	45.0	36.0	43.0	46.0	40.0	45.0	49.0	56.0	30.0	30.0
182	28.0	37.0	37.0	37.0	40.0	51.0	37.0	40.0	36.0	36.0	42.0	32.0	46.0	43.0	34.0	38.0	23.0	30.0	34.0
183	33.0	31.0	38.0	30.0	46.0	36.0	41.0	46.0	42.0	34.0	43.0	31.0	40.0	39.0	42.0	32.0	38.0	32.0	35.0
186	56.0	36.0	39.0	38.0	43.0	46.0	43.0	39.0	47.0	54.0	48.0	40.0	40.0	42.0	43.0	35.0	41.0	38.0	43.0
MEAN	46.5	41.5	40.2	39.8	46.0	46.2	44.2	44.0	46.0	44.7	44.0	40.8	46.8	43.8	43.3	46.5	45.5	37.7	38.2
S.D.	13.46	11.11	9.41	9.24	12.41	8.13	4.79	6.84	6.29	8.19	5.48	8.28	6.59	4.62	5.54	13.95	14.43	8.62	6.11
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 16 PP
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	56.0	51.0	30.0	46.0	53.0	47.0	40.0	45.0	41.0	46.0	43.0	38.0	46.0	44.0	45.0	53.0	51.0	45.0	38.0
184	57.0	46.0	47.0	45.0	62.0	51.0	42.0	35.0	50.0	34.0	34.0	40.0	46.0	41.0	41.0	57.0	59.0	42.0	35.0
185	45.0	38.0	33.0	35.0	26.0	32.0	35.0	35.0	42.0	40.0	33.0	38.0	39.0	26.0	43.0	44.0	47.0	29.0	28.0
182	29.0	34.0	43.0	34.0	41.0	48.0	43.0	37.0	34.0	32.0	43.0	31.0	36.0	36.0	29.0	40.0	18.0	25.0	28.0
183	29.0	22.0	35.0	25.0	42.0	28.0	35.0	39.0	35.0	27.0	31.0	27.0	35.0	28.0	33.0	27.0	35.0	33.0	20.0
186	42.0	37.0	35.0	34.0	40.0	41.0	38.0	36.0	38.0	52.0	44.0	36.0	38.0	37.0	42.0	34.0	38.0	35.0	39.0
MEAN	45.0	38.0	37.2	36.5	44.0	41.2	38.8	37.8	40.0	38.5	38.0	35.0	40.0	35.3	38.8	42.5	41.3	34.8	31.3
S.D.	12.35	10.06	6.46	7.87	12.31	9.33	3.43	3.82	5.83	9.33	5.93	4.98	4.86	7.09	6.34	11.33	14.38	7.60	7.31
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 16 PP
=40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	52.0	43.0	31.0	39.0	51.0	44.0	38.0	48.0	40.0	43.0	39.0	42.0	42.0	47.0	43.0	52.0	52.0	34.0	40.0
184	57.0	45.0	37.0	43.0	60.0	50.0	39.0	30.0	41.0	34.0	42.0	35.0	-99.0	39.0	35.0	52.0	63.0	41.0	36.0
186	42.0	33.0	34.0	26.0	24.0	24.0	34.0	29.0	43.0	36.0	29.0	36.0	36.0	27.0	43.0	43.0	47.0	26.0	24.0
182	25.0	35.0	38.0	43.0	43.0	45.0	40.0	39.0	27.0	28.0	38.0	32.0	26.0	37.0	28.0	36.0	24.0	26.0	28.0
183	29.0	27.0	39.0	31.0	35.0	27.0	30.0	32.0	25.0	28.0	31.0	27.0	31.0	24.0	29.0	23.0	23.0	24.0	24.0
185	39.0	36.0	33.0	30.0	40.0	37.0	36.0	29.0	38.0	47.0	44.0	29.0	33.0	33.0	37.0	29.0	34.0	33.0	31.0
MEAN	40.7	36.5	33.8	35.3	42.2	37.8	36.2	34.5	35.7	36.0	37.2	33.5	33.6	34.5	35.8	39.2	40.5	30.7	30.5
S.D.	12.50	6.63	3.19	7.28	12.51	10.46	3.71	7.61	7.69	7.77	5.98	5.39	5.94	8.38	6.52	11.99	16.13	6.50	6.50
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 16 PP
=50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	40.0	39.0	23.0	37.0	57.0	37.0	39.0	45.0	42.0	45.0	33.0	41.0	36.0	43.0	39.0	45.0	45.0	37.0	33.0
184	54.0	46.0	39.0	44.0	63.0	50.0	34.0	32.0	37.0	25.0	35.0	36.0	-99.0	32.0	44.0	50.0	31.0	35.0	32.0
186	39.0	39.0	28.0	29.0	28.0	22.0	28.0	29.0	38.0	33.0	26.0	33.0	37.0	26.0	41.0	41.0	36.0	29.0	24.0
182	25.0	34.0	34.0	35.0	36.0	40.0	40.0	33.0	24.0	27.0	27.0	34.0	30.0	36.0	29.0	38.0	17.0	23.0	24.0
183	24.0	21.0	26.0	30.0	24.0	22.0	20.0	26.0	23.0	28.0	23.0	22.0	20.0	13.0	28.0	21.0	23.0	23.0	17.0
185	37.0	35.0	31.0	27.0	36.0	33.0	33.0	26.0	37.0	45.0	39.0	30.0	32.0	33.0	30.0	26.0	31.0	34.0	29.0
MEAN	36.5	35.7	30.2	34.2	40.7	34.0	32.3	31.8	33.5	33.8	30.5	32.7	31.0	30.5	35.2	36.8	30.5	30.2	26.5
S.D.	11.08	8.33	5.78	6.55	15.79	10.86	7.45	7.08	7.97	9.04	6.12	6.38	6.78	10.21	6.97	11.20	9.79	6.15	6.02
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 16 PP
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	60.0	49.0	45.0	52.0	70.0	52.0	53.0	54.0	49.0	59.0	54.0	52.0	51.0	51.0	43.0	58.0	53.0	43.0	46.0
184	59.0	49.0	56.0	52.0	72.0	61.0	52.0	44.0	53.0	48.0	40.0	46.0	56.0	49.0	53.0	59.0	56.0	47.0	46.0
186	43.0	52.0	34.0	38.0	28.0	33.0	40.0	35.0	43.0	43.0	42.0	42.0	50.0	36.0	51.0	46.0	49.0	26.0	28.0
182	-99.0	35.0	50.0	29.0	38.0	43.0	42.0	38.0	33.0	39.0	40.0	42.0	39.0	45.0	28.0	32.0	29.0	33.0	30.0
183	34.0	26.0	38.0	38.0	37.0	30.0	32.0	33.0	33.0	31.0	37.0	32.0	35.0	32.0	34.0	31.0	39.0	35.0	31.0
185	44.0	38.0	37.0	37.0	40.0	45.0	39.0	40.0	46.0	51.0	49.0	41.0	40.0	44.0	39.0	37.0	40.0	37.0	40.0
MEAN	48.0	41.5	43.3	41.0	47.5	44.0	43.0	41.7	42.8	45.2	43.7	42.5	45.2	42.8	41.3	43.8	44.3	37.2	36.8
S.D.	11.20	10.17	8.52	9.17	18.67	11.59	8.10	6.71	8.30	9.77	6.47	6.57	8.28	7.41	9.69	12.54	10.15	6.88	6.21
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 17 XLV
CONTROL

SUBJ	PRE-BEDREST 1	2	3	4	5	IN BEDREST 6	7	8	9	10	11	12	13	14	POST-BEDREST - SPECIAL - 15	16	17	18	19
							SPECIAL												
181	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
184	0.00	0.10	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
186	0.10	0.80	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
183	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
185	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEAN	0.05	0.18	0.02	0.00	0.00	0.0	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.D.	0.083	0.313	0.041	0.000	0.000	0.000	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 17 XLV
-30 MM HG

SUBJ	PRE-BEDREST 1	2	3	4	5	IN BEDREST 6	7	8	9	10	11	12	13	14	POST-BEDREST - SPECIAL - 15	16	17	18	19
							SPECIAL												
181	1.30	1.00	0.20	1.00	0.50	1.40	1.20	0.80	0.90	1.30	0.80	1.00	0.90	1.70	0.70	0.60	0.50	0.30	0.20
184	1.20	2.00	1.40	1.40	1.20	1.20	1.00	1.20	1.10	2.40	1.10	1.70	1.30	0.50	1.30	1.20	1.10	1.20	1.60
186	1.60	0.20	1.20	1.00	1.20	0.50	1.90	0.90	1.00	0.50	0.20	0.20	0.40	0.30	0.30	0.40	0.50	0.50	0.70
182	1.70	1.00	0.50	1.40	1.10	1.70	1.40	1.60	1.00	1.40	0.60	1.00	1.20	1.40	1.10	1.30	1.50	1.20	0.90
183	1.30	1.50	1.00	1.20	0.50	2.30	1.30	1.20	1.40	1.40	1.60	1.10	2.10	1.10	0.60	0.90	0.60	0.50	1.20
185	1.00	0.60	0.80	0.70	0.80	0.60	0.60	0.60	1.00	0.90	1.10	1.10	0.40	0.60	0.80	0.60	0.90	0.50	0.80
MEAN	1.35	1.05	0.85	1.12	0.88	1.3	1.23	1.05	1.07	1.32	0.90	1.02	1.05	0.93	0.80	0.83	0.85	0.70	0.90
S.D.	0.259	0.638	0.446	0.271	0.331	0.679	0.432	0.356	0.175	0.637	0.482	0.479	0.641	0.554	0.358	0.361	0.399	0.395	0.473
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 17 XLV
-60 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	2.30	1.50	0.60	1.50	0.90	2.40	1.90	1.70	1.60	2.40	1.50	1.60	1.50	2.80	1.80	1.00	1.00	0.80	0.50
184	2.30	2.80	2.60	2.40	1.90	1.70	1.50	2.00	2.00	3.00	2.40	3.70	-99.00	0.00	1.70	2.00	1.50	1.60	3.20
186	2.20	1.20	1.80	1.70	1.80	1.30	2.40	1.50	2.00	0.90	0.90	0.20	0.80	0.60	0.70	0.80	0.90	0.90	1.30
182	2.60	1.80	1.10	2.10	1.80	2.60	2.50	2.80	1.70	2.60	2.40	1.90	2.10	0.70	1.90	2.00	2.20	2.00	1.70
183	1.80	2.50	1.50	2.00	0.40	2.90	2.40	2.10	2.30	2.80	2.50	1.60	3.30	0.00	1.20	1.50	1.20	1.10	1.50
185	1.60	1.00	1.30	1.10	1.40	1.20	1.10	1.10	1.60	1.40	1.90	1.80	1.00	0.60	1.00	1.00	1.60	1.10	1.10
MEAN	2.13	1.80	1.48	1.80	1.37	2.0	1.97	1.87	1.87	2.18	1.93	1.80	1.74	0.78	1.38	1.38	1.40	1.25	1.55
S.D.	0.357	0.718	0.679	0.465	0.602	0.714	0.572	0.582	0.280	0.840	0.635	1.119	1.006	1.036	0.488	0.531	0.477	0.459	0.907
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 17 XLV
-50 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	2.90	1.90	1.10	2.20	1.90	3.70	3.20	2.60	2.70	3.70	2.40	3.00	2.40	3.90	3.90	1.90	1.60	1.30	1.00
184	3.30	3.70	3.70	3.40	2.30	2.40	2.80	2.80	2.70	4.20	2.90	4.90	-99.00	1.90	2.30	3.00	2.10	2.50	3.20
186	3.30	1.60	2.50	2.30	2.10	2.10	3.40	3.30	2.90	1.70	2.70	1.90	1.60	1.20	1.40	1.40	1.50	1.60	2.00
182	3.00	3.40	1.60	3.00	2.60	3.60	3.70	3.50	2.90	3.90	3.50	3.30	2.90	2.70	2.60	2.90	3.30	3.20	2.60
183	2.40	3.50	2.20	2.70	2.70	5.20	2.70	2.70	3.20	4.00	3.50	2.40	3.30	3.00	2.20	2.20	1.80	1.90	2.50
185	2.70	1.40	1.90	1.80	2.10	1.70	1.70	1.50	2.30	2.10	2.60	2.80	1.50	1.40	1.70	1.60	2.30	1.70	1.70
MEAN	2.93	2.58	2.17	2.57	2.28	3.1	2.92	2.73	2.78	3.27	2.93	3.05	2.34	2.35	2.35	2.17	2.10	2.03	2.17
S.D.	0.350	1.057	0.894	0.582	0.313	1.301	0.703	0.700	0.299	1.078	0.468	1.029	0.789	1.037	0.873	0.665	0.660	0.698	0.771
N	5	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 17 XLV
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.10	0.20	-0.50	0.20	0.20	0.90	0.90	0.70	0.90	2.10	0.30	1.50	0.70	0.90	1.50	0.70	0.40	-0.20	0.10
184	0.20	0.90	-1.00	-1.00	0.00	-1.00	-1.00	0.10	0.50	1.10	-0.80	1.40	-0.20	0.50	-0.80	0.10	-0.40	0.00	0.10
186	1.20	0.40	-0.40	0.30	0.20	0.50	1.10	1.70	1.90	0.10	1.30	0.80	0.60	0.00	0.50	0.30	0.30	0.30	0.20
182	0.70	0.90	0.00	0.40	0.40	1.20	1.50	1.30	0.30	0.60	0.80	2.30	1.10	0.60	0.70	0.90	1.10	0.90	0.80
183	0.00	-0.20	0.10	0.00	-1.00	-0.30	0.30	0.20	0.50	0.70	-0.20	0.30	0.50	0.80	0.20	0.30	0.30	0.10	-0.70
185	0.70	-0.20	0.30	0.30	0.10	0.30	0.40	0.50	0.60	0.40	1.00	0.90	0.40	0.30	0.00	0.10	0.30	0.40	0.40
MEAN	0.49	0.33	-0.25	0.03	-0.02	0.3	0.53	0.75	0.78	0.83	0.40	1.20	0.52	0.52	0.35	0.40	0.33	0.25	0.15
S.D.	0.462	0.497	0.476	0.524	0.500	0.807	0.873	0.632	0.581	0.703	0.792	0.693	0.426	0.331	0.766	0.329	0.476	0.383	0.493
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 18 ATMP
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	74.0	73.8	73.8	73.8	72.2	71.0	72.5	76.6	73.3	76.8	75.5	78.0	73.2	73.9	72.5	73.8	73.9	72.0	74.2
184	75.1	75.0	74.8	74.2	73.9	72.8	75.0	78.5	75.2	77.8	77.6	79.2	74.2	75.5	73.2	74.2	74.2	71.9	75.0
186	75.2	75.2	75.0	74.2	74.3	73.0	76.3	77.8	76.8	79.0	78.8	79.9	74.5	76.8	74.0	74.3	75.0	72.5	75.8
182	74.0	73.0	72.2	74.5	72.5	73.5	73.0	76.0	73.2	76.0	73.3	76.5	72.3	71.5	73.3	76.3	74.5	74.2	74.1
183	75.2	74.0	73.3	75.3	74.0	75.2	75.1	77.1	75.2	77.0	75.2	77.1	73.8	72.1	74.2	77.5	74.9	74.9	75.0
185	75.2	74.5	72.8	75.8	75.1	76.1	76.1	77.9	76.9	77.8	76.5	77.8	75.0	72.8	74.9	78.7	75.1	74.2	74.8
MEAN	74.8	74.2	73.7	74.6	73.7	73.6	74.7	77.7	75.1	77.4	76.1	78.1	73.8	73.8	73.7	75.8	74.6	73.3	74.8
S.D.	0.61	0.82	1.10	0.76	1.10	1.82	1.58	1.01	1.61	1.03	1.93	1.27	0.97	2.05	0.86	2.02	0.48	1.30	0.62
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 18 ATMP
-30 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	74.1	74.1	74.0	73.9	73.0	71.1	72.6	78.8	73.4	76.9	75.6	78.1	73.3	73.9	72.5	73.9	74.0	72.1	74.3
184	75.1	75.0	75.0	74.3	74.0	73.1	75.2	78.2	75.3	77.8	77.6	79.2	74.3	75.5	73.2	74.2	74.5	71.9	75.1
186	75.2	75.3	75.0	74.5	74.6	73.2	76.4	77.8	76.8	79.0	78.9	79.9	74.6	76.8	74.3	74.3	75.0	72.6	75.8
182	74.1	73.0	72.5	74.9	72.7	73.5	73.0	76.1	73.2	76.0	73.4	76.6	72.3	71.5	73.3	76.3	74.5	74.3	74.1
183	75.2	74.0	73.5	75.5	74.1	75.2	75.3	77.2	75.3	77.2	75.3	77.3	73.9	72.1	74.3	77.5	75.0	74.9	75.1
185	75.3	74.3	72.8	75.9	75.2	76.1	76.2	78.0	76.9	77.9	76.7	77.8	75.0	72.8	74.9	78.7	75.3	74.2	74.8
MEAN	74.8	74.3	73.8	74.8	73.9	73.7	74.8	77.7	75.1	77.5	76.2	78.2	73.9	73.8	73.7	75.8	74.7	73.3	74.9
S.D.	0.57	0.61	1.07	0.76	0.95	1.75	1.61	0.93	1.59	1.02	1.92	1.22	0.98	2.05	0.89	2.00	0.47	1.29	0.61
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 18 ATMP
-40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	74.2	74.0	74.1	73.8	73.5	71.3	72.8	78.7	73.4	77.0	75.8	78.2	73.5	73.9	72.6	74.0	74.1	72.1	74.4
184	75.1	75.0	75.0	74.5	74.2	73.0	75.3	78.2	75.5	77.8	77.7	79.2	-99.0	75.5	73.2	74.2	74.6	72.0	75.1
186	75.2	75.3	75.0	74.5	74.8	73.3	76.6	77.9	76.7	79.1	78.9	79.9	74.8	76.9	74.3	74.4	75.0	72.6	75.9
182	74.1	73.0	72.8	75.0	73.0	73.7	73.0	76.3	73.3	76.1	73.4	76.7	72.3	71.7	73.2	76.4	74.8	74.5	74.1
183	75.1	74.0	73.5	75.7	74.5	75.5	75.3	77.3	75.5	77.3	75.5	77.2	73.9	72.2	74.3	77.5	75.0	75.0	75.1
185	75.3	74.5	72.8	76.1	75.2	76.2	76.3	78.0	76.9	77.9	76.8	77.8	75.1	75.0	75.0	78.7	75.3	74.5	75.0
MEAN	74.8	74.3	73.9	74.9	74.2	73.8	74.9	77.7	75.2	77.5	76.4	78.2	73.9	74.2	73.8	75.9	74.8	73.4	74.9
S.D.	0.53	0.82	1.00	0.85	0.82	1.78	1.62	0.83	1.56	1.01	1.91	1.21	1.11	2.00	0.90	1.97	0.41	1.36	0.63
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 18 ATMP
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	74.3	74.1	74.2	73.8	73.5	71.4	73.0	78.8	73.4	77.0	75.8	78.3	73.5	73.9	72.6	74.1	74.1	72.1	74.5
184	75.1	75.0	75.0	74.5	74.2	73.2	75.4	78.3	75.5	77.8	77.8	79.2	-99.0	75.5	73.2	74.3	74.6	72.1	75.1
186	75.2	75.5	74.8	74.5	74.8	73.5	76.7	77.9	76.7	79.1	79.0	79.8	75.0	77.0	74.3	74.5	74.8	72.6	76.0
182	74.1	73.0	72.8	75.0	73.0	73.7	73.1	76.3	73.3	76.1	73.4	76.6	72.3	71.1	73.2	76.5	74.8	74.5	74.2
183	75.2	74.0	73.5	75.8	74.7	75.5	75.3	77.2	75.5	77.4	75.6	77.2	73.9	72.3	74.3	77.5	75.0	75.0	75.1
185	75.3	74.4	72.5	76.1	75.0	76.1	76.3	77.9	76.9	77.9	78.8	77.8	75.1	72.8	75.0	78.7	75.5	74.5	75.0
MEAN	74.9	74.3	73.8	75.0	74.2	73.9	75.0	77.7	75.2	77.5	76.7	78.2	74.0	73.8	73.8	75.9	74.8	73.5	75.0
S.D.	0.53	0.87	1.04	0.87	0.80	1.69	1.56	0.88	1.56	1.01	2.18	1.20	1.16	2.18	0.90	1.93	0.46	1.34	0.61
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 18 ATMP

RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	74.5	74.1	74.2	73.8	73.7	71.6	73.4	78.8	73.4	77.1	75.9	78.4	73.5	73.9	72.6	74.1	74.1	72.1	74.5
184	75.1	75.0	75.0	74.5	74.2	73.2	75.4	78.3	75.6	77.8	77.9	79.2	74.3	75.5	73.2	74.2	74.6	72.1	75.1
186	75.2	75.4	74.7	74.5	74.7	73.5	76.9	77.9	76.7	79.2	79.1	79.8	75.0	77.0	74.3	74.5	74.7	72.6	76.0
182	-99.0	73.0	72.8	75.0	73.1	73.8	73.3	76.3	73.5	76.1	73.5	76.6	72.3	71.7	73.2	76.5	74.8	74.5	74.2
183	75.2	74.0	73.5	75.9	74.6	75.6	75.3	77.3	76.0	77.5	75.8	77.2	73.9	72.3	74.3	77.7	75.0	75.0	75.1
185	75.3	74.5	72.6	76.1	75.1	76.1	76.4	77.9	76.9	77.9	77.0	77.8	75.2	72.8	75.0	78.7	75.5	74.5	75.0
MEAN	75.1	74.3	73.8	75.0	74.2	74.0	75.1	77.7	75.3	77.6	76.5	78.2	74.0	73.9	73.8	75.9	74.8	73.5	75.0
S.D.	0.32	0.84	0.99	0.89	0.73	1.65	1.50	0.87	1.55	1.02	1.94	1.21	1.07	2.04	0.90	1.98	0.47	1.34	0.61
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 19 CTMP
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	75.1	75.5	75.0	75.6	72.2	71.5	74.0	79.0	74.6	78.5	76.5	79.2	74.0	74.9	75.2	75.8	74.8	74.5	76.0
184	75.3	77.0	76.5	76.8	76.0	75.0	77.1	80.2	77.0	79.8	79.1	80.7	75.8	77.4	75.1	76.5	76.0	74.8	77.0
186	75.5	77.5	77.0	76.9	76.8	75.2	79.0	80.5	78.8	81.0	80.5	81.7	76.4	78.9	76.1	77.1	76.8	75.1	77.8
182	75.2	74.0	74.0	76.3	74.2	74.2	74.5	75.7	74.2	77.2	75.0	74.4	73.8	73.1	75.0	78.0	75.1	75.5	75.8
183	77.9	76.0	75.5	78.6	76.8	77.4	77.3	79.8	77.1	79.8	77.8	79.2	76.3	75.0	76.1	78.8	77.0	77.1	77.1
185	77.9	76.2	76.0	79.0	77.1	77.8	78.6	80.2	78.9	80.0	78.8	79.8	76.5	75.0	76.8	79.9	77.0	76.9	77.0
MEAN	76.1	76.0	75.7	77.2	75.5	75.2	76.8	79.2	76.8	79.4	78.0	79.2	75.5	75.7	75.7	77.7	76.1	75.6	76.8
S.D.	1.36	1.23	1.08	1.33	1.94	2.29	2.07	1.81	2.01	1.33	1.97	2.53	1.24	2.07	0.72	1.52	0.98	1.00	0.75
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 19 CTMP
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	75.2	75.7	75.1	76.0	75.6	72.0	74.1	79.2	74.6	78.5	76.5	79.3	74.1	75.0	75.2	75.8	75.0	74.5	76.2
184	75.4	77.1	76.6	76.9	76.2	75.2	77.3	80.1	77.2	79.8	79.2	80.8	76.0	77.4	75.1	76.5	76.2	74.8	77.2
186	75.6	77.9	77.0	77.0	76.9	75.1	79.0	80.5	78.8	81.0	80.5	81.8	76.6	78.9	76.1	77.1	76.8	75.1	77.8
182	75.4	74.7	74.1	76.8	74.3	74.8	74.5	75.7	74.2	77.3	75.0	77.5	73.8	73.1	75.0	78.0	75.1	75.5	75.9
183	78.0	76.0	76.0	78.8	76.9	77.8	77.3	79.9	77.3	80.0	77.9	79.4	76.3	75.0	76.3	78.8	77.2	77.1	77.2
185	77.8	76.5	76.2	79.0	77.2	77.8	78.3	80.3	79.0	80.1	78.9	79.8	76.5	75.0	76.9	79.9	77.0	76.8	77.0
MEAN	76.2	76.3	75.8	77.4	76.2	75.5	76.7	79.3	76.9	79.5	78.0	79.8	75.6	75.7	75.8	77.7	76.2	75.6	76.9
S.D.	1.30	1.12	1.06	1.20	1.09	2.17	2.01	1.81	2.08	1.32	1.99	1.86	1.26	2.07	0.78	1.52	0.96	1.00	0.71
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 19 CTMP
-40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	75.1	75.8	75.5	76.0	75.8	72.8	74.3	79.1	74.6	78.6	77.0	79.4	74.2	75.0	75.2	76.0	75.5	74.6	76.5
184	75.4	77.1	76.6	76.9	76.4	75.3	77.5	80.3	77.2	80.0	79.2	80.8	76.0	77.4	75.1	76.5	76.5	74.9	72.5
186	75.6	77.9	77.0	77.0	77.0	75.4	79.4	80.7	78.8	81.2	80.6	81.9	76.6	78.9	76.2	77.1	77.1	75.1	78.1
182	75.8	75.0	74.5	77.1	74.9	75.2	74.5	75.7	74.3	77.4	75.0	77.6	73.9	73.1	75.1	78.1	75.5	75.7	76.0
183	78.0	76.1	76.0	79.0	77.1	77.9	77.5	79.9	77.6	79.9	78.0	79.3	76.3	75.2	76.5	79.0	77.5	77.1	77.2
185	77.9	76.5	75.9	79.0	77.2	78.0	78.5	80.3	79.0	80.2	78.9	80.0	76.6	75.0	76.9	79.9	77.0	76.6	77.2
MEAN	76.3	76.4	75.9	77.5	76.4	75.8	76.9	79.3	76.9	79.5	78.1	79.8	75.6	75.8	75.8	77.8	76.5	75.7	76.2
S.D.	1.30	1.01	0.88	1.23	0.90	1.95	2.10	1.86	2.03	1.34	1.95	1.46	1.22	2.05	0.80	1.51	0.85	0.99	1.97
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 19 CTMP
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	75.2	76.0	75.8	76.0	75.8	73.1	74.6	79.2	74.5	78.6	77.1	79.5	74.2	75.0	75.2	76.0	75.7	74.7	76.5
184	75.4	77.1	76.7	76.9	76.4	75.5	77.6	80.3	77.3	80.0	79.4	80.8	-99.0	77.5	75.1	76.5	76.5	74.9	72.7
186	75.7	77.9	77.0	77.0	77.0	75.6	79.6	80.8	78.8	81.2	80.7	81.9	76.8	78.9	76.2	77.1	77.1	75.1	78.1
182	76.0	75.0	74.7	77.1	74.9	75.6	74.5	76.0	74.3	77.6	75.0	77.7	73.9	73.1	75.1	78.1	75.7	75.7	76.0
183	78.0	76.2	76.1	79.0	77.2	78.1	77.5	79.9	72.8	79.9	78.0	79.3	76.3	75.2	76.5	79.0	77.0	77.2	77.2
185	77.8	76.5	75.8	79.0	77.1	78.7	78.6	80.3	79.0	80.2	78.9	80.0	76.6	75.0	76.9	79.9	77.0	76.6	77.2
MEAN	76.4	76.4	76.0	77.5	76.4	76.1	77.1	79.4	76.1	79.6	78.2	79.9	75.6	75.8	75.8	77.8	76.5	75.7	76.3
S.D.	1.23	0.99	0.81	1.23	0.90	2.03	2.09	1.76	2.60	1.28	1.98	1.42	1.39	2.07	0.80	1.51	0.65	1.00	1.90
N	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6

VARIABLE NUMBER 19 CTMP
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	75.2	76.1	76.0	76.0	76.1	73.8	74.7	79.1	74.5	78.6	77.2	79.6	74.2	75.0	75.2	76.0	75.7	74.7	76.5
184	75.5	77.1	76.8	77.1	76.3	76.0	78.0	80.3	77.3	79.8	79.5	80.8	76.1	77.6	75.1	76.5	76.8	74.9	72.7
186	75.8	78.0	77.0	77.1	77.0	75.7	79.8	80.9	78.9	81.2	80.8	82.0	76.8	78.9	76.2	77.1	77.1	75.1	78.1
182	-99.0	75.0	75.0	77.2	75.0	75.6	74.5	76.0	74.4	77.7	75.1	77.8	73.9	73.1	75.1	78.1	76.1	75.7	76.0
183	78.1	76.7	76.0	79.1	77.3	78.2	77.6	80.0	77.8	79.9	78.3	79.3	76.4	75.2	76.5	79.0	77.5	77.2	77.4
185	77.8	76.5	75.7	79.1	77.1	79.1	78.6	80.3	79.1	80.3	78.9	80.0	76.7	75.1	76.9	79.9	77.0	76.6	77.2
MEAN	76.5	76.6	76.1	77.6	76.5	76.4	77.2	79.4	77.0	79.6	78.3	79.9	75.7	75.8	75.8	77.8	76.7	75.7	76.3
S.D.	1.36	1.01	0.73	1.24	0.86	1.93	2.15	1.78	2.08	1.25	1.97	1.42	1.29	2.08	0.80	1.51	0.67	1.00	1.92
N	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

VARIABLE NUMBER 20 ABFR
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	4.93	5.58	3.35	3.57	4.36	2.40	-99.00	-99.00	2.13	3.41	-99.00	-99.00	5.04	2.96	5.04	1.56	1.75	3.19	1.85
184	3.22	2.12	1.98	2.04	2.13	2.70	2.72	3.36	2.12	3.55	-99.00	-99.00	3.61	2.65	1.33	1.54	10.20	1.25	2.70
186	2.55	2.88	3.14	2.82	2.25	2.56	7.23	3.61	4.58	3.92	-99.00	-99.00	4.16	5.45	3.92	2.99	3.41	4.16	4.93
182	2.26	2.90	1.83	7.76	5.22	3.03	-99.00	-99.00	4.30	4.12	3.40	5.43	3.16	4.02	2.28	2.13	2.73	3.52	2.93
183	4.69	1.92	3.91	3.86	7.18	4.43	-99.00	-99.00	3.43	4.93	5.45	5.30	-99.00	3.60	3.95	3.03	3.74	3.11	2.96
185	3.28	2.99	3.69	3.41	2.21	2.67	-99.00	-99.00	3.23	2.72	4.06	2.52	2.64	1.85	3.25	1.12	2.12	2.38	3.77
MEAN	3.51	3.05	2.96	3.91	3.89	3.0	4.98	3.49	3.30	3.78	4.30	4.42	3.76	3.42	3.30	2.06	3.99	2.94	3.19
S.D.	1.051	1.329	0.878	1.994	2.070	0.747	3.189	0.177	1.041	0.744	1.046	1.644	0.870	1.248	1.323	0.802	3.133	1.009	1.051
N	6	6	6	6	6	6	2	2	6	6	3	3	5	6	6	6	6	6	6

VARIABLE NUMBER 20 ABFR
-30 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.00	3.76	2.52	1.77	3.20	0.53	-99.00	-99.00	2.43	1.80	-99.00	-99.00	2.01	1.68	2.38	1.14	0.93	2.63	2.53
184	-99.00	1.46	1.08	1.62	1.60	-99.00	0.78	0.68	1.75	2.30	-99.00	-99.00	2.45	-99.00	1.16	0.27	7.42	0.44	1.25
186	1.60	1.02	2.37	0.93	1.60	1.52	2.56	2.66	3.47	2.81	-99.00	-99.00	3.71	4.14	1.37	2.03	1.48	1.71	2.81
182	1.70	0.43	1.08	3.01	2.43	1.27	-99.00	-99.00	1.82	3.45	1.60	2.02	2.08	2.73	4.80	1.89	1.53	1.56	1.08
183	3.10	0.97	2.36	2.11	3.56	2.65	-99.00	-99.00	2.02	3.26	3.65	3.62	-99.00	1.53	2.32	2.39	1.38	1.75	2.05
185	2.10	2.34	2.46	1.60	1.30	0.47	-99.00	-99.00	1.86	1.53	2.38	2.66	1.47	2.27	1.95	0.63	1.01	0.63	1.74
MEAN	2.13	1.66	1.95	1.84	2.28	1.3	1.67	1.67	2.23	2.53	2.54	2.77	2.34	2.47	2.33	1.39	2.29	1.45	1.91
S.D.	0.685	1.209	0.672	0.690	0.937	0.888	1.259	1.400	0.657	0.780	1.035	0.805	0.840	1.049	1.307	0.843	2.525	0.807	0.688
N	4	6	6	6	6	5	2	2	6	6	3	3	5	5	6	6	6	6	6

VARIABLE NUMBER 20 ABFR
-40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	1.39	3.57	1.35	1.06	1.84	0.87	-99.00	-99.00	1.30	2.47	-99.00	-99.00	1.19	2.10	3.19	0.45	1.30	2.62	0.90
184	1.54	1.32	1.35	0.56	1.28	0.94	0.56	0.25	1.06	2.49	-99.00	-99.00	2.52	-99.00	1.80	1.01	11.70	0.55	2.07
186	1.34	0.62	1.62	1.24	0.82	1.55	2.48	2.62	2.92	3.36	-99.00	-99.00	3.77	3.66	2.05	1.79	2.45	2.50	3.38
182	1.55	1.66	0.96	2.68	2.94	0.85	-99.00	-99.00	1.49	2.42	2.07	2.72	3.04	2.09	1.39	1.41	1.19	1.24	1.94
183	3.01	0.45	1.85	2.11	2.92	3.29	-99.00	-99.00	1.69	3.73	3.75	2.65	-99.00	2.92	2.29	1.32	1.05	0.60	1.59
185	2.59	2.06	1.50	2.09	2.00	0.32	-99.00	-99.00	1.77	1.59	2.48	2.85	1.22	1.76	1.86	1.13	1.35	1.32	1.63
MEAN	1.90	1.62	1.44	1.62	1.97	1.3	1.52	1.44	1.69	2.73	2.77	2.74	2.35	2.51	2.10	1.19	3.17	1.47	1.92
S.D.	0.712	1.134	0.300	0.796	0.856	1.049	1.358	1.676	0.651	0.682	0.476	0.102	1.134	0.774	0.613	0.449	4.207	0.901	0.823
N	6	6	6	6	6	6	2	2	6	6	3	3	5	5	6	6	6	6	6

VARIABLE NUMBER 20 ABFR
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	1.53	3.81	1.03	0.45	3.28	0.43	-99.00	1.17	1.57	1.74	-99.00	-99.00	1.19	1.03	3.01	0.30	0.93	2.38	2.07
184	1.62	0.74	0.98	0.76	0.56	0.49	0.55	0.47	0.92	1.87	-99.00	-99.00	-99.00	0.73	2.38	0.54	8.97	1.27	1.25
186	3.17	-99.00	1.34	0.84	0.75	1.31	2.38	2.34	2.40	2.79	-99.00	-99.00	2.74	3.14	1.58	1.12	2.21	1.11	2.15
182	-99.00	1.30	0.70	2.60	2.70	0.20	-99.00	-99.00	0.60	3.10	1.80	2.20	2.60	1.68	0.17	1.97	0.82	1.52	0.69
183	2.36	0.73	1.24	1.52	1.42	1.83	-99.00	-99.00	2.35	2.72	2.65	2.17	-99.00	3.32	1.40	0.10	1.46	1.09	1.21
185	3.29	2.38	1.62	1.51	0.95	0.76	-99.00	-99.00	0.93	1.14	3.30	0.64	2.39	1.48	1.86	0.63	1.37	0.61	0.89
MEAN	2.39	1.79	1.15	1.28	1.61	0.8	1.47	1.33	1.46	2.23	2.58	1.67	2.23	1.90	1.73	0.78	2.63	1.33	1.38
S.D.	0.829	1.313	0.320	0.775	1.122	0.618	1.294	0.945	0.775	0.757	0.752	0.892	0.708	1.087	0.964	0.679	3.146	0.594	0.605
N	5	5	6	6	6	6	2	3	6	6	3	3	4	6	6	6	6	6	6

VARIABLE NUMBER 20 ABFR
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	5.03	6.22	-99.00	2.86	3.72	2.20	-99.00	3.30	2.66	3.59	-99.00	-99.00	3.79	4.27	5.15	2.90	3.02	3.57	2.72
184	3.38	2.62	2.75	3.00	2.72	2.03	2.22	2.03	3.07	4.40	-99.00	-99.00	3.36	3.38	2.56	2.32	16.80	2.27	2.36
186	5.20	3.15	3.78	2.57	2.03	3.91	6.96	3.25	3.63	4.04	-99.00	-99.00	6.94	5.05	3.60	2.19	3.86	3.65	3.90
182	-99.00	2.12	2.99	7.53	5.87	2.80	-99.00	-99.00	2.88	5.85	4.35	5.95	4.89	5.06	7.92	2.74	1.90	4.83	4.58
183	4.37	1.70	5.00	3.61	4.75	5.02	-99.00	-99.00	3.28	4.60	4.57	5.47	-99.00	4.81	5.24	3.29	3.53	6.20	3.64
185	4.57	3.42	3.14	4.40	3.73	2.11	-99.00	-99.00	2.55	3.16	5.25	2.38	2.38	2.91	4.20	1.68	3.11	2.70	1.97
MEAN	4.51	3.20	3.53	4.00	3.80	3.0	5.59	2.86	3.01	4.27	4.72	4.60	4.27	4.25	4.78	2.52	5.37	3.87	3.23
S.D.	0.715	1.908	0.905	1.848	1.378	1.210	4.766	0.719	0.403	0.935	0.469	1.937	1.742	0.912	1.837	0.573	5.639	1.443	1.025
N	5	6	5	6	6	6	2	3	5	6	3	3	5	6	6	6	6	5	6

VARIABLE NUMBER 21 STHR
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 21 STHR
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 21 STHR
-80 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	65.0	66.0	73.0	66.0	59.0	54.0	-99.0	-99.0	-99.0	51.0	-99.0	-99.0	75.0	92.0	89.0	69.0	79.0	72.0	67.0
184	76.0	58.0	73.0	71.0	71.0	77.0	69.0	54.0	73.0	68.0	-99.0	-99.0	113.0	89.0	104.0	97.0	105.0	85.0	72.0
186	69.0	65.0	63.0	62.0	55.0	54.0	73.0	62.0	78.0	56.0	-99.0	-99.0	107.0	106.0	82.0	88.0	94.0	87.0	61.0
182	63.0	68.0	56.0	64.0	63.0	-99.0	-99.0	-99.0	61.0	69.0	61.0	73.0	87.0	104.0	109.0	70.0	72.0	-99.0	77.0
183	76.0	56.0	82.0	75.0	74.0	-99.0	-99.0	-99.0	96.0	76.0	98.0	68.0	109.0	97.0	108.0	76.0	90.0	86.0	-99.0
185	70.0	62.0	60.0	62.0	57.0	-99.0	-99.0	-99.0	89.0	76.0	84.0	65.0	80.0	80.0	82.0	67.0	72.0	74.0	-99.0
MEAN	69.8	62.5	67.8	66.7	63.2	61.7	71.0	58.0	79.4	66.0	81.0	68.7	95.2	94.7	95.7	77.8	85.8	80.8	69.2
S.D.	5.42	4.72	9.79	5.28	7.76	13.28	2.83	5.66	13.69	10.37	18.68	4.04	16.45	9.75	12.79	12.09	14.18	7.19	6.85
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	4

VARIABLE NUMBER 21 STHR
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 21 8THR
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	49.0	52.0	46.0	47.0	43.0	34.0	-99.0	-99.0	-99.0	35.0	-99.0	-99.0	47.0	57.0	53.0	54.0	52.0	50.0	53.0
184	56.0	49.0	49.0	52.0	48.0	42.0	40.0	38.0	35.0	41.0	-99.0	-99.0	73.0	58.0	66.0	78.0	78.0	53.0	51.0
186	56.0	60.0	53.0	60.0	50.0	41.0	47.0	44.0	52.0	49.0	-99.0	-99.0	76.0	75.0	66.0	74.0	74.0	71.0	55.0
182	53.0	54.0	47.0	50.0	50.0	-99.0	-99.0	-99.0	46.0	50.0	46.0	51.0	60.0	62.0	71.0	54.0	54.0	-99.0	53.0
183	56.0	51.0	57.0	61.0	55.0	-99.0	-99.0	-99.0	63.0	56.0	67.0	57.0	72.0	64.0	77.0	63.0	67.0	62.0	52.0
185	54.0	54.0	54.0	52.0	51.0	-99.0	-99.0	-99.0	60.0	64.0	64.0	59.0	55.0	58.0	68.0	66.0	66.0	64.0	-99.0
MEAN	53.8	53.3	51.0	53.7	49.5	39.0	43.5	41.0	51.2	49.2	59.0	55.7	63.8	62.3	66.8	64.8	65.2	60.0	52.8
S.D.	3.13	3.78	4.34	5.61	3.94	4.34	4.95	4.24	11.26	10.34	11.36	4.16	11.62	6.77	7.94	9.97	10.44	8.51	1.48
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	5

VARIABLE NUMBER 24
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 24
-30 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 24
-40 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 24
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
186	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 24
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
184	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
182	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
183	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
185	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.D.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VARIABLE NUMBER 25 PEPT
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.37	0.33	0.33	0.34	0.36	0.36	-99.00	0.32	-99.00	0.35	-99.00	-99.00	0.35	0.47	0.48	0.42	0.38	0.37	0.39
184	0.33	0.33	0.31	-99.00	0.31	0.32	0.33	0.32	0.31	0.33	-99.00	-99.00	0.38	0.34	0.43	0.39	0.32	0.32	0.33
186	0.32	0.33	0.36	0.31	0.35	0.40	0.37	0.34	0.35	0.36	-99.00	-99.00	0.41	0.45	0.44	0.33	0.36	0.41	0.34
182	0.32	0.32	0.32	0.32	0.35	-99.00	-99.00	-99.00	0.33	0.33	0.35	0.35	0.32	0.35	0.37	0.33	0.33	0.34	0.35
183	0.36	0.36	0.32	0.35	0.34	-99.00	-99.00	-99.00	0.38	0.37	0.36	0.39	0.36	0.37	0.43	0.38	0.35	0.39	0.40
185	0.35	0.38	0.34	0.30	0.32	-99.00	-99.00	-99.00	0.38	0.34	0.35	0.38	0.36	0.38	0.38	0.38	0.33	0.32	0.32
MEAN	0.34	0.34	0.33	0.32	0.34	0.4	0.35	0.33	0.35	0.35	0.35	0.37	0.36	0.39	0.42	0.37	0.35	0.36	0.36
S.D.	0.023	0.023	0.018	0.021	0.019	0.040	0.028	0.012	0.031	0.016	0.006	0.021	0.030	0.054	0.041	0.035	0.023	0.038	0.033
N	6	6	6	5	6	3	2	3	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 25 PEPT
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.46	0.50	0.40	0.45	0.46	0.50	-99.00	-99.00	-99.00	0.51	-99.00	-99.00	0.47	0.61	0.56	0.54	0.64	0.50	0.52
184	0.35	0.38	0.41	0.39	0.39	0.40	0.43	0.40	0.44	0.50	-99.00	-99.00	0.59	0.45	0.66	0.51	0.42	0.45	0.44
186	0.39	0.46	0.43	0.37	0.40	0.50	0.52	0.44	0.45	0.48	-99.00	-99.00	0.48	0.58	0.52	0.44	0.46	0.53	0.44
182	0.45	0.40	0.38	0.41	0.43	-99.00	-99.00	-99.00	0.42	0.43	0.44	0.49	0.44	0.44	0.50	0.47	0.50	0.48	0.46
183	0.45	0.52	0.23	0.51	0.53	-99.00	-99.00	-99.00	0.52	0.48	0.54	0.52	0.45	0.43	0.60	0.50	0.43	0.45	0.49
185	0.42	0.50	0.42	0.41	0.45	-99.00	-99.00	-99.00	0.43	0.43	0.46	0.46	0.36	0.50	0.46	0.46	0.41	0.47	0.45
MEAN	0.42	0.45	0.39	0.42	0.44	0.5	0.48	0.42	0.45	0.47	0.48	0.49	0.46	0.50	0.55	0.49	0.48	0.48	0.47
S.D.	0.043	0.058	0.051	0.050	0.050	0.058	0.063	0.028	0.040	0.034	0.053	0.030	0.074	0.076	0.072	0.037	0.056	0.031	0.032
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 25 PEPT
-20 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.51	0.59	0.47	0.55	0.53	0.56	-99.00	-99.00	-99.00	0.55	-99.00	-99.00	0.57	0.67	0.67	0.64	0.68	0.55	0.65
184	0.41	0.41	0.50	0.39	0.45	0.48	0.51	0.48	0.49	0.54	-99.00	-99.00	0.59	0.58	0.72	0.57	0.48	0.54	0.51
186	0.48	0.52	0.48	0.54	0.44	0.55	0.60	0.56	0.50	0.54	-99.00	-99.00	0.66	0.65	0.59	0.48	0.53	0.56	0.51
182	0.49	0.44	0.44	0.45	0.46	-99.00	-99.00	-99.00	0.49	0.51	0.51	0.56	0.55	0.53	0.64	0.53	0.57	-99.00	0.53
183	0.55	0.52	0.32	0.58	0.53	-99.00	-99.00	-99.00	0.70	0.58	0.64	0.58	0.53	0.51	0.56	0.57	0.56	0.52	-99.00
185	0.47	0.54	0.50	0.49	0.51	-99.00	-99.00	-99.00	0.52	0.50	0.55	0.51	0.52	0.59	0.55	0.59	0.52	0.52	-99.00
MEAN	0.49	0.50	0.45	0.50	0.49	0.5	0.55	0.52	0.54	0.54	0.57	0.55	0.57	0.59	0.64	0.56	0.56	0.54	0.55
S.D.	0.046	0.066	0.068	0.071	0.041	0.044	0.063	0.057	0.090	0.029	0.066	0.036	0.051	0.063	0.060	0.054	0.068	0.018	0.067
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	4

VARIABLE NUMBER 25 PEPT
-50 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.55	0.68	0.54	0.62	0.56	0.59	-99.00	-99.00	-99.00	0.60	-99.00	-99.00	0.62	0.74	0.75	0.71	0.75	0.73	0.70
184	0.50	0.46	0.57	0.54	0.50	0.55	0.56	0.55	0.56	0.61	-99.00	-99.00	-99.00	0.71	0.77	0.66	-99.00	0.64	0.58
186	0.56	0.61	0.53	0.52	0.53	0.64	0.63	-99.00	0.55	0.60	-99.00	-99.00	0.73	0.72	0.62	0.63	0.54	0.65	0.57
182	0.55	0.48	0.45	0.53	0.53	-99.00	-99.00	-99.00	0.55	0.58	0.59	0.63	0.67	0.66	0.74	0.62	0.65	-99.00	0.63
183	0.66	0.62	0.59	0.60	0.56	-99.00	-99.00	-99.00	0.79	0.63	0.75	0.64	0.63	-99.00	0.70	0.63	0.66	0.58	0.64
185	0.52	0.57	0.54	0.56	0.55	-99.00	-99.00	-99.00	0.59	0.54	0.60	0.57	0.58	0.61	0.63	0.66	0.56	0.56	0.58
MEAN	0.56	0.57	0.54	0.56	0.55	0.6	0.59	0.55	0.61	0.59	0.65	0.61	0.65	0.69	0.70	0.65	0.63	0.63	0.62
S.D.	0.055	0.085	0.048	0.040	0.014	0.045	0.050	0.000	0.103	0.031	0.089	0.038	0.057	0.053	0.063	0.033	0.084	0.066	0.050
N	6	6	6	6	6	3	2	1	5	6	3	3	5	5	6	6	5	5	6

VARIABLE NUMBER 25 PEPT
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	0.34	0.47	0.35	0.33	0.34	0.33	-99.00	-99.00	0.35	0.40	-99.00	0.30	0.48	0.48	0.42	0.42	0.39	0.42	0.43
184	0.29	0.34	0.32	0.31	0.31	0.33	0.33	0.31	0.31	0.33	-99.00	-99.00	0.39	0.36	0.43	0.39	0.32	0.35	0.33
186	0.34	0.35	0.37	0.40	0.34	0.39	0.37	0.36	0.34	0.36	-99.00	-99.00	0.42	0.50	0.41	0.36	0.38	0.39	0.38
182	0.26	0.32	0.35	0.32	0.35	-99.00	-99.00	-99.00	0.34	0.34	0.35	0.35	0.38	0.39	0.39	0.34	0.34	-99.00	0.35
183	0.40	0.39	0.41	0.35	0.36	-99.00	-99.00	-99.00	0.39	0.38	0.44	0.38	0.38	0.37	0.42	0.40	0.33	0.38	0.38
185	0.35	0.38	0.50	0.34	0.34	-99.00	-99.00	-99.00	0.41	0.34	0.37	0.38	0.38	0.37	0.38	0.37	0.35	0.36	-99.00
MEAN	0.33	0.37	0.38	0.34	0.34	0.4	0.35	0.34	0.36	0.36	0.39	0.35	0.41	0.41	0.41	0.38	0.35	0.38	0.37
S.D.	0.049	0.053	0.064	0.032	0.017	0.035	0.028	0.035	0.037	0.027	0.047	0.038	0.040	0.062	0.019	0.029	0.028	0.027	0.038
N	6	6	6	6	6	3	2	2	6	6	3	4	6	6	6	6	6	5	5

VARIABLE NUMBER 26 ETI
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	355.0	369.0	350.0	351.0	369.0	420.0	-99.0	433.0	-99.0	422.0	-99.0	-99.0	364.0	318.0	324.0	353.0	358.0	356.0	359.0
184	376.0	376.0	373.0	-99.0	362.0	437.0	451.0	451.0	463.0	447.0	-99.0	-99.0	345.0	354.0	361.0	363.0	371.0	371.0	371.0
186	379.0	379.0	371.0	382.0	379.0	438.0	424.0	443.0	434.0	451.0	-99.0	-99.0	343.0	335.0	358.0	378.0	369.0	366.0	394.0
182	380.0	373.0	387.0	378.0	375.0	-99.0	-99.0	-99.0	389.0	371.0	378.0	368.0	382.0	357.0	358.0	388.0	386.0	382.0	377.0
183	379.0	360.0	375.0	373.0	381.0	-99.0	-99.0	-99.0	376.0	368.0	376.0	381.0	358.0	357.0	358.0	368.0	374.0	380.0	378.0
185	374.0	370.0	375.0	396.0	387.0	-99.0	-99.0	-99.0	371.0	378.0	373.0	373.0	368.0	369.0	368.0	377.0	385.0	388.0	367.0
MEAN	373.8	374.5	371.8	376.0	375.5	431.7	437.5	442.3	406.6	406.2	375.7	374.0	360.0	348.3	354.5	374.5	374.2	373.8	377.7
S.D.	9.50	4.59	12.07	16.39	8.94	10.12	19.09	9.02	40.14	38.51	2.52	6.56	14.71	18.48	15.44	13.98	11.02	11.77	12.23
N	6	6	6	5	6	3	2	3	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 26 ETI
-31 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	328.0	319.0	356.0	318.0	324.0	365.0	-99.0	-99.0	-99.0	378.0	-99.0	-99.0	344.0	295.0	306.0	325.0	329.0	316.0	334.0
184	353.0	353.0	336.0	341.0	339.0	392.0	398.0	419.0	401.0	392.0	-99.0	-99.0	325.0	332.0	328.0	335.0	346.0	340.0	337.0
186	350.0	352.0	350.0	365.0	370.0	398.0	364.0	403.0	389.0	421.0	-99.0	-99.0	332.0	314.0	336.0	357.0	341.0	340.0	372.0
182	351.0	343.0	377.0	352.0	359.0	-99.0	-99.0	-99.0	362.0	350.0	349.0	335.0	333.0	328.0	328.0	360.0	348.0	342.0	338.0
183	342.0	332.0	36.0	325.0	319.0	-99.0	-99.0	-99.0	336.0	332.0	321.0	349.0	329.0	340.0	317.0	353.0	349.0	350.0	346.0
185	350.0	350.0	95.0	365.0	356.0	-99.0	-99.0	-99.0	349.0	353.0	343.0	359.0	368.0	339.0	331.0	362.0	360.0	350.0	357.0
MEAN	345.7	341.5	258.3	344.3	344.5	385.0	381.0	411.0	367.2	371.0	337.7	347.7	338.5	324.7	324.3	348.7	345.5	339.7	347.3
S.D.	9.44	13.52	151.09	17.96	20.46	17.58	24.04	11.31	26.96	32.48	14.74	12.06	15.78	17.32	10.93	15.11	10.21	12.48	14.67
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 26 ETI
-40 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	320.0	309.0	319.0	305.0	306.0	346.0	-99.0	-99.0	-99.0	362.0	-99.0	-99.0	328.0	288.0	305.0	314.0	314.0	309.0	304.0
184	338.0	337.0	324.0	341.0	327.0	364.0	379.0	389.0	383.0	375.0	-99.0	-99.0	325.0	324.0	326.0	328.0	335.0	326.0	315.0
186	331.0	336.0	337.0	326.0	356.0	380.0	355.0	369.0	366.0	398.0	-99.0	-99.0	320.0	317.0	317.0	347.0	325.0	341.0	355.0
182	338.0	333.0	359.0	330.0	351.0	-99.0	-99.0	-99.0	349.0	335.0	336.0	321.0	312.0	329.0	321.0	341.0	329.0	-99.0	322.0
183	318.0	332.0	406.0	308.0	319.0	-99.0	-99.0	-99.0	304.0	316.0	313.0	327.0	321.0	326.0	314.0	339.0	330.0	337.0	-99.0
185	335.0	336.0	339.0	342.0	341.0	-99.0	-99.0	-99.0	326.0	334.0	326.0	347.0	321.0	320.0	333.0	334.0	349.0	339.0	-99.0
MEAN	330.0	339.5	347.3	325.3	333.3	363.3	367.0	379.0	345.6	353.3	325.0	331.7	321.2	317.3	319.3	333.8	330.3	330.4	324.0
S.D.	8.92	10.71	31.94	15.87	19.38	17.01	16.97	14.14	31.39	30.47	11.53	13.61	5.42	14.99	9.73	11.65	11.55	13.30	21.95
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	4

VARIABLE NUMBER 26 ETI
-50 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	308.0	304.0	311.0	290.0	293.0	332.0	-99.0	-99.0	-99.0	341.0	-99.0	-99.0	322.0	294.0	308.0	309.0	310.0	299.0	300.0
184	321.0	329.0	308.0	317.0	313.0	353.0	371.0	367.0	370.0	366.0	-99.0	-99.0	-99.0	322.0	326.0	331.0	-99.0	326.0	308.0
186	318.0	319.0	328.0	327.0	333.0	357.0	347.0	-99.0	352.0	386.0	-99.0	-99.0	318.0	312.0	314.0	328.0	327.0	325.0	343.0
182	329.0	316.0	347.0	320.0	331.0	-99.0	-99.0	-99.0	333.0	322.0	323.0	312.0	312.0	317.0	319.0	326.0	313.0	-99.0	308.0
183	309.0	305.0	309.0	312.0	313.0	-99.0	-99.0	-99.0	304.0	315.0	309.0	314.0	321.0	-99.0	312.0	321.0	310.0	330.0	320.0
185	327.0	329.0	324.0	325.0	330.0	-99.0	-99.0	-99.0	309.0	326.0	312.0	332.0	312.0	312.0	320.0	323.0	332.0	328.0	319.0
MEAN	318.7	317.2	321.2	315.2	318.8	347.3	359.0	367.0	333.6	342.7	314.7	319.3	317.0	311.4	316.5	323.0	318.4	321.6	316.3
S.D.	8.82	10.30	15.14	13.47	15.55	13.43	16.97	0.00	28.04	27.91	7.37	11.02	4.80	10.57	6.44	7.72	10.36	12.78	15.08
N	6	6	6	6	6	3	2	1	5	6	3	3	5	5	6	6	5	5	6

VARIABLE NUMBER 26 ETI
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	355.0	344.0	345.0	344.0	344.0	429.0	-99.0	-99.0	-99.0	426.0	-99.0	-99.0	332.0	323.0	331.0	348.0	349.0	345.0	352.0
184	367.0	362.0	364.0	371.0	364.0	433.0	459.0	447.0	453.0	443.0	-99.0	-99.0	349.0	358.0	365.0	363.0	368.0	367.0	366.0
186	366.0	373.0	368.0	358.0	376.0	443.0	430.0	443.0	442.0	461.0	-99.0	-99.0	346.0	336.0	357.0	371.0	358.0	373.0	378.0
182	392.0	362.0	376.0	374.0	379.0	-99.0	-99.0	-99.0	381.0	370.0	376.0	374.0	361.0	357.0	356.0	380.0	386.0	-99.0	369.0
183	375.0	370.0	363.0	373.0	377.0	-99.0	-99.0	-99.0	374.0	369.0	355.0	381.0	365.0	380.0	362.0	376.0	391.0	381.0	391.0
185	372.0	369.0	329.0	377.0	382.0	-99.0	-99.0	-99.0	358.0	373.0	364.0	371.0	364.0	372.0	362.0	381.0	376.0	375.0	-99.0
MEAN	371.2	363.3	357.7	366.2	370.3	435.0	444.5	445.0	401.6	407.0	365.0	375.3	352.8	354.3	355.5	369.8	371.3	368.2	371.2
S.D.	12.29	10.46	17.14	12.70	14.29	7.21	20.51	2.83	42.90	41.33	10.54	5.13	12.92	21.49	12.47	12.58	16.19	13.90	14.48
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	5

VARIABLE NUMBER 27 0321
CONTROL

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	386.0	404.0	380.0	384.0	400.0	444.0	-99.0	456.0	-99.0	445.0	-99.0	-99.0	397.0	355.0	362.0	389.0	393.0	386.0	396.0
184	416.0	409.0	408.0	-99.0	393.0	465.0	479.0	479.0	490.0	475.0	-99.0	-99.0	388.0	391.0	403.0	409.0	416.0	408.0	404.0
186	418.0	417.0	406.0	415.0	409.0	466.0	458.0	471.0	468.0	481.0	-99.0	-99.0	391.0	377.0	398.0	425.0	419.0	408.0	431.0
182	412.0	409.0	418.0	415.0	409.0	-99.0	-99.0	-99.0	419.0	400.0	408.0	400.0	416.0	394.0	396.0	423.0	418.0	424.0	413.0
183	413.0	409.0	411.0	407.0	419.0	-99.0	-99.0	-99.0	412.0	402.0	415.0	416.0	399.0	393.0	403.0	425.0	413.0	417.0	409.0
185	410.0	405.0	409.0	430.0	419.0	-99.0	-99.0	-99.0	409.0	422.0	414.0	408.0	405.0	407.0	411.0	416.0	428.0	429.0	425.0
MEAN	409.2	408.8	405.3	410.2	408.2	458.3	468.5	468.7	439.6	437.5	412.3	408.0	399.3	386.2	395.5	414.5	414.5	412.3	413.0
S.D.	11.70	4.58	13.08	16.84	10.32	12.42	14.85	11.68	36.98	35.39	3.79	8.00	10.13	18.00	17.21	13.97	11.67	14.60	13.07
N	6	6	6	5	6	3	2	3	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 27 0321
-30 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	364.0	357.0	397.0	356.0	358.0	393.0	-99.0	-99.0	-99.0	405.0	-99.0	-99.0	387.0	348.0	354.0	367.0	371.0	356.0	-99.0
184	396.0	389.0	378.0	384.0	374.0	429.0	440.0	452.0	438.0	429.0	-99.0	-99.0	393.0	378.0	385.0	384.0	397.0	391.0	-99.0
186	388.0	390.0	387.0	399.0	405.0	428.0	407.0	433.0	432.0	453.0	-99.0	-99.0	387.0	366.0	381.0	404.0	395.0	390.0	-99.0
182	387.0	379.0	413.0	390.0	396.0	-99.0	36.0	-99.0	394.0	388.0	384.0	376.0	379.0	383.0	382.0	400.0	389.0	391.0	-99.0
183	380.0	366.0	442.0	368.0	363.0	-99.0	-99.0	-99.0	382.0	373.0	372.0	388.0	385.0	390.0	371.0	395.0	398.0	395.0	-99.0
185	388.0	385.0	389.0	400.0	390.0	-99.0	-99.0	-99.0	396.0	395.0	390.0	397.0	405.0	383.0	378.0	401.0	402.0	392.0	-99.0
MEAN	383.8	377.7	401.0	382.8	381.0	416.7	294.3	442.5	408.4	407.2	382.0	387.0	389.3	374.0	375.2	391.8	392.0	385.8	0.0
S.D.	10.96	13.41	23.28	17.60	18.89	20.50	224.33	13.44	24.96	29.21	9.17	10.58	8.89	16.72	11.41	14.05	11.14	14.72	0.00
N	6	6	6	6	6	3	3	2	5	6	3	3	6	6	6	6	6	6	0

VARIABLE NUMBER 27 QS2I
-40 MM HG

	PRE-BEDREST					IN BEDREST								POST-BEDREST				
							SPECIAL							- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	359.0	349.0	354.0	345.0	341.0	378.0	-99.0	-99.0	-99.0	393.0	-99.0	-99.0	372.0	343.0	358.0	355.0	361.0	351.0	345.0
184	383.0	372.0	367.0	384.0	370.0	410.0	420.0	421.0	427.0	416.0	-99.0	-99.0	393.0	378.0	389.0	387.0	400.0	377.0	358.0
186	372.0	375.0	375.0	363.0	389.0	412.0	398.0	407.0	413.0	432.0	-99.0	-99.0	384.0	380.0	366.0	400.0	381.0	393.0	392.0
182	375.0	374.0	393.0	368.0	389.0	-99.0	-99.0	-99.0	386.0	376.0	373.0	364.0	364.0	392.0	386.0	383.0	372.0	-99.0	368.0
183	364.0	366.0	455.0	353.0	363.0	-99.0	-99.0	-99.0	362.0	361.0	372.0	368.0	386.0	385.0	379.0	384.0	384.0	389.0	-99.0
185	377.0	373.0	375.0	379.0	375.0	-99.0	-99.0	-99.0	379.0	379.0	376.0	387.0	369.0	368.0	383.0	375.0	392.0	383.0	-99.0
MEAN	371.7	368.2	388.2	365.3	371.2	400.0	409.0	414.0	393.4	392.8	373.7	373.0	378.0	374.3	376.8	380.7	381.7	378.6	365.7
S.D.	8.80	9.91	34.26	14.92	18.05	19.08	15.56	9.90	26.27	26.68	2.08	12.29	11.30	17.28	12.22	14.98	13.92	16.58	19.87
N	5	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	4

VARIABLE NUMBER 27 QS2I
-50 MM HG

	PRE-BEDREST					IN BEDREST								POST-BEDREST				
							SPECIAL							- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	348.0	346.0	362.0	330.0	327.0	367.0	-99.0	-99.0	-99.0	373.0	-99.0	-99.0	372.0	355.0	370.0	352.0	359.0	347.0	350.0
184	372.0	376.0	357.0	365.0	361.0	401.0	419.0	403.0	413.0	414.0	-99.0	-99.0	-99.0	393.0	398.0	401.0	-99.0	390.0	358.0
186	366.0	360.0	369.0	369.0	366.0	397.0	390.0	-99.0	400.0	422.0	-99.0	-99.0	392.0	379.0	372.0	390.0	393.0	379.0	383.0
182	371.0	351.0	365.0	362.0	367.0	-99.0	-99.0	-99.0	377.0	370.0	368.0	362.0	374.0	386.0	388.0	372.0	362.0	-99.0	359.0
183	361.0	346.0	366.0	371.0	366.0	-99.0	-99.0	-99.0	373.0	369.0	380.0	363.0	396.0	-99.0	383.0	373.0	366.0	369.0	370.0
185	370.0	366.0	367.0	363.0	366.0	-99.0	-99.0	-99.0	365.0	376.0	366.0	376.0	365.0	368.0	376.0	367.0	338.0	375.0	363.0
MEAN	364.7	357.5	367.7	360.0	358.8	388.3	404.5	403.0	385.6	387.3	371.3	367.0	379.8	376.2	381.2	375.8	363.6	376.0	363.8
S.D.	9.11	12.06	9.50	15.10	15.74	18.58	20.51	0.00	20.09	24.01	7.57	7.81	13.46	15.02	10.67	17.34	19.68	17.44	11.04
N	6	6	6	6	6	3	2	1	5	6	3	3	5	5	6	6	5	5	6

VARIABLE NUMBER 27 0521
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	384.0	375.0	374.0	373.0	370.0	449.0	-99.0	-99.0	-99.0	447.0	-99.0	-99.0	360.0	357.0	363.0	380.0	380.0	375.0	383.0
184	401.0	392.0	394.0	403.0	393.0	458.0	483.0	471.0	474.0	467.0	-99.0	-99.0	393.0	393.0	404.0	410.0	414.0	399.0	396.0
186	400.0	409.0	400.0	394.0	406.0	468.0	458.0	470.0	473.0	491.0	-99.0	-99.0	392.0	381.0	397.0	416.0	403.0	415.0	410.0
182	424.0	394.0	404.0	405.0	409.0	-99.0	-99.0	-99.0	409.0	400.0	404.0	404.0	397.0	394.0	399.0	413.0	418.0	-99.0	401.0
183	408.0	400.0	397.0	410.0	410.0	-99.0	-99.0	-99.0	412.0	402.0	395.0	415.0	408.0	418.0	408.0	414.0	432.0	418.0	423.0
185	404.0	401.0	361.0	409.0	412.0	-99.0	-99.0	-99.0	394.0	411.0	403.0	406.0	397.0	407.0	403.0	420.0	415.0	413.0	-99.0
MEAN	403.5	395.2	388.3	399.0	400.0	458.3	470.5	470.5	432.4	436.3	400.7	408.3	391.2	391.7	395.7	408.8	410.3	404.0	402.6
S.D.	12.96	11.55	16.98	13.96	16.19	9.50	17.68	0.71	38.14	37.90	4.93	5.86	16.29	21.22	16.46	14.51	17.53	17.78	15.01
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	5	5

VARIABLE NUMBER 28 PEPI
CONTROL

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	127.0	128.0	116.0	117.0	129.0	148.0	-99.0	137.0	-99.0	146.0	-99.0	-99.0	127.0	138.0	144.0	140.0	130.0	127.0	135.0
184	123.0	121.0	116.0	-99.0	114.0	137.0	146.0	142.0	144.0	145.0	-99.0	-99.0	125.0	120.0	145.0	135.0	119.0	119.0	121.0
186	122.0	125.0	131.0	117.0	129.0	168.0	154.0	149.0	148.0	159.0	-99.0	-99.0	132.0	139.0	146.0	123.0	130.0	142.0	132.0
182	122.0	115.0	123.0	121.0	128.0	-99.0	-99.0	-99.0	125.0	122.0	128.0	127.0	122.0	123.0	129.0	127.0	128.0	126.0	129.0
183	133.0	134.0	119.0	128.0	129.0	-99.0	-99.0	-99.0	138.0	133.0	131.0	141.0	126.0	129.0	144.0	142.0	130.0	141.0	146.0
185	131.0	137.0	125.0	120.0	124.0	-99.0	-99.0	-99.0	136.0	128.0	127.0	136.0	130.0	134.0	133.0	139.0	125.0	123.0	124.0
MEAN	126.3	127.2	121.7	120.6	125.5	151.0	150.0	142.7	138.2	138.8	128.7	135.3	127.0	130.5	140.2	134.3	127.0	129.7	131.2
S.D.	4.80	7.36	5.35	4.51	5.96	15.72	5.66	6.03	8.79	13.64	2.08	7.37	3.58	7.87	7.25	7.69	4.38	9.58	8.89
N	6	6	6	5	6	3	2	3	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 28 PEPI
-30 MM HG

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								- SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	141.0	145.0	135.0	132.0	138.0	170.0	-99.0	-99.0	-99.0	183.0	-99.0	-99.0	149.0	152.0	148.0	158.0	181.0	144.0	156.0
184	121.0	129.0	130.0	126.0	126.0	150.0	162.0	161.0	157.0	182.0	-99.0	-99.0	156.0	137.0	177.0	152.0	136.0	140.0	138.0
186	132.0	150.0	141.0	132.0	143.0	188.0	171.0	170.0	162.0	193.0	-99.0	-99.0	143.0	156.0	157.0	146.0	141.0	160.0	154.0
182	148.0	131.0	137.0	136.0	145.0	-99.0	-99.0	-99.0	144.0	141.0	145.0	151.0	135.0	132.0	145.0	156.0	160.0	150.0	144.0
183	144.0	159.0	119.0	150.0	149.0	-99.0	-99.0	-99.0	157.0	146.0	152.0	166.0	134.0	135.0	160.0	162.0	140.0	146.0	156.0
185	139.0	160.0	141.0	142.0	151.0	-99.0	-99.0	-99.0	140.0	141.0	146.0	153.0	130.0	154.0	139.0	155.0	139.0	151.0	148.0
MEAN	137.5	145.7	133.8	136.3	142.0	169.3	166.5	165.5	154.0	164.3	147.7	156.7	141.2	144.3	154.3	154.8	149.5	148.5	149.3
S.D.	9.69	13.38	8.35	8.52	9.08	19.01	6.36	6.36	11.60	24.11	3.79	8.14	9.99	10.78	13.53	5.46	17.65	6.92	7.34
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	6	6	6

VARIABLE NUMBER 28 PEPI
-40 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	148.0	161.0	137.0	149.0	147.0	177.0	-99.0	-99.0	-99.0	184.0	-99.0	-99.0	164.0	155.0	166.0	176.0	-99.0	151.0	170.0
184	130.0	131.0	147.0	126.0	137.0	160.0	177.0	174.0	171.0	185.0	-99.0	-99.0	156.0	160.0	186.0	159.0	-99.0	155.0	145.0
186	144.0	159.0	148.0	159.0	147.0	192.0	189.0	188.0	166.0	199.0	-99.0	-99.0	168.0	164.0	162.0	150.0	-99.0	166.0	166.0
182	151.0	137.0	148.0	138.0	150.0	-99.0	-99.0	-99.0	157.0	154.0	156.0	160.0	148.0	148.0	165.0	163.0	-99.0	-99.0	151.0
183	155.0	159.0	128.0	155.0	149.0	-99.0	-99.0	-99.0	170.0	160.0	163.0	169.0	143.0	145.0	164.0	171.0	-99.0	156.0	-99.0
185	145.0	164.0	155.0	155.0	160.0	-99.0	-99.0	-99.0	148.0	149.0	155.0	161.0	147.0	164.0	162.0	175.0	-99.0	158.0	-99.0
MEAN	145.5	151.8	143.8	147.0	148.3	176.3	163.0	181.0	162.4	171.8	158.0	163.3	154.3	156.0	167.5	165.7	0.0	157.2	158.0
S.D.	8.60	14.06	9.66	12.63	7.37	16.01	8.49	9.90	9.76	20.19	4.46	4.93	10.05	8.12	9.20	10.19	0.00	5.54	11.92
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	0	5	4

VARIABLE NUMBER 28 PEPI
-50 MM HG

	PRE-BEDREST					IN BEDREST SPECIAL									POST-BEDREST - SPECIAL -				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	150.0	176.0	145.0	155.0	147.0	178.0	-99.0	-99.0	-99.0	186.0	-99.0	-99.0	170.0	167.0	179.0	184.0	190.0	179.0	173.0
184	142.0	138.0	151.0	150.0	148.0	171.0	185.0	184.0	186.0	196.0	-99.0	-99.0	-99.0	174.0	188.0	171.0	-99.0	167.0	153.0
186	155.0	170.0	157.0	154.0	163.0	204.0	191.0	-99.0	170.0	210.0	-99.0	-99.0	173.0	172.0	161.0	170.0	149.0	176.0	175.0
182	161.0	140.0	145.0	152.0	158.0	-99.0	-99.0	-99.0	162.0	162.0	167.0	165.0	166.0	163.0	178.0	175.0	171.0	-99.0	162.0
183	165.0	166.0	153.0	154.0	151.0	-99.0	-99.0	-99.0	177.0	165.0	171.0	169.0	155.0	-99.0	168.0	170.0	169.0	161.0	173.0
185	152.0	168.0	156.0	162.0	163.0	-99.0	-99.0	-99.0	152.0	155.0	156.0	166.0	154.0	159.0	167.0	183.0	164.0	161.0	162.0
MEAN	154.7	159.7	151.3	154.5	155.0	184.3	188.0	184.0	169.4	179.0	164.7	166.7	163.6	167.0	173.5	175.5	168.6	168.8	166.3
S.D.	9.03	16.37	5.01	4.09	7.29	17.39	4.24	0.00	13.15	21.73	7.77	2.08	8.68	6.20	9.89	6.47	14.74	8.38	8.71
N	6	6	6	6	6	3	2	1	5	6	3	3	5	5	6	6	5	5	4

VARIABLE NUMBER 28 PEPI
RECOVERY

	PRE-BEDREST					IN BEDREST									POST-BEDREST				
							SPECIAL								SPECIAL				
SUBJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
181	115.0	151.0	118.0	114.0	115.0	141.0	-99.0	-99.0	-99.0	144.0	-99.0	-99.0	149.0	142.0	133.0	140.0	-99.0	137.0	142.0
184	107.0	120.0	116.0	114.0	113.0	141.0	148.0	142.0	141.0	143.0	-99.0	-99.0	129.0	127.0	147.0	134.0	-99.0	126.0	121.0
186	122.0	126.0	133.0	137.0	126.0	168.0	154.0	158.0	147.0	162.0	-99.0	-99.0	135.0	152.0	140.0	129.0	-99.0	140.0	138.0
182	104.0	115.0	128.0	119.0	129.0	-99.0	-99.0	-99.0	127.0	124.0	128.0	129.0	132.0	134.0	132.0	128.0	-99.0	-99.0	128.0
183	145.0	138.0	143.0	129.0	132.0	-99.0	-99.0	-99.0	139.0	136.0	146.0	141.0	134.0	137.0	144.0	143.0	-99.0	139.0	143.0
185	126.0	137.0	151.0	126.0	127.0	-99.0	-99.0	-99.0	140.0	125.0	131.0	136.0	134.0	135.0	133.0	137.0	-99.0	132.0	-99.0
MEAN	120.3	131.2	131.5	123.2	123.7	150.0	151.0	150.0	138.8	139.0	135.0	135.3	135.5	137.8	138.2	135.2	0.0	134.8	134.4
S.D.	14.79	13.32	13.78	9.15	7.79	15.59	4.24	11.31	7.29	14.14	9.64	6.03	6.95	8.47	6.43	5.98	0.00	5.81	9.56
N	6	6	6	6	6	3	2	2	5	6	3	3	6	6	6	6	0	5	5

SUMMARY REPORT ON EXERCISE STRESS TESTING CONDUCTED AS PART OF THE JSC/METHODIST HOSPITAL 28 DAY BEDREST STUDY

C. F. Sawin, Ph.D.; M. C. Buderer, Ph.D.;
A. P. Schachter, Ph.D.; and J. A. Rummel, Ph.D.

September 28, 1976

CONTENTS

Page(s)

Results

I.	Changes Observed During Bedrest	1-2
II.	Supine Changes Post-Bedrest	2-3
III.	Upright Changes Post-Bedrest	3-4
IV.	Crossover Study	5-6
V.	Effect of Saline and 4HR LBNP on R+0	6
VI.	Transient Response Analysis of Respiratory Parameters	7-10

Discussion

I.	Analysis of Results From the 28-day Bedrest Study Compared with Those from the JSC/Methodist Hospital 14-day Bedrest Study.	11
II.	Comparison of Apollo Postflight Studies with Results from the 28-day Bedrest Study.	11-12
III.	Comparison of Skylab Postflight Studies with Results from the 28-day Bedrest Study.	12-14

Appendices

A. Statistical Evaluation of Bedrest Exercise Testing

B. Figures depicting Response to Exercise During and Following Bedrest

C. Tabular Data for Primary and Derived Measurements Made During the Bedrest Study.

BEDREST REPORT

Results:

I. Changes Observed During Bedrest

A. Supine Rest

Resting heart rates increased slightly during bedrest, although a statistically significant (paired t-test) increase in heart rate was shown only on the 21st day of bedrest ($P<.05$). No changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), or in mean arterial pressure (MAP) were noted during bedrest. Resting cardiac output ($\dot{Q}$) was statistically significantly elevated only on the 15th day of bedrest. Total peripheral resistance (TPR) was unchanged during bedrest.

No significant change in resting oxygen consumption ($\dot{V}_{O_2}$) was observed during bedrest. The carbon dioxide production changes observed ($\downarrow\dot{V}_{CO_2}$ @ rest on Day 14 of bedrest and $\uparrow\dot{V}_{CO_2}$ @ rest on Day 27 of bedrest) were minimal in magnitude and statistical significance ($P<.05$). No changes were observed in minute ventilation ($\dot{V}_E$).

B. 75W Exercise (Supine)

A statistically significant increase in heart rate was observed only on the 21st day of bedrest. SBP was elevated on Day 7 of bedrest. No changes in DBP or MAP were observed during bedrest. Exercise SV and $\dot{Q}$ were statistically significantly elevated throughout bedrest. Total peripheral resistance was significantly decreased during bedrest. This apparently permitted increased $\dot{Q}$ without concomitant increases in blood pressure.

Exercise $\dot{V}_{CO_2}$ was elevated on Day 27 of bedrest, which might indicate decreased mechanical efficiency following 27 days of bedrest. The gas exchange data on Day 14 seem slightly opposed to the general trends in respiratory gas exchange. Since the gas exchange measurement system was calibrated prior to each run, there is no justification for excluding the Day 14 respiratory gas exchange data at this time.

C. Recovery Post 75W (Supine)

A trend toward increased recovery heart rate was observed throughout bedrest. Statistically significantly higher recovery heart rates were observed on Days 14, 21 and 27 of bedrest. Minor changes were noted in respiratory gas exchange during the recovery period.

II. Post-Bedrest Supine Examinations

A. Rest

Heart rate was statistically significantly elevated on R+0 (end of bedrest), R+1 and R+2. No significant changes were observed in SBP, DBP or MAP. Resting cardiac output was unchanged post-bedrest. Resting $\dot{V}_{O_2}$ was slightly elevated on R+8. No changes were noted in resting $\dot{V}_{CO_2}$ or in $\dot{V}_E$. There were no statistically significant alterations in SV or $\dot{Q}$, but TPR was statistically significantly decreased on R+1 and R+2. The most significant change was that of an elevated heart rate on R+0, R+1 and R+2.

B. 75W Exercise

Heart rate was statistically significantly elevated at all post-bedrest tests. Peak exercise heart rate was observed on R+1. Essentially no changes were observed in SBP, DBP or MAP. Cardiac output was

statistically significantly elevated on R+0, R+1, R+2 and the R+8 examinations while stroke volume was statistically significantly elevated only on R+2 and R+8. Total peripheral resistance was statistically significantly decreased on R+2 and R+8, which likely permitted increased venous return and increased SV on those dates.

Exercise $\dot{V}_{O_2}$ was statistically significantly increased on R+0, R+1, R+2 and through the R+8 exam. This is interpreted to represent decreased mechanical efficiency because the workload remained at 75 watts for all tests. Exercise $\dot{V}_{CO_2}$ was elevated on R+0 and remained statistically significantly elevated through the R+2 exam. Exercise $\dot{V}_E$ remained stable throughout all phases of the bedrest study. The fact that $\dot{V}_E$ remained essentially unchanged while $\dot{V}_{O_2}$ increased (R+0 through R+8) implies slightly increased respiratory efficiency ($\dot{V}_E/\dot{V}_{O_2}$).

C. Post-Exercise Recovery

Recovery heart rates were statistically significantly elevated during all post-bedrest tests. $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ were elevated on R+0, R+1 and R+2. $\dot{V}_E$ was unchanged. DBP and MAP values were statistically significantly reduced on R+0, but these returned to pre-bedrest levels by R+1. SBP was elevated only on R+1.

III. Upright Changes Noted Post-Bedrest

A. Rest

Resting heart rate was elevated (+33%) on R+0, and although it decreased sharply by R+2, it remained elevated (+12%) through the final test on R+18. SBP was statistically significantly elevated on R+1

($P<.01$) although the mean difference was only 6 mmHg, and on R+2 ($P<.05$) although the mean difference was only 7 mmHg. DBP and MAP were not statistically significantly different post-bedrest relative to pre-bedrest.

Resting $\dot{Q}$ trended upward from R+0 through R+2, but was not statistically significantly different from pre-bedrest. SV was statistically significantly decreased on R+0 only ($P<.05$). TPR was unchanged post-bedrest. Resting $\dot{V}_{O_2}$ was statistically significantly elevated on R+1 although the actual increase was quite small (mean increase of 0.038 L/min). There were no changes in resting $\dot{V}_{CO_2}$ or $\dot{V}_E$.

B. 75W Exercise

Exercise heart rate response paralleled the resting heart rate response. The mean R+0 exercise heart rate was approximately +14% above the pre-bedrest mean response.

SBP, DBP and MAP were unchanged post-bedrest. $\dot{Q}$ was statistically significantly elevated on R+0 through R+8, while SV was statistically significantly decreased on R+0. SV then increased until it was statistically significantly elevated on R+8 relative to pre-bedrest. TPR was statistically significantly decreased on R+2 and R+8.

$\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ were statistically significantly elevated on R+0 through R+8. This is attributed to reduced mechanical efficiency post-bedrest. $\dot{V}_E$ was elevated on R+0 and R+1.

C. Recovery

Heart rate on R+0 was +47% above the pre-bedrest mean. In general, recovery heart rate response paralleled both the resting and exercise heart rates.

IV. In-Bedrest Crossover Study

Table 1 summarizes the Δ% changes in parameters between morning and afternoon exercise stress evaluations. Results are shown for rest, 75W exercise, and recovery periods. The "placebo" or no treatment column essentially shows changes in the observed parameters due either to the morning/afternoon circadian differences or due to the fatigue of having repeated the LBNP/exercise test series for the second time that day. The second and third columns under each test period show respectively the results following saline treatment only, and then following saline treatment plus 4hr LBNP at -30 mmHg.

A. Rest

All gas exchange parameters and $\dot{Q}$ were reduced in the afternoon test relative to the morning test without any treatment. This seems to indicate a circadian difference.

The changes observed following saline treatment only were more profound than those following saline and LBNP. This is likely due to the fact that the LBNP exposure evokes extravasation of fluid and results in a lower circulating blood volume than occurs if the same quantity of saline is administered without LBNP.

The observation by the LBNP investigators that the combined saline plus LBNP treatment had a more positive carry-over effect to the following day (with respect to LBNP responses) may be explained by the assumed reabsorption of extravasated fluid via the lymph and return of that fluid to the circulating blood volume.

TABLE 1.

Δ% Changes Following Treatment

PARAMETER	REST			75w			RECOVERY		
	PLACEBO	SALINE	SALINE + LBNP	PLACEBO	SALINE	SALINE + LBNP	PLACEBO	SALINE	SALINE + LBNP
HR	-2.2	-0.5	-1.1	-0.8	2.0	-0.5	-2.0	-1.2	-0.7
$\dot{V}_{O_2}$	-9.1	-5.0	-12.8	-4.1	-12.1	-11.9	-8.3	-15	-10.8
$\dot{V}_{CO_2}$	-12.5	-6.7	-9.5	-4.2	-12.6	-10.8	-4.6	-5.1	-6.1
$\dot{V}_E$	-5.7	-14.6	-6	3.0	-4.9	-5.5	4.1	-5.8	18.2
RR	3.4	12.9	4.9	-7.5	17.5	0	0	8.5	1.9
SBP	0.3	-8.3	-4.9	4.3	-8	-15.2	9.0	-8.5	-10.4
DBP	1.9	-13.4	-6.3	-2.5	-9.8	3.7	0.1	-9.4	-3.6
MAP	1.1	-11.1	-5.6	-3.4	-8.8	-3.8	1.1	-9.0	-7.0
$\dot{Q}$	-9	-29.3	-9.8	-1.6	-18.8	-12.1			
SV	-1.7	-21.1	-11.3	2.8	-18.8	-16			
TPR	12.6	47.3	10.1	-8.1	17.8	9.4			
$\Delta A\text{-}\dot{V}_{O_2}$	14.6	15.8	-11.4	-2.5	8.9	3.9			

G.5 H

B. 75W Exercise

No ready explanation exists for the reductions in gas exchange except to recall that they may represent the apparent circadian shift noticed with the no treatment group. The differences between the two types of treatments and no treatment are not understood by us, if in fact they are even significant. Blood pressure was observed to be reduced more following saline than following saline and LBNP, presumably because the circulating blood volume was greater in the first case relative to that in the second case.

It appears that $\dot{Q}$ and SV are significantly reduced both at rest and at 75W exercise following both saline and saline plus LBNP treatments.

V. Effect of Saline and 4HR LBNP (-30 mmHg) on R+0

Table 2 summarizes the general observations made in both supine and upright testing during the afternoon of R+0 following saline and 4hr LBNP (-30 mmHg).

A. Supine

Basically, we observed reduced heart rates and blood pressures both at rest and during 75W exercise relative to the a.m. pretreatment exam. TPR was reduced, while SV and $\dot{Q}$ were somewhat increased. Respiratory gas exchange ($\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, and $\dot{V}_E$) was unchanged.

B. Erect

Heart rate was decreased while blood pressure was not appreciably changed. Both $\dot{Q}$ and SV were elevated while TPR was decreased both at rest and during 75W exercise. Respiratory gas exchange was unchanged.

TABLE 2.

EFFECT OF SALINE + 4hr LBNP on R+0

SUPINE:

↓HR (-5 BPM @ rest; no Δ@Ex; -3 BPM @ REC)
↓SBP (-5% @ rest and Ex)
↓DBP (-16% @ 75w and rest)
↓MAP (-14% @ rest and -11% @ 75w)
↑$\dot{Q}$(5% @ rest and 75w)
↑SV (15% @ rest 5% @ 75w)
↓TPR (-23% @ rest and -14% @ 75w)
$\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, and $\dot{V}_E$ unchanged

ERECT:

↓↓ HR (-13 BPM @ rest; -9 BPM @ 75w; -13 BPM @ REC)
NOΔ SBP
SLIGHT↑ DBP
SLIGHT↑ MAP
↑ $\dot{Q}$ (~16%) Rest and Ex
↑ SV (~27%) Rest and Ex about the same
↓ TPR (~-10%) Rest and Ex about the same
$\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, and $\dot{V}_E$ unchanged

VI. Transient Response Analysis of Respiratory Parameters

During the 28 day bedrest study, six subjects were tested in both the supine and upright positions on the bicycle ergometer pre- and post-bedrest and in the supine position during bedrest. Exercise testing provided a technique for an evaluation of exercise tolerance under conditions of minimal or normal gravitational stress. The time course of changes in cardio-respiratory parameters may be correlated with other indicators of physiologic function such as blood volume, orthostalic tolerance, hormonal changes and electrolyte balance.

One research objective in physiology is to quantitatively describe system responses to a variety of stimuli. The use of exercise stress tests to evaluate the physiological effects of bedrest or spaceflight on cardiovascular status has primarily depended upon the evaluation of change in steady-state changes in heart rate, cardiac output, stroke volume, TPR, minute ventilation, respiratory quotient and blood pressure. Recently, many investigators have been analyzing the time course of the response of heart rate and ventilation during step changes in work rate. This study assumed a single time constant model to describe the dynamic changes in cardio-respiratory parameters and noted the effect of bedrest on this response.

Data from three of the exercise tests conducted before bedrest (BR-14, -7 and -1) were used to establish baseline conditions for each subject. On days 7, 11, 13, 14, 15, 21 and 27 of bedrest, supine exercise stress tests were performed for comparison with baseline values. Post bedrest exercise tests were obtained on days BR+0, BR+1, BR+2, BR+7, BR+8 and BR+17,19.

In order to evaluate the time course of changes in $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, $\dot{V}_E$ and heart rate (HR), gas analysis and volume measurement data were sampled and stored on a per breath basis. HR data were stored at five second intervals. A parameter identification scheme, based on the works of Powell (5) and Zangwill (6) was programmed on the Univac 1108 to optimize the estimation of steady state values, no-load pedaling values, and the time constant, TAU. These values were computed for $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, $\dot{V}_E$ and HR for each 75 watt step change in work rate. TAU is obtained by assuming a response of the form:

(1) $P(t) = P_{\text{no load pedaling}} + (P_{\text{steady-state}} - P_{\text{no load pedaling}})\, e^{-t/TAU}$

Fig. (25) indicates the form of the response, where P(t) is the time course of the cardio-respiratory parameter response to the step change in work rate.

A paired t test was used to determine statistically significant changes during and after bedrest in the steady-state values, no load pedaling values, and TAU's for the variables $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, $\dot{V}_E$ and HR. Group means with variances and results of the statistical analysis are given in Appendix B.

This section summarizes results of the analysis of the transient response of respiratory parameters obtained as a part of exercise stress tests conducted during the 28 day bedrest study.

A. Changes observed during bedrest

1. Supine no load pedaling values

No change from pre-bedrest values

2. Supine exercise (75 watts) steady state values

Exercise $\dot{V}_{CO_2}$ was significantly increased on days 7 and 11 of bedrest. HR was elevated on day 14. On days 21 and 27 of bedrest HR, $\dot{V}_{CO_2}$ and $\dot{V}_E$ were significantly increased.

3. Supine exercise time constant (TAU) of response to on-set of work rate

TAU's for $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ were significantly increased on days 21 and 27 of bedrest.

B. Changes observed during post-bedrest exercise stress tests

1. No load pedaling values

(a) Supine ergometry: HR was significantly increased on R+0, R+1 and R+2. On days R+7,8, $\dot{V}_{CO_2}$ was significantly elevated.

(b) Upright ergometry: HR was significantly increased R+0, R+1 and R+2. On R+2, $\dot{V}_{O_2}$ was significantly elevated.

2. Steady state values during exercise

(a) Supine ergometry: HR was significantly increased R+0, R+1, R+2 and R+17,19. $\dot{V}_{CO_2}$ was elevated R+0, R+1, R+2 and R+7,8. $\dot{V}_{O_2}$ was increased R+1 and $\dot{V}_E$ was significantly increased R+2.

(b) Upright ergometry: HR was significantly increased R+0, R+1, R+2 and R+17,19. $\dot{V}_E$ was increased R+0 and R+1, and $\dot{V}_{O_2}$ was elevated significantly R+1.

3. Time constant

(a) Supine ergometry: No significant changes in TAU

(b) Upright ergometry: TAU for HR was significantly increased R+0 and R+1.

During the first two weeks of bedrest changes were minor. However, by days 21 and 27 all steady state values and time constants were above pre-bedrest values. There is a definite indication of changes in the ability to respond to exercise stress. There may be changes in mechanical efficiency or muscular ability to do work. Immediately after bedrest the supine exercise time constants of most subjects were near pre-bedrest values. However some subjects had increased time constants through R+7, 8. During upright exercise the time constants of all subjects for HR were elevated R+0 and R+1. Steady state values for HR, $\dot{V}_{CO_2}$, $\dot{V}_{O_2}$ and $\dot{V}_E$ were elevated during some or all of the post-bedrest tests on R+0, R+1 and R+2. HR was significantly increased on R+17, 19. These data are consistent with other findings that bedrest significantly affects the ability to perform exercise in the upright position and that some of the parameters measured are not at pre-bedrest levels by R+17, 19.

Discussion:

I. Analysis of results from the current 28-d bedrest study and those obtained from the JSC/Methodist Hospital 14-d bedrest study conducted in 1975.

There were major differences between these two studies besides the durations. Cycle ergometry was performed only pre- and post-bedrest in the 1975 study; furthermore, only upright ergometry testing was utilized. The standard Skylab protocol (1) was utilized although the work levels did not truly represent 25%, 50% and 75% maximum aerobic capacity for each crewman. The work levels chosen were sufficient to evoke a group mean heart rate of 159 beats/minute at the 75% maximum level. No exercise was performed during the course of the 14-d bedrest.

The 75% maximum work level was 100 to 125 watts. In the current study all subjects exercised at 75 watts. It is interesting to note that all parameters (heart rate, SBP, DBP, MAP and SV) returned to normal by R+1 both at rest and during the exercise in the 14-d study. These results (Table 3) are quite different from those of the current study. It appears that 14 days of bedrest is not nearly so severe a stress as 28 days of bedrest.

II. Comparison of Apollo post flight studies with results from the 28-d bedrest study.

A direct comparison of exercise data between these two studies is extremely difficult because the Apollo tests utilized a heart rate

CHANGES IN CARDIOVASCULAR PARAMETERS
FOLLOWING 14 DAYS OF BEDREST

TABLE 3

VARIABLE	PRE-BEDREST			END OF BEDREST			DAY AFTER END OF BEDREST		
	MEAN	±SD	N	MEAN	PROBABILITY LEVEL	N	MEAN	PROBABILITY LEVEL	N
RESTING									
Sitting Heart Rate (Beats/Min.)	82.0	±5.4	18	98.3	$P \leq .005$	6	83.3	NS	6
Diastolic Blood Pressure (mmHg)	63.9	±8.3	17	75.0	$P \leq .01$	6	66.0	NS	6
Mean Arterial Pressure (mmHg)	78.7	±8.2	17	89.2	$P \leq .001$	6	80.8	NS	6
EXERCISE STRESS									
Heart Rate (Beats/Min.)									
@25% $\dot{V}_{O_2}$ max	101.2	±4.9	18	119.3	$P \leq .001$	6	103.1	NS	6
@50% $\dot{V}_{O_2}$ max	124.2	±7.2	18	145.9	$P \leq .001$	6	128.4	NS	6
@75% $\dot{V}_{O_2}$ max	144.4	±7.8	17	158.9	$P \leq .001$	4	152.2	NS	6
Diastolic Blood Pressure (mmHg)									
@25% $\dot{V}_{O_2}$ max	58.2	±7.6	17	70.0	$P \leq .02$	6	61.3	NS	6
@50% $\dot{V}_{O_2}$ max	60.9	±7.5	16	72.2	$P \leq .001$	6	66.2	NS	6
Mean Arterial Pressure (mmHg)									
@25% $\dot{V}_{O_2}$ max	84.6	±9.2	6	97.5	$P \leq .01$	6	89	NS	6
@50% $\dot{V}_{O_2}$ max	93.1	±5.7	6	103.7	$P \leq .02$	6	95.9	NS	6
Exercise Stroke Volume (ml)	77.5	±6.4	6	64.2	$P \leq .01$	6	71.8	NS	6

control protocol vs. the constant work protocol of the 28-d bedrest study. The Apollo studies (2, 3) show that resting heart rate and $\dot{V}_E$ were elevated on R+0 while $\dot{V}_E$ and RER were elevated on R+1. $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, SBP and DBP were unchanged. Oxygen pulse was decreased on R+0 but normal by R+1.

SBP and DBP were reduced on R+0 during Apollo exercise tests, but these parameters returned to normal levels by R+1. In contrast, no changes in blood pressures were noted post-bedrest.

Cardiac output ($\dot{Q}$) was 30% decreased during Apollo exercise studies on R+0 but normal on R+1. Following bedrest, $\dot{Q}$ was statistically significantly elevated through R+8.

In summary, bedrest does not appear to be a good analog of Apollo if the bedrest duration exceeds 14 days.

III. Comparison of results from 28-d bedrest Study with Skylab Postflight Studies.

A. Skylab 2 (28-d orbital flight)

Post-Skylab heart rate responses both at rest and during exercise were similar to the heart rate response seen following bedrest. $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ remained constant at all exercise levels inflight and post-flight. This is in contrast to the finding post-bedrest where elevated exercise $\dot{V}_{O_2}$ implied decreased mechanical efficiency. No significant trends in SBP were noted inflight or post-flight in the Skylab crewmen. This finding was similar to that observed in our 28-d bedrest study. DBP trended down in flight but was elevated immediately post flight.

The Skylab astronauts exhibited an approximate 30% $\dot{Q}$ decrease coupled with an approximate 50% decrease in SV. As noted earlier, we observed an increased $\dot{Q}$ during the first week post-bedrest.

B. Skylab 4 (84-d orbital flight) - Consideration of upright and supine ergometry performed immediately post flight.

A disclaimer is required to the effect that there should not be any rigorous comparison between the 84-d Skylab Mission and the 28-d bedrest study. The differences in duration and physical activity levels preclude any such comparison. However, it is of interest to evaluate the post flight supine/upright ergometry studies with the supine/upright exercise testing immediately post 28-d bedrest.

1. Upright ergometry post flight vs. post bedrest.

Heart rate remained elevated through R+18 post-bedrest whereas it was not statistically significantly elevated post flight on R+0, but it was elevated on R+1. MAP was elevated post flight only on R+0; no elevation in MAP was observed post-bedrest. Post-flight, we observed decreased SV and $\dot{Q}$ with increased TPR on R+0. SV remained decreased on R+1 but this was compensated for by tachycardia to maintain $\dot{Q}$ at preflight levels. Post-bedrest we observed decreased SV on R+0 which increased until it was elevated above pre-bedrest levels on R+8. SV returned to pre-bedrest levels by R+18. $\dot{Q}$ was elevated R+0 through R+8 post-bedrest. TPR was significantly reduced on R+2 and R+8 post-bedrest. Therefore, the results of measurements made upright at comparable work levels post-spaceflight and post-bedrest were not similar.

2. Supine ergometry post-flight vs. post-bedrest.

Heart rate was elevated only on R+1 post-flight, whereas it was elevated at all post-bedrest tests through R+18. MAP was elevated both on R+0 and R+1 post-flight; no change in MAP was observed post-bedrest. Postflight SV was decreased, TPR was increased and tachycardia maintained $\dot{Q}$ within preflight limits on R+0. Post-bedrest, SV was normal on R+0 and R+1 but elevated on R+2 and R+8. $\dot{Q}$ was elevated on R+0, R+1, R+2 and R+8; TPR was decreased on R+2 and R+8. Exercise $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ were elevated post-bedrest whereas they were unchanged post spaceflight. In summary, the magnitude of response, the time course of the return to normal and the parameters affected are different following these two study conditions. Bedrest does not appear to be a good analog for studies of spaceflight, at least with respect to the physiological parameters measured in the studies compared in this report. A comparison of trends in cardiovascular parameters during moderate exercise following bedrest and spaceflight is shown in Table 4.

TABLE 4.

TRENDS IN CARDIOVASCULAR PARAMETERS DURING MODERATE EXERCISE FOLLOWING BEDREST AND SPACEFLIGHT

PARAMETER	DAY	HR	SBP	DBP	MAP	SV	$\dot{Q}$	TPR	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	$\dot{V}_E$
28-d Bedrest Study (Supine Exercise)	R+0	↑	-	-	-	-	↑	-	↑	↑	-
	R+1	↑	-	-	-	-	↑	-	↑	↑	-
28-d Bedrest Study (Upright Exercise)	R+0	↑	-	-	-	↓	↑	-	↑	↑	↑
	R+1	↑	-	-	-	-	↑	-	↑	↑	↑
14-d Bedrest Study (Upright Exercise)	R+0	↑	↑	↑	↑	↓	-	-	↑	-	-
	R+1	-	-	-	-	-	-	-	-	-	-
Apollo	R+0	-	↓	↓	-	-	↓	-	↓	-	-
	R+1	-	-	-	-	-	-	-	-	-	-
Skylab 28-d Mission (Upright Exercise)	R+0	↑	-	↑	-	↓	↓	↑	-	--	-
	R+1	↑	-	-	-	↓	↓	↑	-	-	-
Skylab 84-d Mission (Upright Ergometry)	R+0	-	↑	-	↑	↓	↓	↑	-	-	-
	R+1	↑	-	-	-	↓	-	-	-	-	-
Skylab 84-d Mission (Supine Ergometry)	R+0	-	↑	↑	↑	↓	-	↑	-	-	-
	R+1	↑	↑	↑	↑	-	-	-	-	-	-

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APPENDIX A

STATISTICAL EVALUATION OF BEDREST EXERCISE TESTING

TABLE A-1 MEASUREMENTS MADE DURING BEDREST PRIOR TO SUPINE EXERCISE. GROUP MEAN RESPONSE WAS TESTED FOR STATISTICAL SIGNIFICANCE RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSE USING THE PAIRED T-TEST.

TABLE A-2 MEASUREMENTS MADE DURING 75W SUPINE CYCLE ERGOMETRY IN BEDREST. GROUP MEAN RESPONSE WAS TESTED FOR STATISTICAL SIGNIFICANCE RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSE TO 75W EXERCISE.

TABLE A-3 THE RECOVERY PERIOD MEASUREMENTS MADE IN BEDREST AND TESTED FOR STATISTICALLY SIGNIFICANT DIFFERENCES RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSES.

TABLE A-4 POST-BEDREST MEASUREMENTS MADE IN THE SUPINE REST PERIOD WERE TESTED FOR STATISTICALLY SIGNIFICANT DIFFERENCES FROM PRE-BEDREST GROUP MEAN RESPONSES.

TABLE A-5 TEST FOR STATISTICALLY SIGNIFICANT DIFFERENCES IN SUPINE 75W EXERCISE RESPONSE. POST-BEDREST RELATIVE TO PRE-BEDREST.

TABLE A-6 STATISTICAL ANALYSIS OF POST-BEDREST SUPINE RECOVERY DATA WHEN COMPARED TO PRE-BEDREST RECOVERY PERIOD DATA.

TABLE A-7 STATISTICAL ANALYSIS OF UPRIGHT REST PERIOD MEASUREMENTS MADE FOLLOWING 28d OF BEDREST.

TABLE A-8 STATISTICAL ANALYSIS OF UPRIGHT 75W EXERCISE DATA OBTAINED POST 28d BEDREST.

TABLE A-9 STATISTICAL ANALYSIS OF UPRIGHT RECOVERY PERIOD DATA OBTAINED FOLLOWING 28d BEDREST.

TABLE A-1
SUPINE REST

PARAMETER		Group 2 Only BR+7	Group 1 Only BR+11	Both Groups 1 & 2 BR+13	BR+14	BR+15	BR+21	Group 1 Only BR+27
HR	n=	3	3	6	6	6	6	3
	t=	1.40	-0.78	-0.27	-0.28	-0.28	-2.96	0.56
	P=						<.05	
$\dot{V}_{O_2}$	n=	3	3	6	5	3	6	3
	t=	-0.52	3.00	1.03	2.01	-0.44	0.97	-0.40
	P=							
$\dot{V}_{CO_2}$	n=	3	3	6	5	3	6	3
	t=	0.76	-0.16	0.97	2.17	0.98	1.49	-2.97
	P=				<.05			<.05
$\dot{V}_E$	n=	3	3	6	5	6	6	3
	t=	1.25	-0.09	0.74	0.94	1.55	0.26	-0.40
	P=							
RR	n=	3	3	6	6	6	6	3
	t=	1.91	0.27	1.60	1.77	1.36	1.76	0.86
	P=							
SBP	n=	3	3	6	6	6	6	3
	t=	-0.82	-0.04	1.10	0.57	0.64	1.26	0.91
	P=							
DBP	n=	3	3	6	6	6	6	3
	t=	-1.42	-0.06	0.39	0.05	-0.72	-0.50	-0.75
	P=							
MAP	n=	3	3	6	6	6	6	3
	t=	-1.63	-1.30	0.68	0.27	-0.24	0.15	-0.08
	P=							
$\dot{Q}$	n=	3		4	4	3	3	
	t=	-1.45		-1.49	-0.24	-3.33	-1.08	
	P=					<.05		
SV	n=	3		6	4	3	3	
	t=	-1.52		-1.21	-0.14	-1.72	-0.43	
	P=							
TPR	n=	3		4	4	3	3	
	t=	1.64		1.73	0.84	3.28	1.27	
	P=							
$A\text{-}V_{O_2}$	n=	3		4	4	3	3	
	t=	1.33		1.94	1.05	1.75	2	
	P=							

TABLE A-2
SUPINE EXERCISE

PARAMETER		Group 2 Only BR+7	Group 1 Only BR+11	Both Groups 1 & 2 BR+13	BR+14	BR+15	BR+21	Group 1 Only BR+27
HR	n=	3	3	6	6	6	6	3
	t=	0.40	0.58	-0.78	-1.35	0.01	-4.91	-2.11
	P=						<.005	
$\dot{V}_{O_2}$	n=	3	3	6	5	3	6	3
	t=	-2.09	-3.39	-0.85	4.12	-2.12	0.63	-5.05
	P=		<.05		<.01			<.05
$\dot{V}_{CO_2}$	n=	3	3	6	5	3	6	3
	t=	-1.97	-2.35	-1.57	3.05	-1.25	-0.10	-6.64
	P=							<.05
$\dot{V}_E$	n=	3	3	6	5	6	6	3
	t=	-0.43	1.15	-0.08	-0.91	0.52	-0.92	-0.80
	P=							
RR	n=	3	3	6	5	6	6	3
	t=	-0.41	-1.69	1.41	0.64	2.53	1.57	2.18
	P=							
SBP	n=	3	3	6	6	6	6	3
	t=	-3.91	0.02	-0.93	-0.10	-1.17	-0.20	-0.19
	P=	<.05						
DBP	n=	3	3	6	6	6	6	3
	t=	-2.19	-0.27	-1.08	0.41	0.63	-0.36	-0.71
	P=							
MAP	n=	3	3	6	6	6	6	3
	t=	-2.76	-0.21	-1.15	0.81	0.28	-0.30	-0.45
	P=							
$\dot{Q}$	n=	3		6	5	2	5	2
	t=	-5.88		-5.3	-9.99	-5.31	-3.13	-4.47
	P=	<.05		<.005	<.005		<.05	
SV	n=	3		6	5	2	5	2
	t=	-4.36		-4.34	-3.58	-2.76	-2.10	-8.48
	P=	<.05		<.005	<.05			<.05
TPR	n=	3		6	5	2	5	2
	t=	5.01		4.09	6.52	7.73	1.73	2.26
	P=	<.05		<.005	<.005	<.05		
$A\text{-}V_{O_2}$	n=	3		6	5	2	5	2
	t=	2.15		6.66	13.2	5.0	2.47	15.8
	P=			<.005	<.005			<.05

TABLE A-3
SUPINE RECOVERY

PARAMETER		Group 2 Only BR+7	Group 1 Only BR+11	Both Groups 1 & 2 BR+13	BR+14	BR+15	BR+21	Group 1 Only BR+27
HR	n=	3	3	6	6	6	6	3
	t=	-0.02	-0.26	-1.74	-2.27↑	-1.45	-3.98	-4.38
	P=				<.05		<.005	<.05
$\dot{V}_{O_2}$	n=	3	3	6	4	3	6	3
	t=	-1.78	-0.38	-0.09	4.12	-1.60	-0.82	-0.55
	P=				<.05			
$\dot{V}_{CO_2}$	n=	3	3	6	5	3	6	3
	t=	-0.31	-5.02	0.12	5.02	-0.04	0.99	3.62
	P=		<.05		<.005			<.05
$\dot{V}_E$	n=	3	3	6	5	6	6	3
	t=	0.60	0.09	0.70	0.04	1.21	-0.89	0.29
	P=							
RR	n=	3	3	6	6	6	6	3
	t=	0.87	-0.31	0.57	0.95	1.57	0.88	1.78
	P=							
SBP	n=	3	3	6	6	6	6	3
	t=	-3.83	-1.45	-3.29	-1.73	-1.58	-1.80	-0.34
	P=	<.05		<.05				
DBP	n=	3	3	6	6	6	6	3
	t=	-1.47	-0.29	-0.74	0.41	-0.20	-1.66	-0.27
	P=							
MAP	n=	3	3	6	6	6	6	3
	t=	-1.62	-0.29	-1.62	-1.09	-1.57	-1.90	-0.86
	P=							
$\dot{Q}$	n=							
	t=							
	P=							
SV	n=							
	t=							
	P=							
TPR	n=							
	t=							
	P=							
$A\text{-}V_{O_2}$	n=							
	t=							
	P=							

TABLE A-4
SUPINE REST

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-8.99	-3.26	-4.3	-0.67	-2.0
	P=	<.005	<.05	<.005		
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-1.49	-2.18	-2.34	-2.93	-0.11
	P=				<.05	
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-0.09	-0.84	-1.06	0.27	1.77
	P=					
$\dot{V}_E$	n=	6	6	6	6	6
	t=	0.12	0.02	-0.17	0.77	1.30
	P=					
RR	n=	6	6	6	6	6
	t=	1.25	1.35	1.86	3.90	2.58
	P=				<.01	
SBP	n=	6	6	6	6	6
	t=	-0.16	0.01	1.51	1.27	-0.64
	P=					
DBP	n=	6	6	6	6	6
	t=	-1.77	0.41	-0.14	-0.51	0.84
	P=					
MAP	n=	6	6	6	6	6
	t=	-1.28	0.14	0.37	1.24	0.02
	P=					
$\dot{Q}$	n=	5	6	5	5	4
	t=	-1.50	-1.28	-1.92	0.30	0.76
	P=					
SV	n=	6	6	5	5	4
	t=	0.03	-0.56	0.58	0.15	1.04
	P=					
TPR	n=	6	6	5	5	4
	t=	0.18	2.54	3.86	0.48	-0.74
	P=		<.05	<.01		
$A\text{-}V_{O_2}$	n=	6	6	5	5	4
	t=	0.15	1.29	-2.18	-1.73	-1.16
	P=			<.05		

TABLE A-5
SUPINE EXERCISE

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-5.53	-13.05	-10.61	-2.35	-5.03
	P=	<.005	<.005	<.005	<.05	<.005
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-5.26	-5.70	-14.11	-2.96	0.26
	P=	<.005	<.005	<.005	<.05	
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-4.23	-8.85	-4.85	-1.42	1.01
	P=	<.005	<.005	<.005		
$\dot{V}_E$	n=	6	6	6	6	6
	t=	-0.65	-1.5	-1.49	1.79	0.17
	P=					
RR	n=	6	6	6	6	6
	t=	2.48	6.5	1.18	3.11	3.70
	P=	<.05	<.005		<.05	<.01
SBP	n=	6	6	6	6	6
	t=	-0.36	-0.70	1.22	1.53	-0.57
	P=					
DBP	n=	6	6	6	6	6
	t=	-1.21	-0.30	0.72	0.58	-0.17
	P=					
MAP	n=	6	6	6	6	6
	t=	-0.85	0.35	1.02	1.33	0.76
	P=					
$\dot{Q}$	n=	6	6	6	6	4
	t=	-2.11	-2.54	-7.08	-2.20	0.12
	P=	<.05	<.05	<.005	<.05	
SV	n=	6	6	6	6	4
	t=	-0.84	-0.90	-3.94	-2.25	1.17
	P=			<.005	<.05	
TPR	n=	6	6	6	6	4
	t=	0.68	1.90	3.31	3.09	0.49
	P=			<.05	<.05	
$A\text{-}V_{O_2}$	n=	6	6	6	6	4
	t=	-0.43	0.04	-0.42	1.33	-0.42
	P=					

TABLE A-6
SUPINE RECOVERY

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-5.79	-7.38	-9.89	-2.14	-3.65
	P=	<.005	<.005	<.005	<.05	<.01
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-2.42	-4.64	-4.58	-1.59	0.40
	P=	<.05	<.005	<.005		
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-2.59	-2.98	-3.36	-0.91	1.71
	P=	<.05	<.05	<.05		
$\dot{V}_E$	n=	6	6	6	6	6
	t=	0.93	-0.52	0.06	0.46	1.18
	P=					
RR	n=	6	6	6	6	6
	t=	-0.17	-0.08	0.74	1.23	1.34
	P=					
SBP	n=	6	6	6	6	6
	t=	-1.93	-2.97	0.37	-1.13	-1.44
	P=		<.05			
DBP	n=	6	6	6	6	6
	t=	-2.13	0.74	0.64	-0.15	-0.56
	P=	<.05				
MAP	n=	6	6	6	6	6
	t=	-2.03	-1.87	-0.30	-1.29	-1.39
	P=	<.05				
$\dot{Q}$	n=					
	t=					
	P=					
SV	n=					
	t=					
	P=					
TPR	n=					
	t=					
	P=					
A-V_{O_2}	n=					
	t=					
	P=					

TABLE A-7
UPRIGHT REST

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-11.58	-6.66	-20.2	-2.11	-2.43
	P=	<.005	<.005	<.005	<.05	<.05
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-1.67	-2.50	-1.48	-0.84	0.46
	P=		<.05			
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-0.07	-0.88	-0.20	0.58	1.44
	P=					
$\dot{V}_E$	n=	6	6	6	6	6
	t=	0.99	0.46	0.83	1.48	1.54
	P=					
RR	n=	6	5	6	6	6
	t=	0.62	0.94	2.03	2.09	-0.25
	P=			<.05	<.05	
SBP	n=	6	6	6	6	6
	t=	-1.92	-3.98	2.46	-0.46	-1.0
	P=		<.01	<.05		
DBP	n=	6	6	6	6	6
	t=	-1.47	0.60	0.16	0.67	0.02
	P=					
MAP	n=	6	6	6	6	6
	t=	-1.93	-0.40	0.64	0.18	-0.56
	P=					
$\dot{Q}$	n=	6	6	5	4	4
	t=	-0.59	-0.89	-0.91	-0.12	0.67
	P=					
SV	n=	6	6	5	4	4
	t=	2.63	0.54	-0.41	-0.15	0.95
	P=	<.05				
TPR	n=	6	6	5	4	4
	t=	-0.78	1.34	0.87	0.27	-0.75
	P=					
$A\text{-}V_{O_2}$	n=	6	6	5	4	4
	t=	-0.91	-0.79	0.41	-0.23	-0.54
	P=					

TABLE A-8
UPRIGHT EXERCISE

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-4.61	-8.58	-8.98	-3.55	-4.05
	P=	<.005	<.005	<.005	<.01	<.005
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-4.76	-9.69	-12.27	-4.77	0.51
	P=	<.005	<.005	<.005	<.005	
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-5.90	-48.08	-8.77	-5.36	-0.30
	P=	<.005	<.005	<.005	<.005	
$\dot{V}_E$	n=	6	6	6	6	6
	t=	-2.40	-2.33	-1.64	-1.09	-1.04
	P=	<.05	<.05			
RR	n=	6	5	6	6	6
	t=	1.04	3.03	0.38	2.63	1.59
	P=		<.05		<.05	
SBP	n=	6	6	6	6	6
	t=	-1.40	-1.25	-0.36	-0.63	-0.54
	P=					
DBP	n=	6	6	6	6	6
	t=	-0.26	0.31	0.61	0.46	-0.54
	P=					
MAP	n=	6	6	6	6	6
	t=	-0.68	-0.53	0.41	0.22	-0.96
	P=					
$\dot{Q}$	n=	6	6	6	5	4
	t=	-3.06	-4.20	-3.78	-5.49	-0.45
	P=	<.05	<.005	<.01	<.005	
SV	n=	6	6	6	5	4
	t=	3.33	0.36	-1.15	-2.27	0.95
	P=	<.05			<.05	
TPR	n=	6	6	6	5	4
	t=	0.54	1.67	3.57	4.82	-0.75
	P=			<.01	<.005	
$A\text{-}V_{O_2}$	n=	6	6	6	5	4
	t=	-1.47	-1.01	2.12	2.82	0.60
	P=			<.05	<.05	

TABLE A-9
UPRIGHT RECOVERY

PARAMETER		R+0	R+1	R+2	R+8	R+18
HR	n=	6	6	6	6	6
	t=	-9.44	-8.87	-18.13	-3.07	-2.24
	P=	<.005	<.005	<.005	<.05	<.05
$\dot{V}_{O_2}$	n=	6	6	6	6	6
	t=	-2.75	-3.17	-3.21	-2.48	0.10
	P=	<.05	<.05	<.05	<.05	
$\dot{V}_{CO_2}$	n=	6	6	6	6	6
	t=	-2.64	-3.21	-2.73	-1.69	1.30
	P=	<.05	<.05	<.05		
$\dot{V}_E$	n=	6	6	6	6	6
	t=	0.03	0.52	0.35	1.92	1.29
	P=					
RR	n=	6	5	6	6	6
	t=	1.11	2.22	0.76	2.16	1.62
	P=		<.05		<.05	
SBP	n=	6	6	6	6	6
	t=	-3.03	-2.11	-1.77	-2.51	-2.37
	P=	<.05	<.05		<.05	<.05
DBP	n=	6	6	6	6	6
	t=	-2.33	-0.50	-0.08	-0.38	-0.42
	P=	<.05				
MAP	n=	6	6	6	6	6
	t=	-2.70	-1.11	-0.69	-1.71	-1.57
	P=	<.05				
$\dot{Q}$	n=					
	t=					
	P=					
SV	n=					
	t=					
	P=					
TPR	n=					
	t=					
	P=					
A-V_{O_2}	n=					
	t=					
	P=					

APPENDIX B

Figure 1. - Supine Resting Heart Rate ±SEM

Figure 2. - Heart Rate - 75W Supine ±SEM

Figure 3. - Supine Recovery Heart Rate ±SEM

Fiture 4. - Stroke Volume (ML/Beat) 75Watts & Rest-Supine

Figure 5. - Cardiac Output Supine Rest & 75W Exercises

Figure 6. - Total Peripheral Resistance - Rest & 75Watts Supine

Figure 7. - SBP Rest & 75W Supine

Figure 8. - DBP Rest & 75W Supine

Figure 9. - Mean Arterial Pressure (mmHg) Supine

Figure 10. - Oxygen Consumption - Rest, 75 Watts & Recovery

Figure 11. - Carbon Dioxide Production - Rest, 75 Watts & Recovery

Figure 12. - Minute Ventilation - Supine

Figure 13. - Heart Rate - Upright Rest

Figure 14. - Heart Rate - 75 Watts Upright

Figure 15. - Heart Rate - Upright Recovery

Figure 16. - Stroke Volume - Upright Rest & 75 Watts

Figure 17. - Cardiac Output - Upright Rest & 75 Watts

Figure 18. - Total Peripheral Resistance - Rest & 75 Watts upright

Figure 19. - SBP Rest & 75 W Upright

Figure 20. - DBP Rest & 75W Upright

Figure 21. - Mean Arterial Pressure (mmHg) Upright Rest & 75W

Figure 22. - Oxygen Consumption - Upright Rest, 75 Watts & Recovery

Figure 23. - Carbon Dioxide Production - Upright Rest, 75 Watts & Recovery

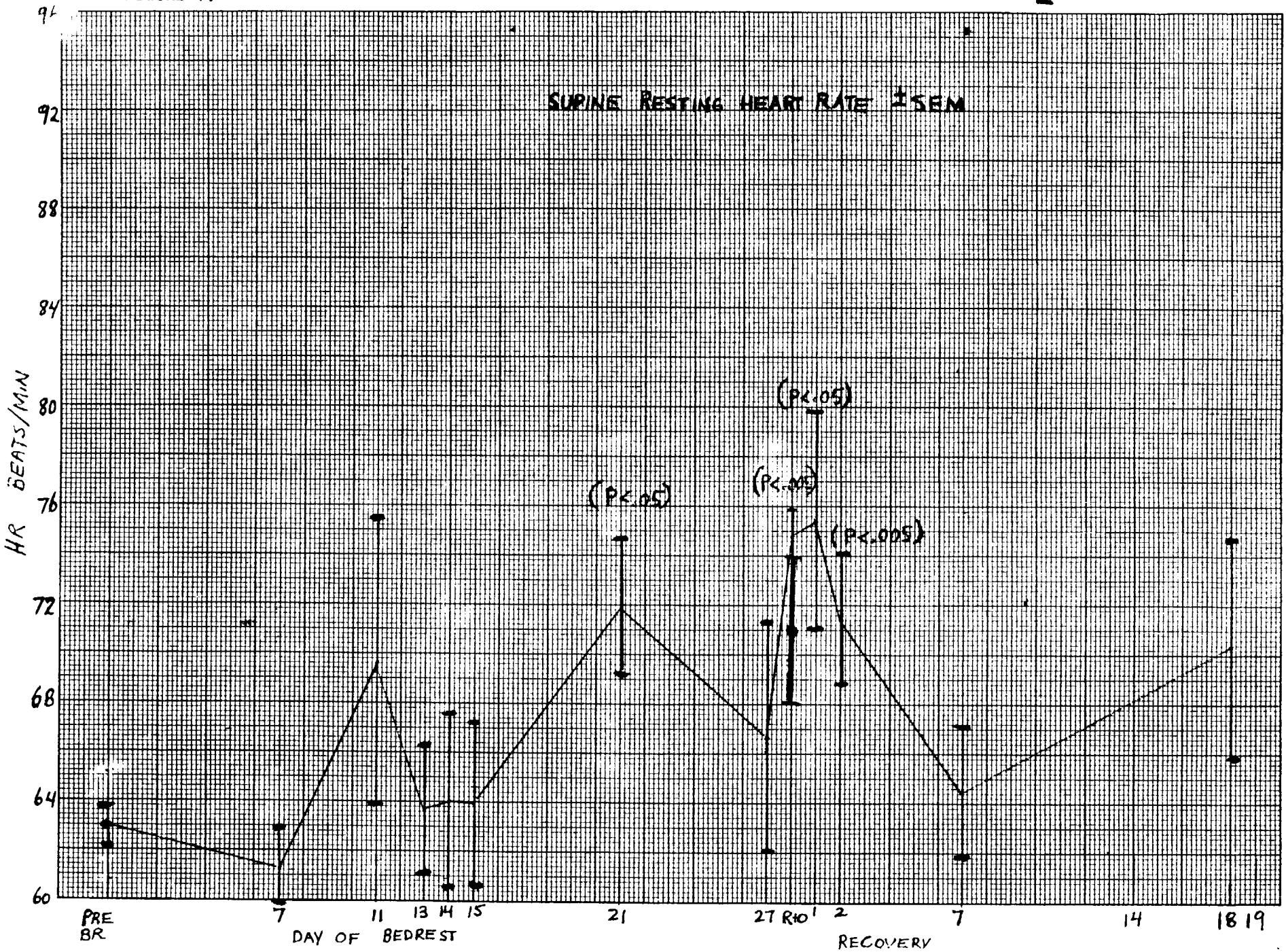
Figure 24. - Minute Ventilation - Upright

Figure 25. - Response of the Transient Analysis Model to a Stop Change in Work Rate

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

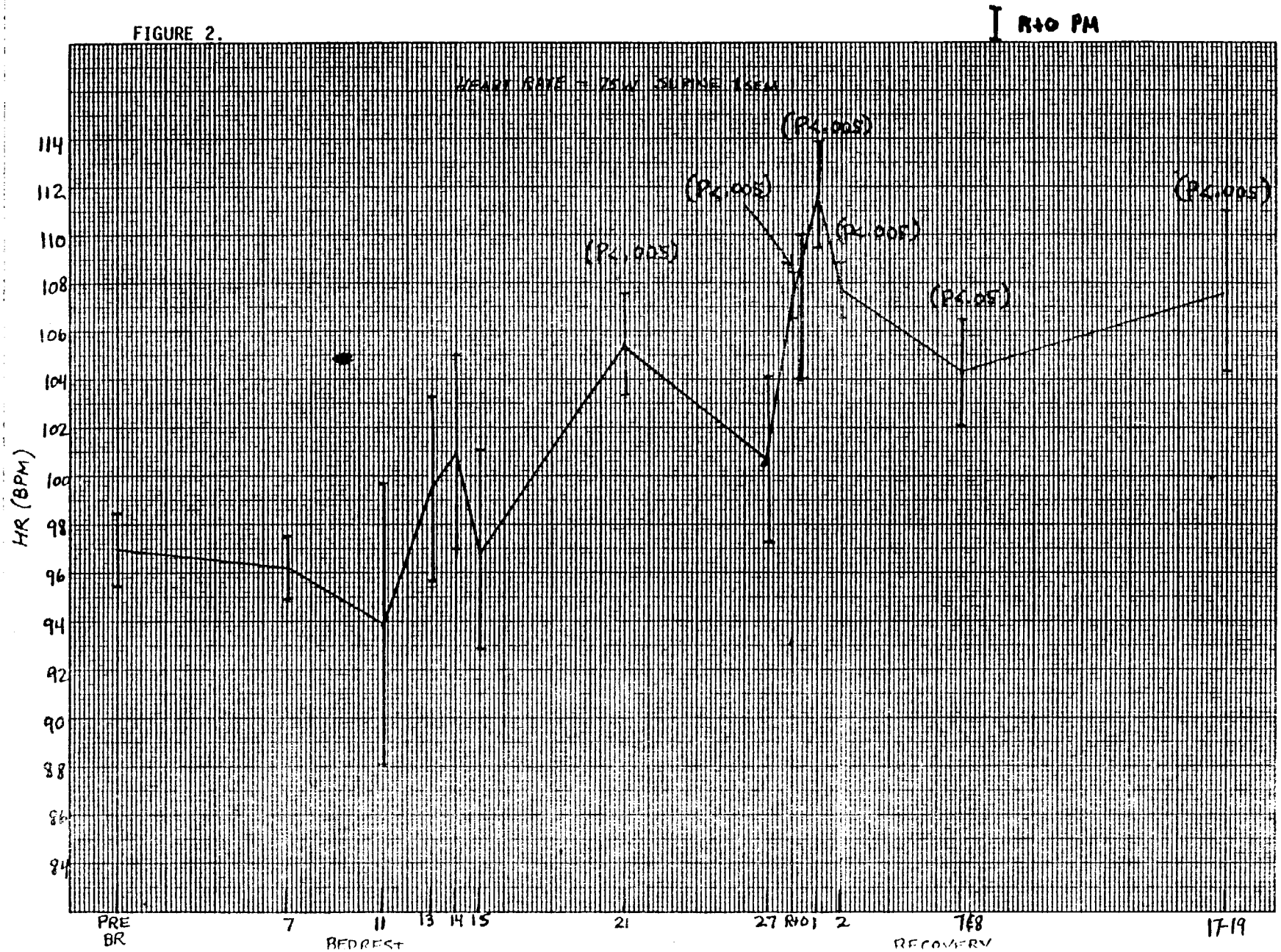
FIGURE 1.

I



K·E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 2.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
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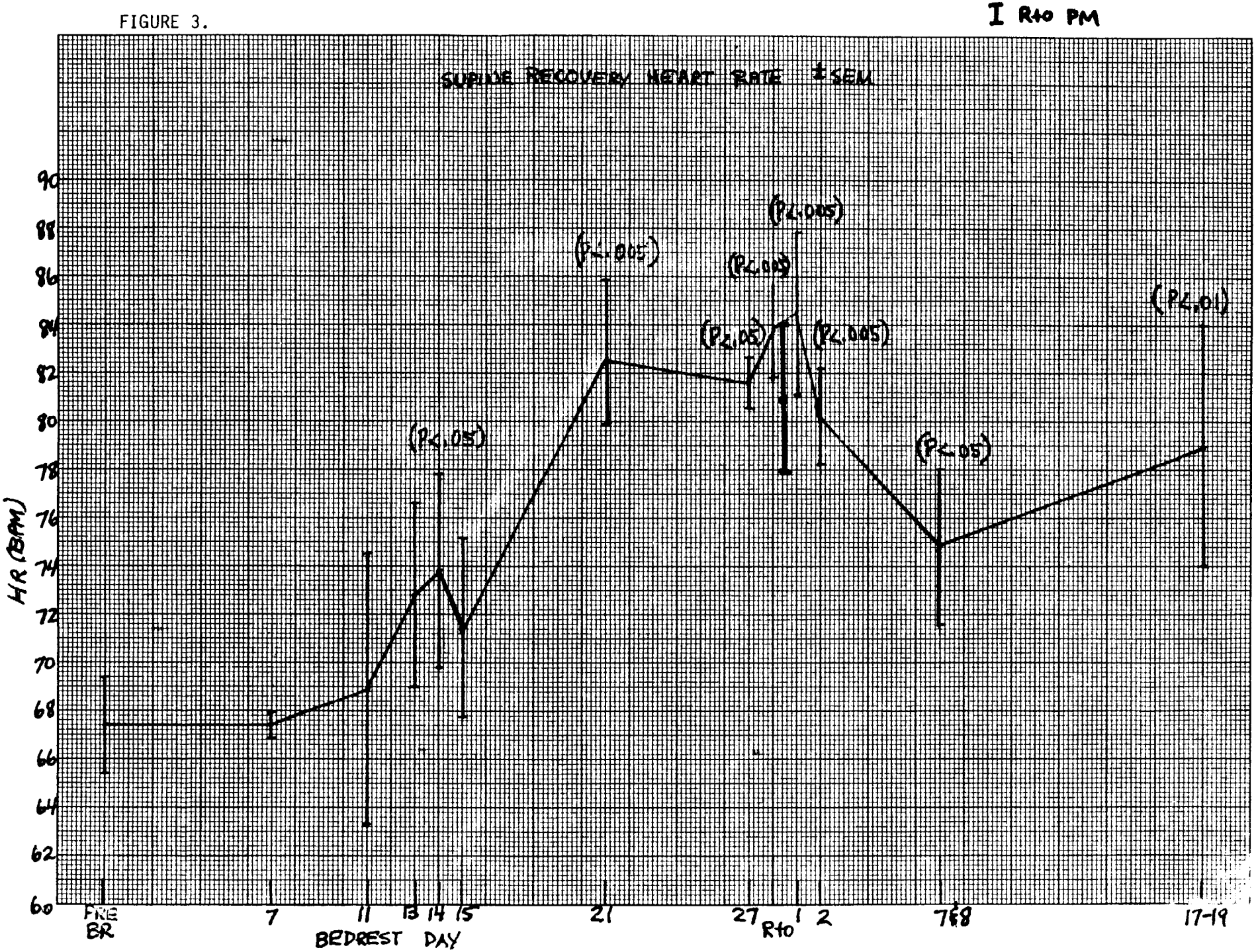
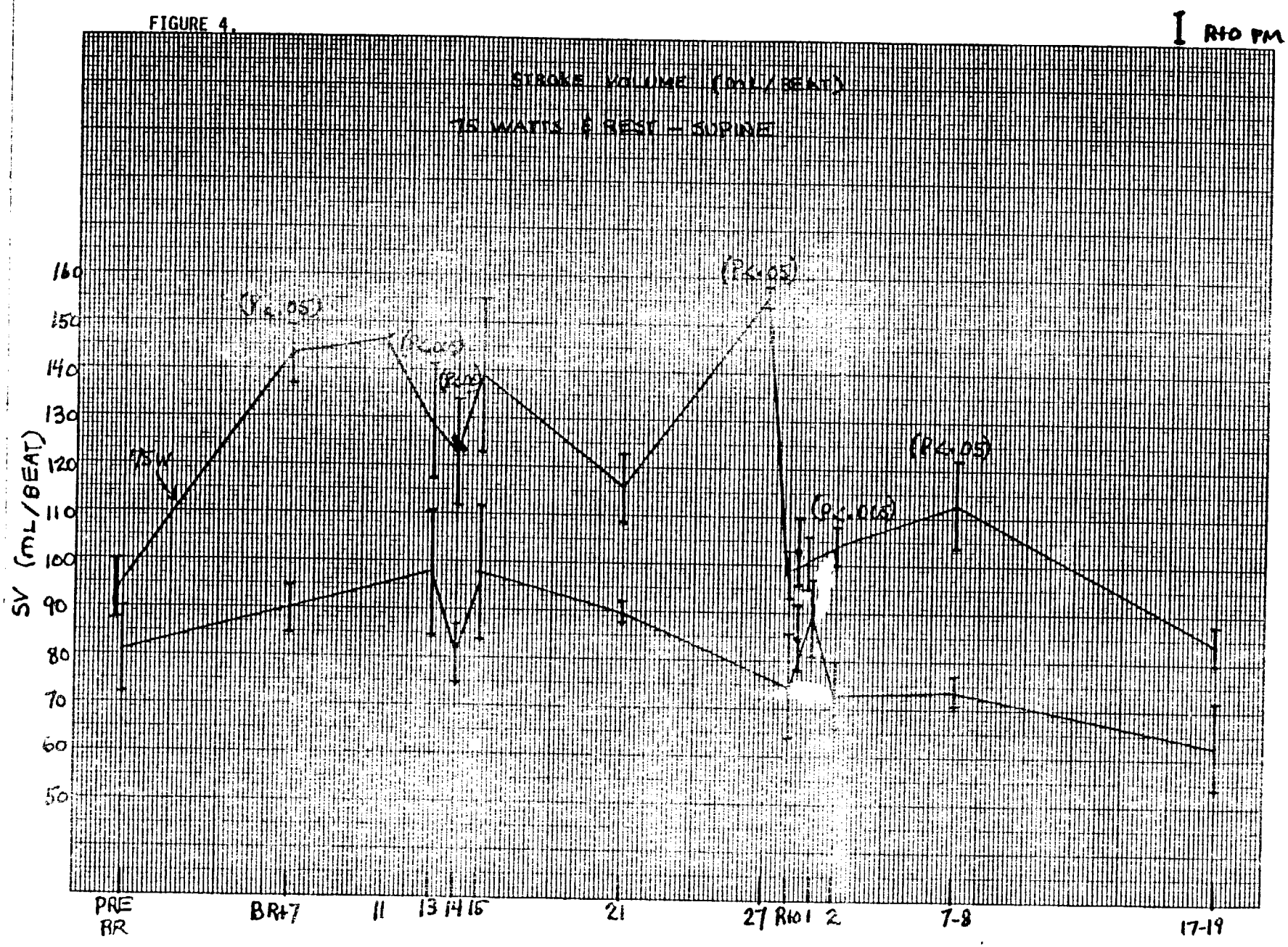
FIGURE 3.



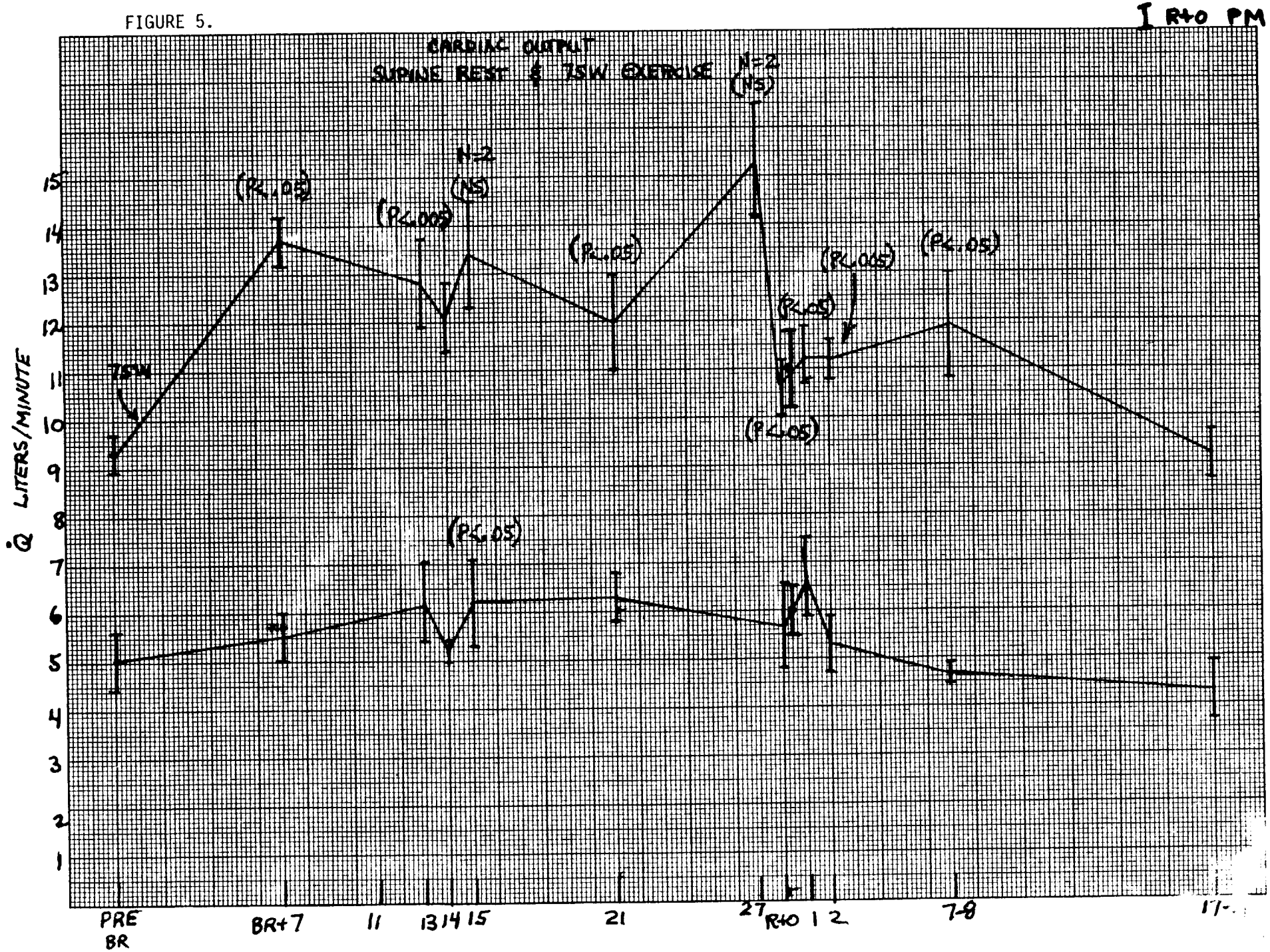
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.



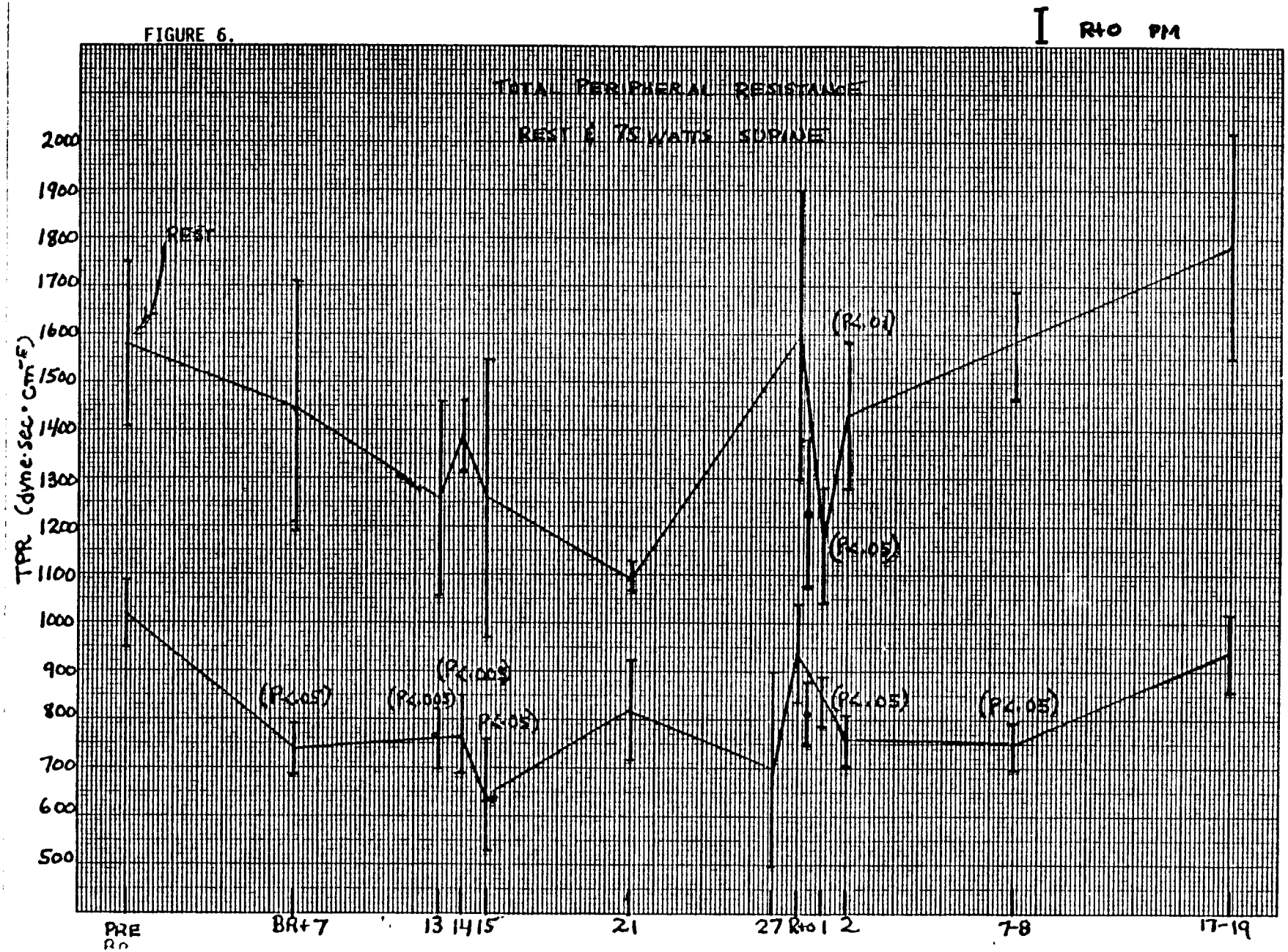
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 5.



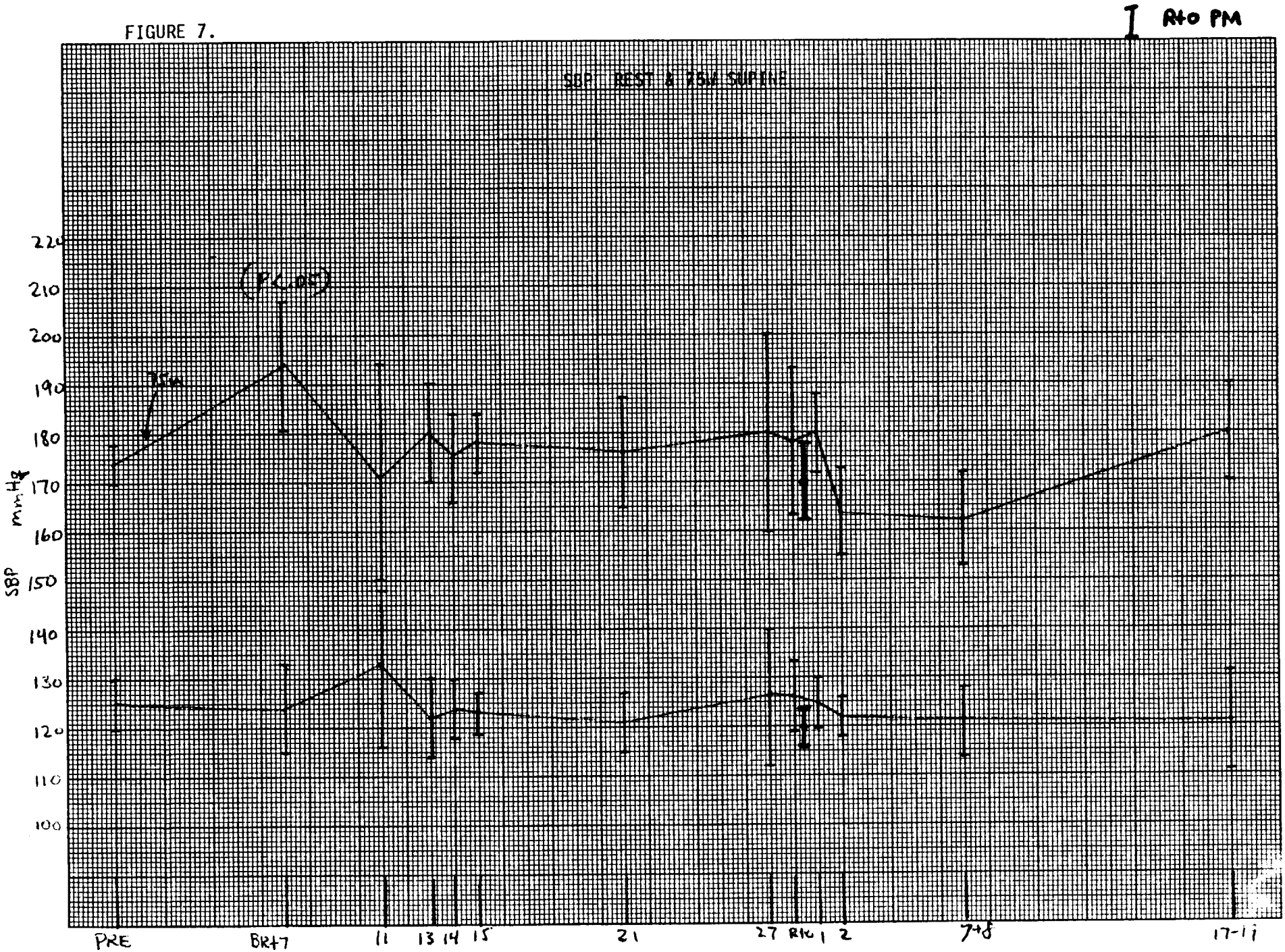
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 6.



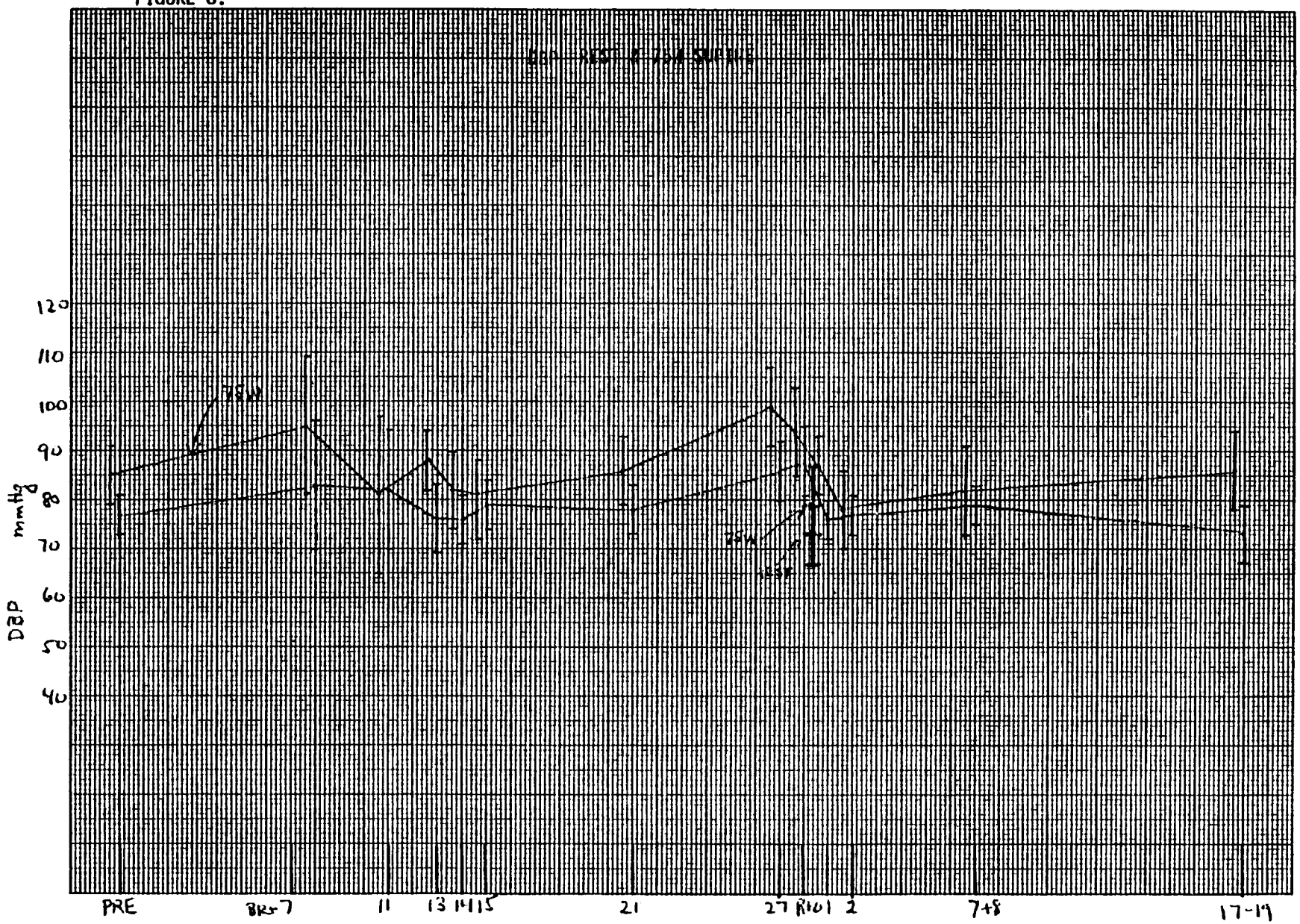
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 7.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 8.

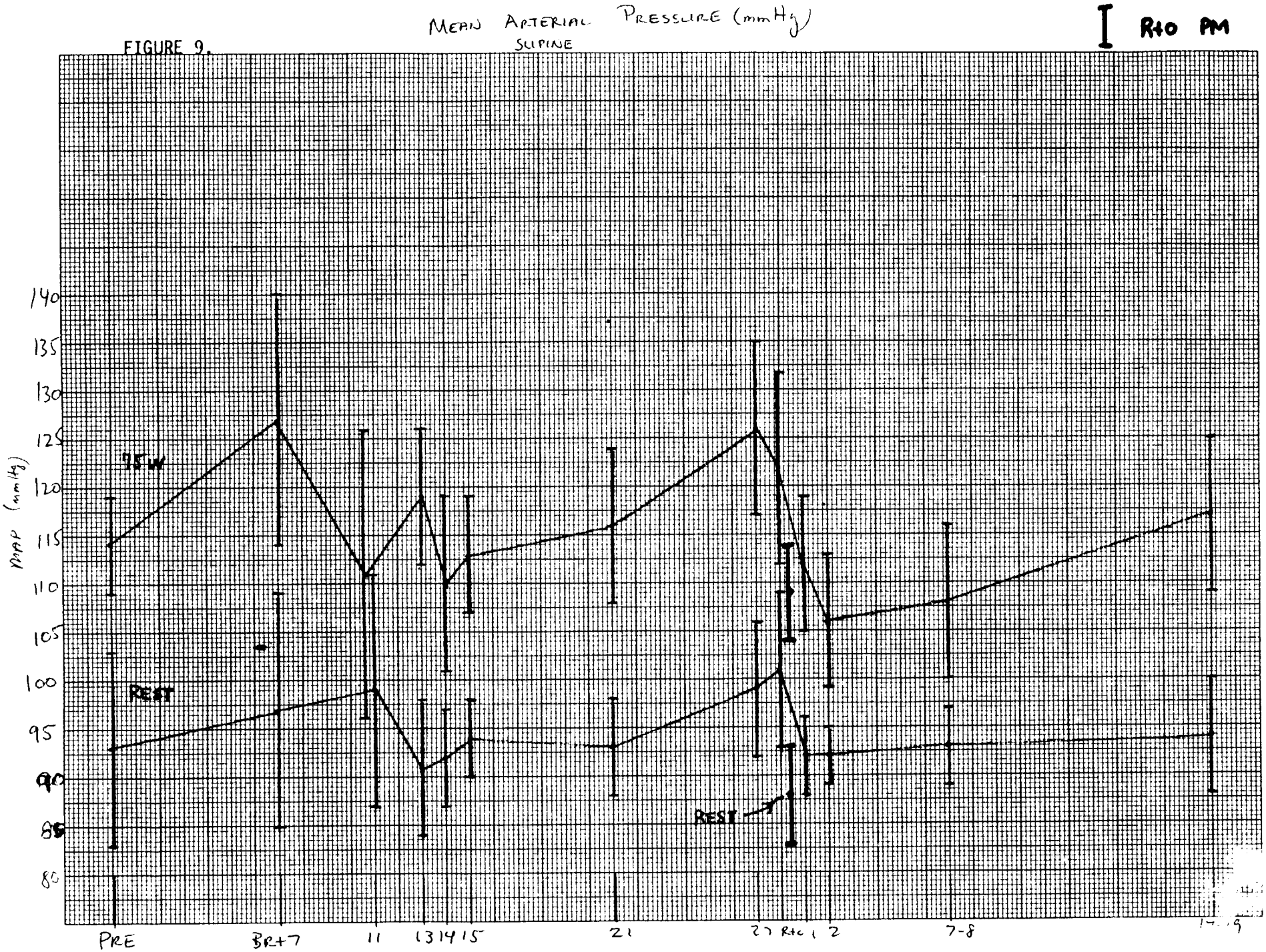


NO. 340-MP DIETZGEN GRAPH PAPER
MILLIMETER

EUGENE DIETZGEN CO.
MADE IN U. S. A.

FIGURE 9.

MEAN ARTERIAL PRESSURE (mmHg)
SUPINE



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 10.

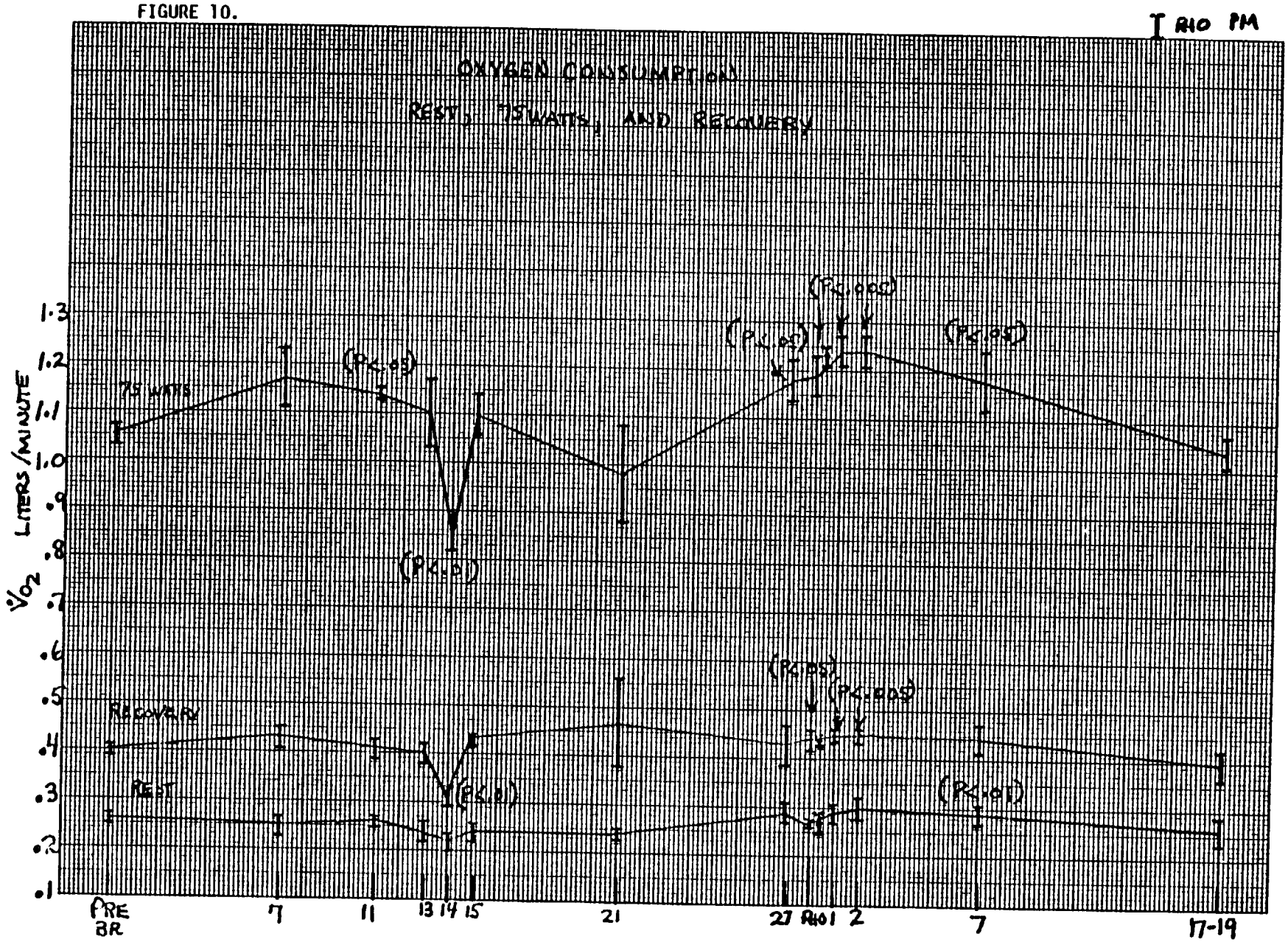


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FIGURE 11.

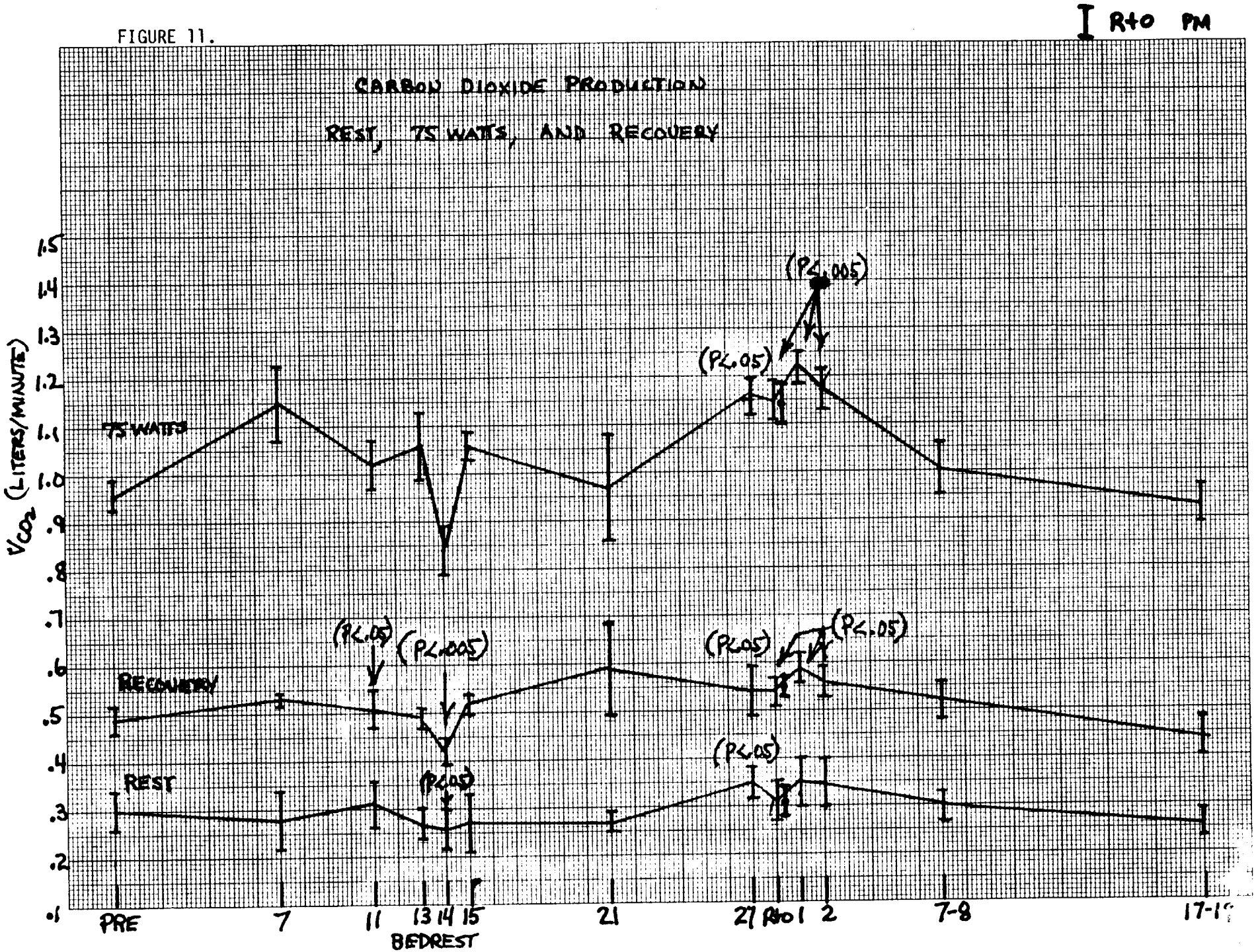

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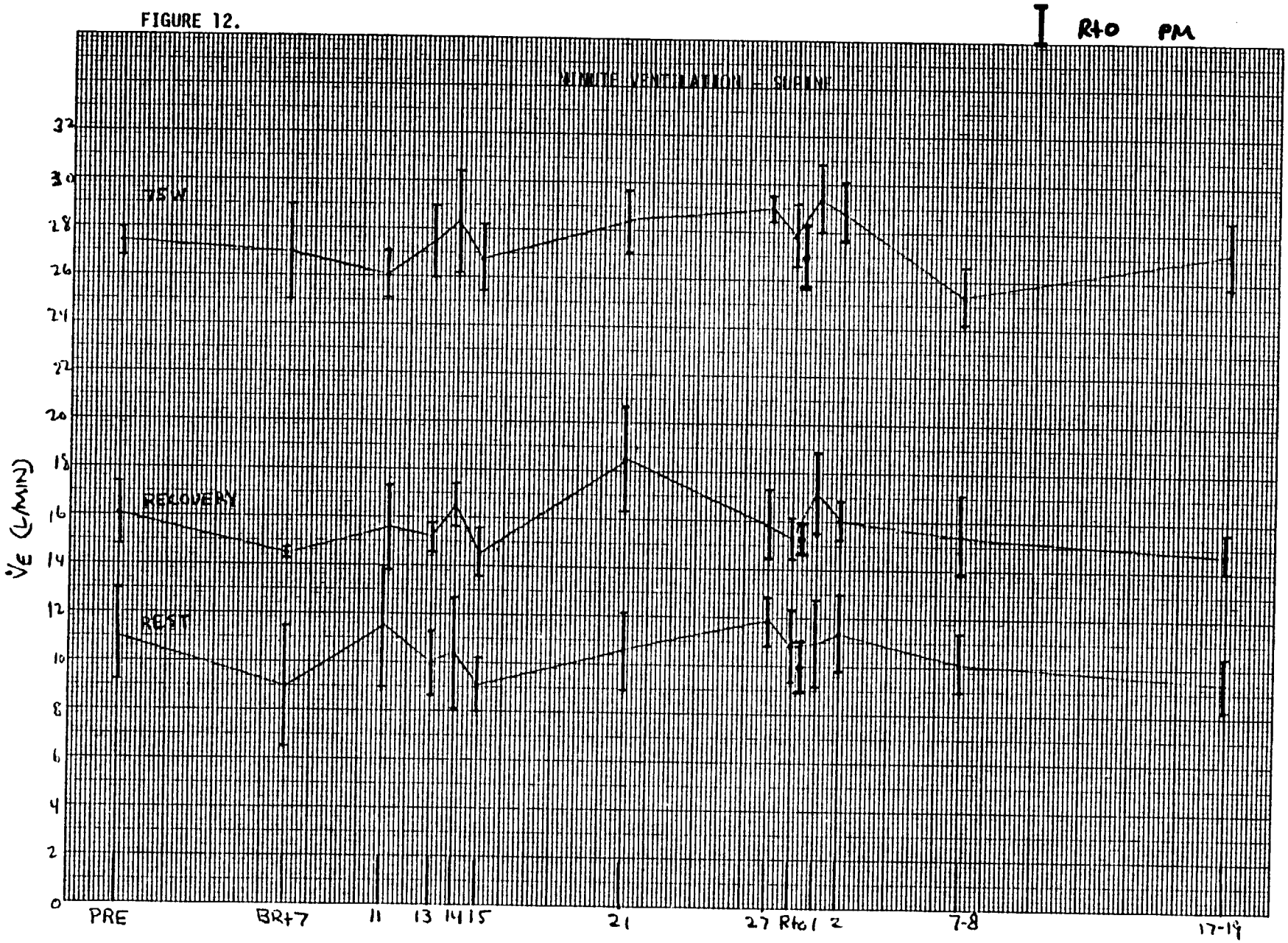
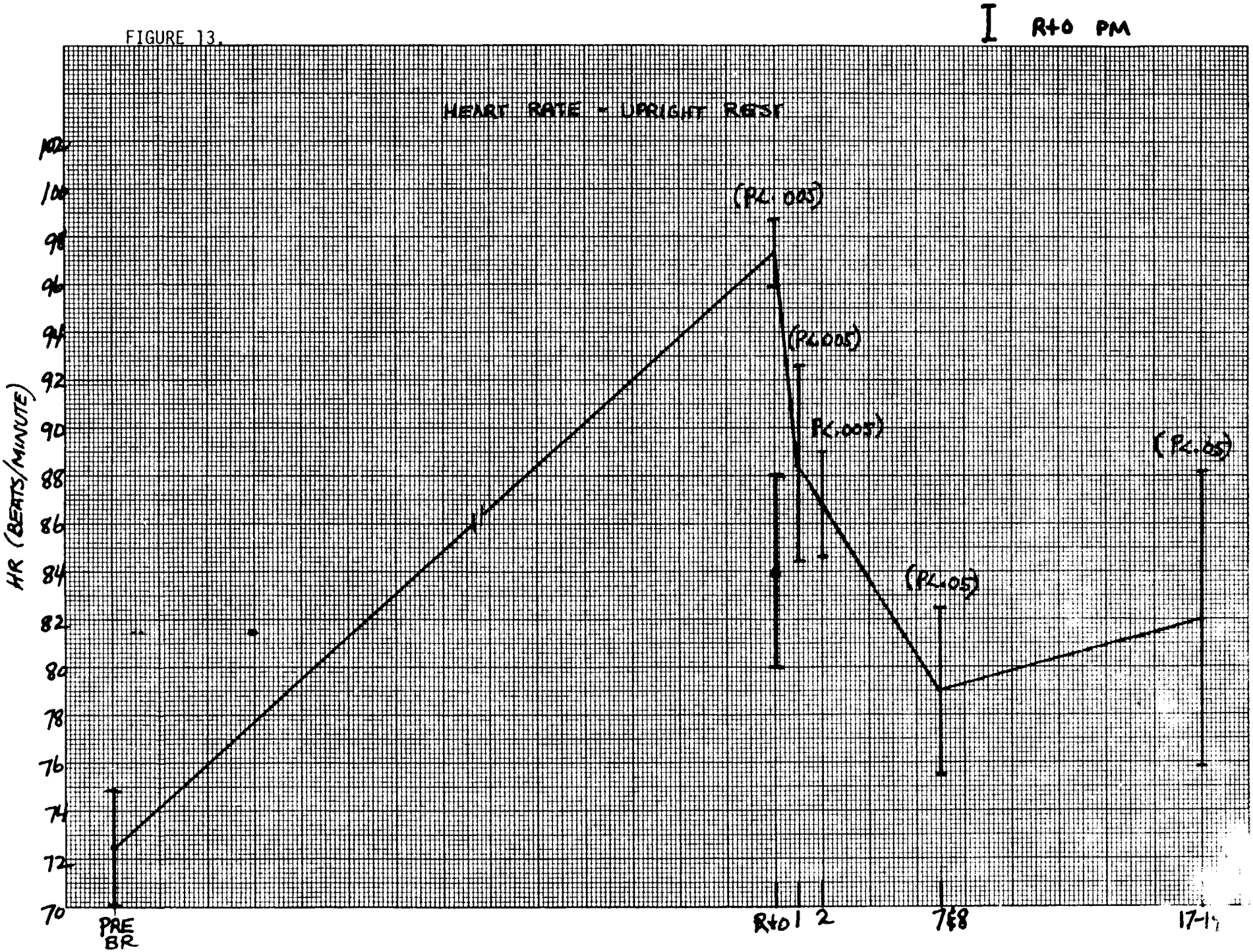
FIGURE 12.



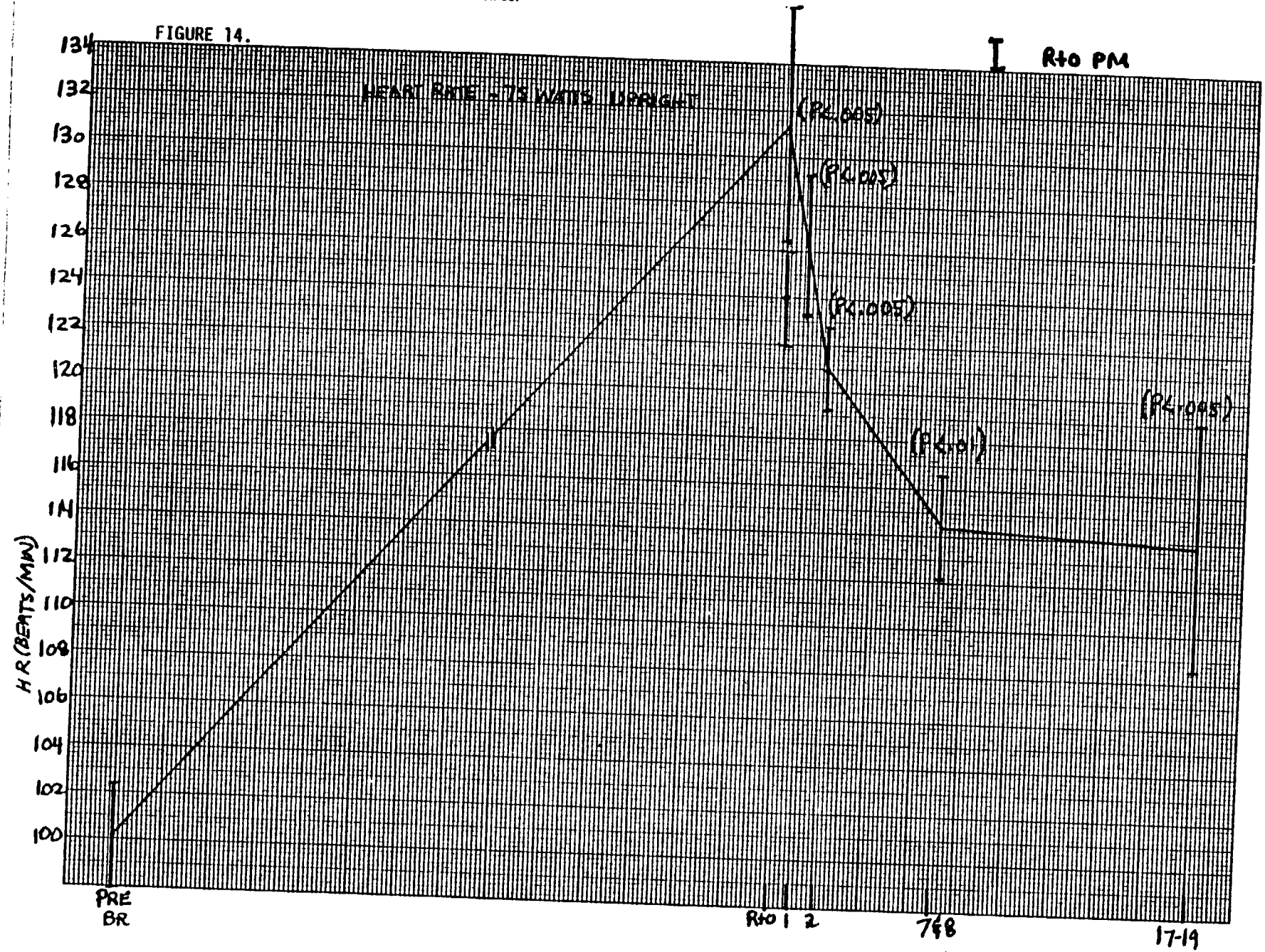
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 13.



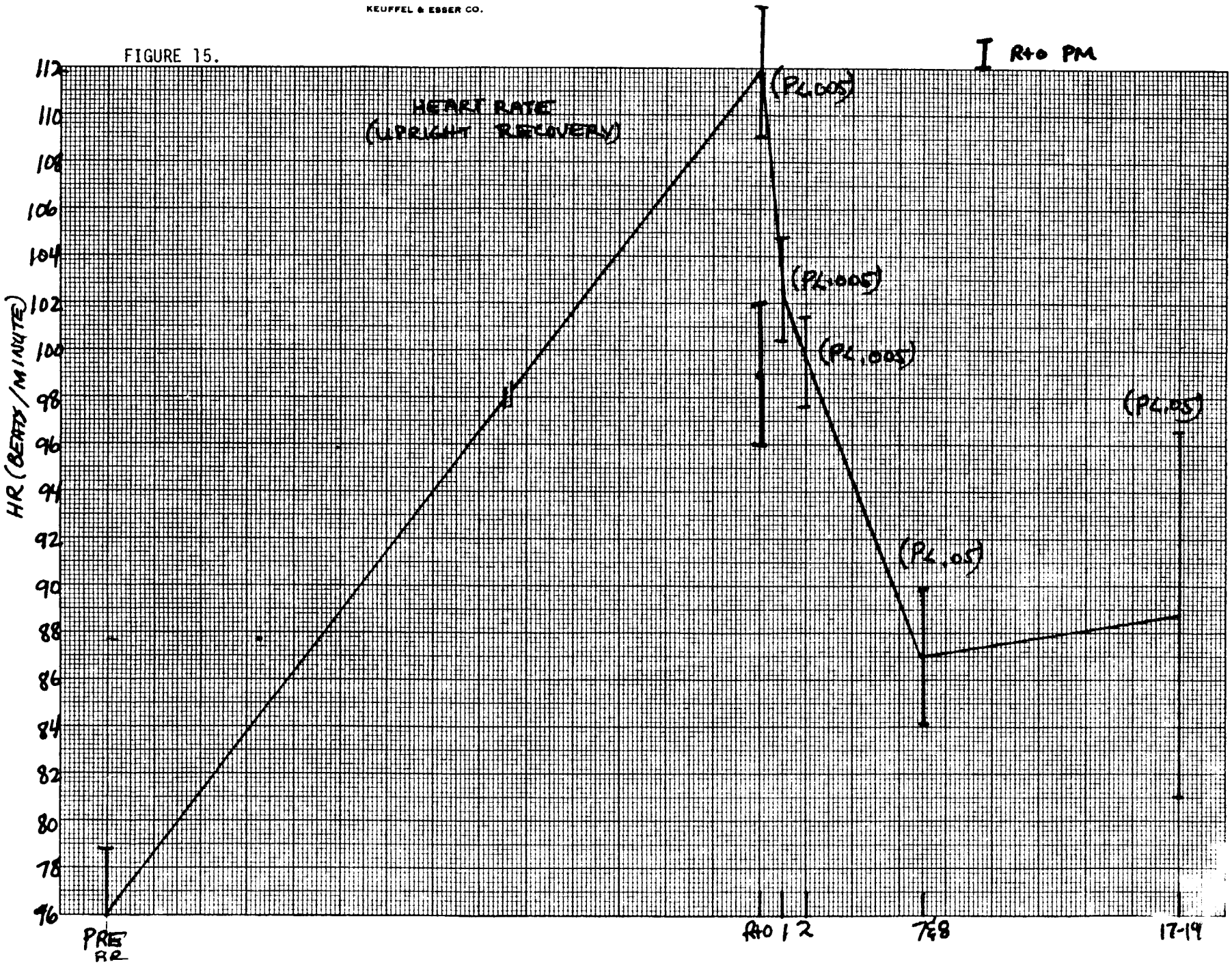
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 14.



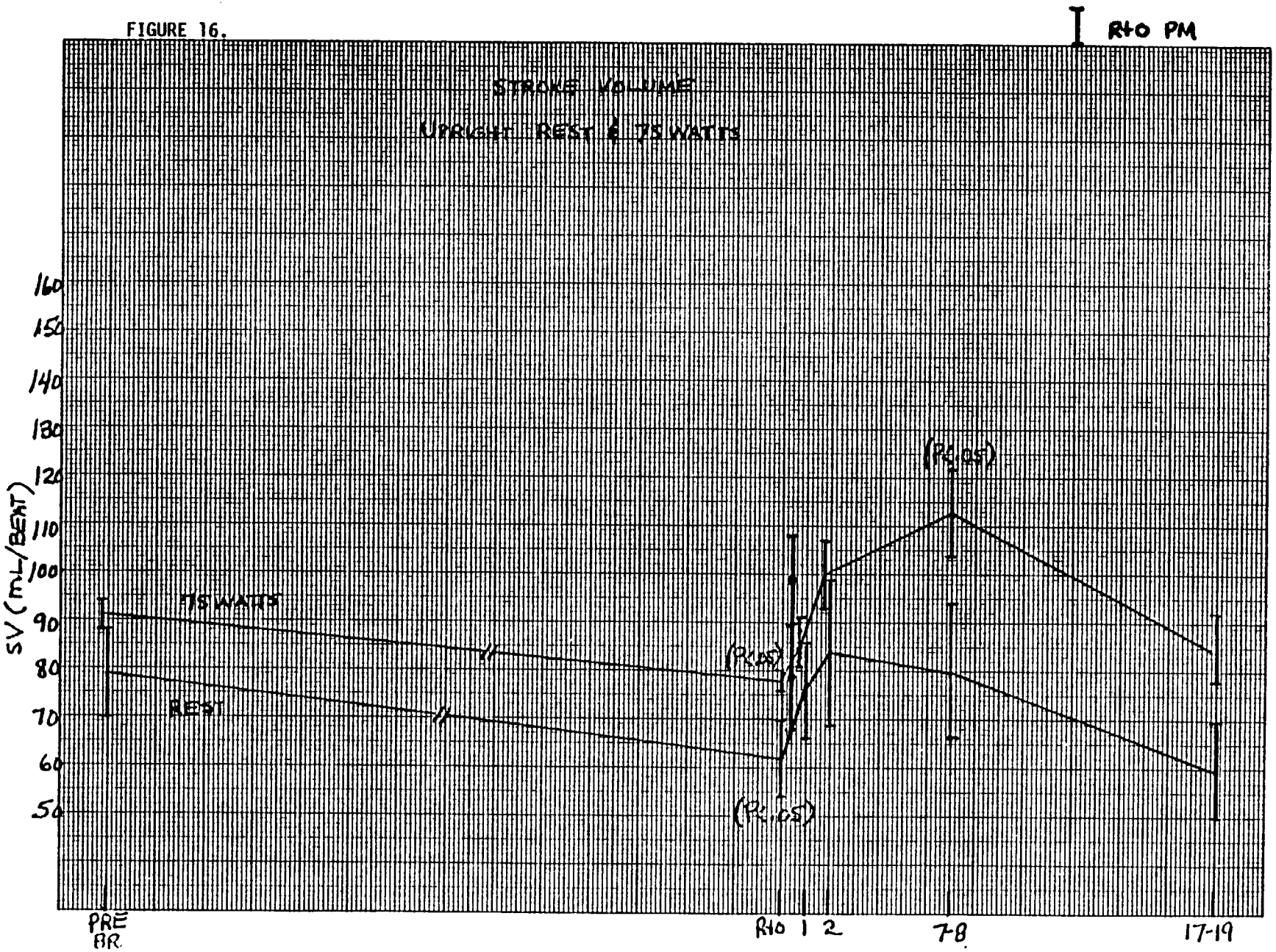
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 15.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 16.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 17.

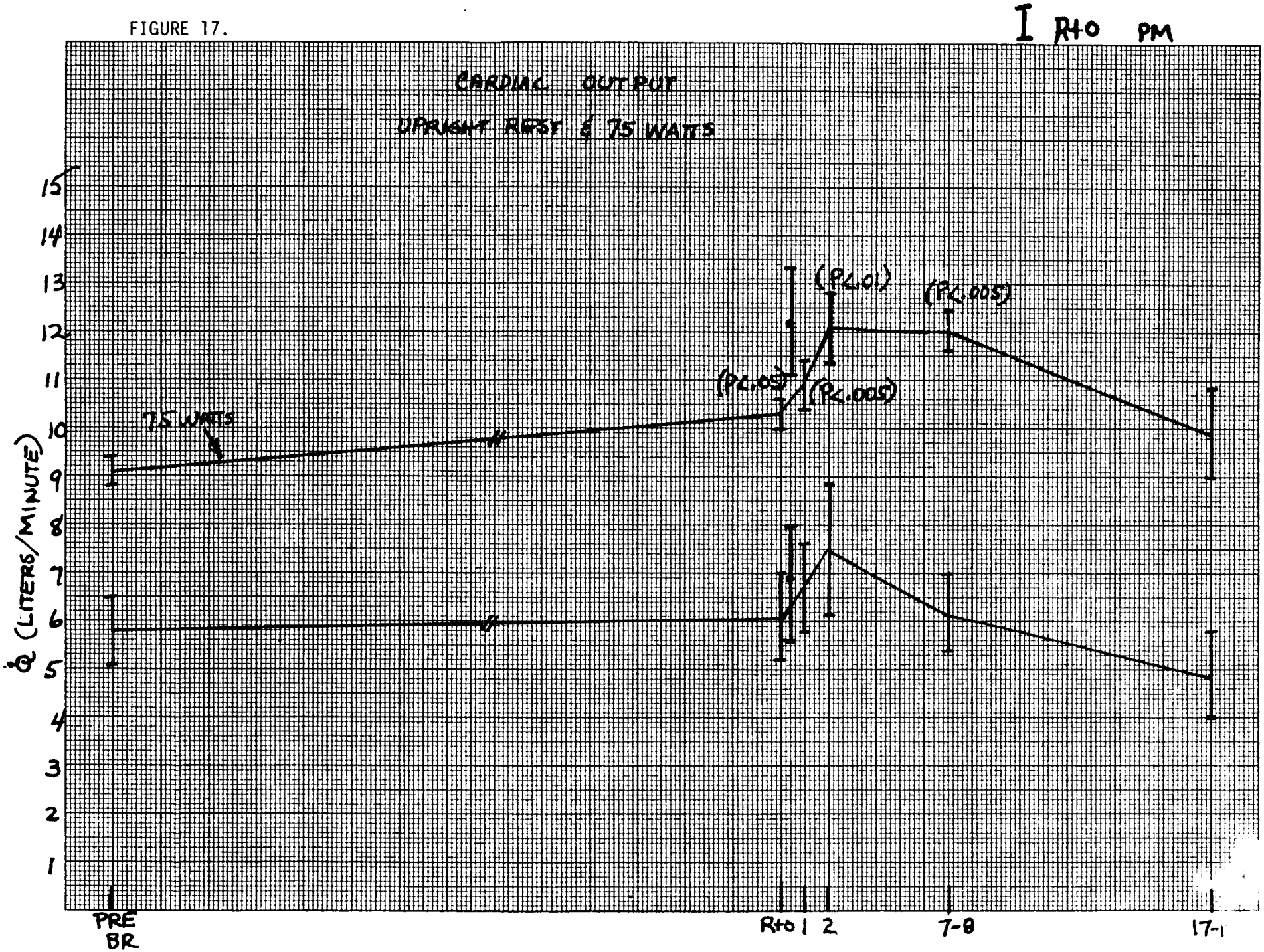


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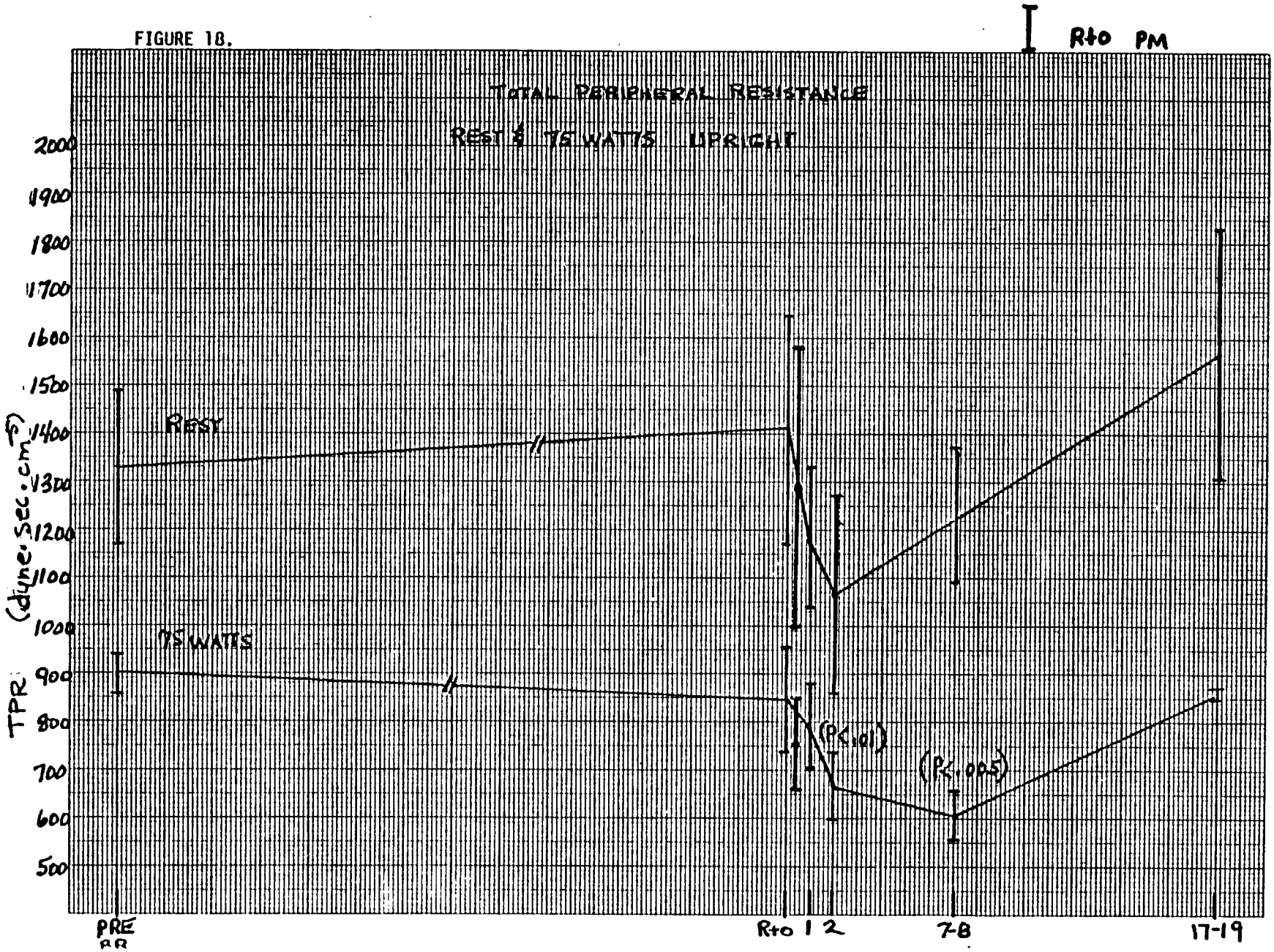
FIGURE 18.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
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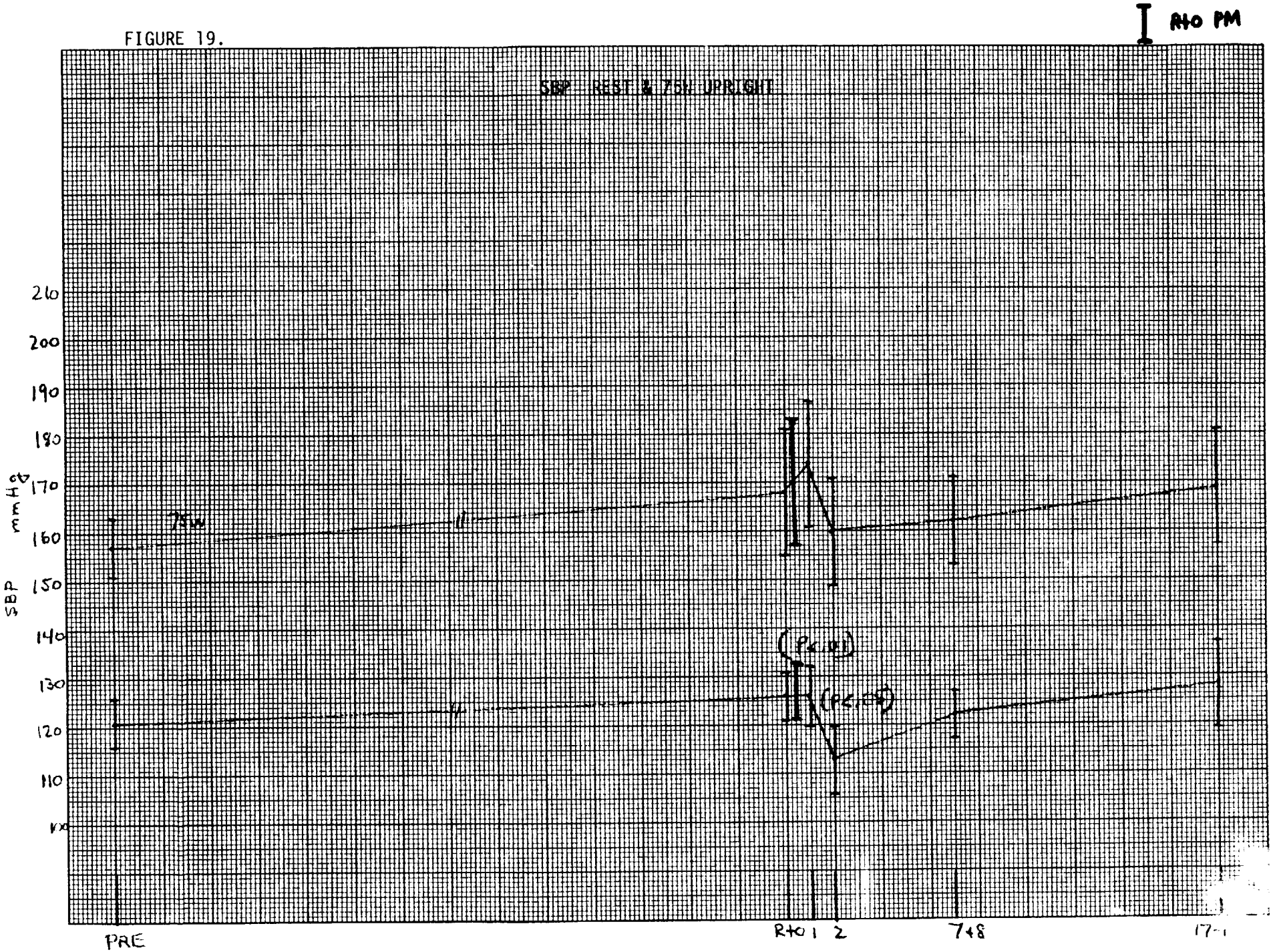
FIGURE 19.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 20.

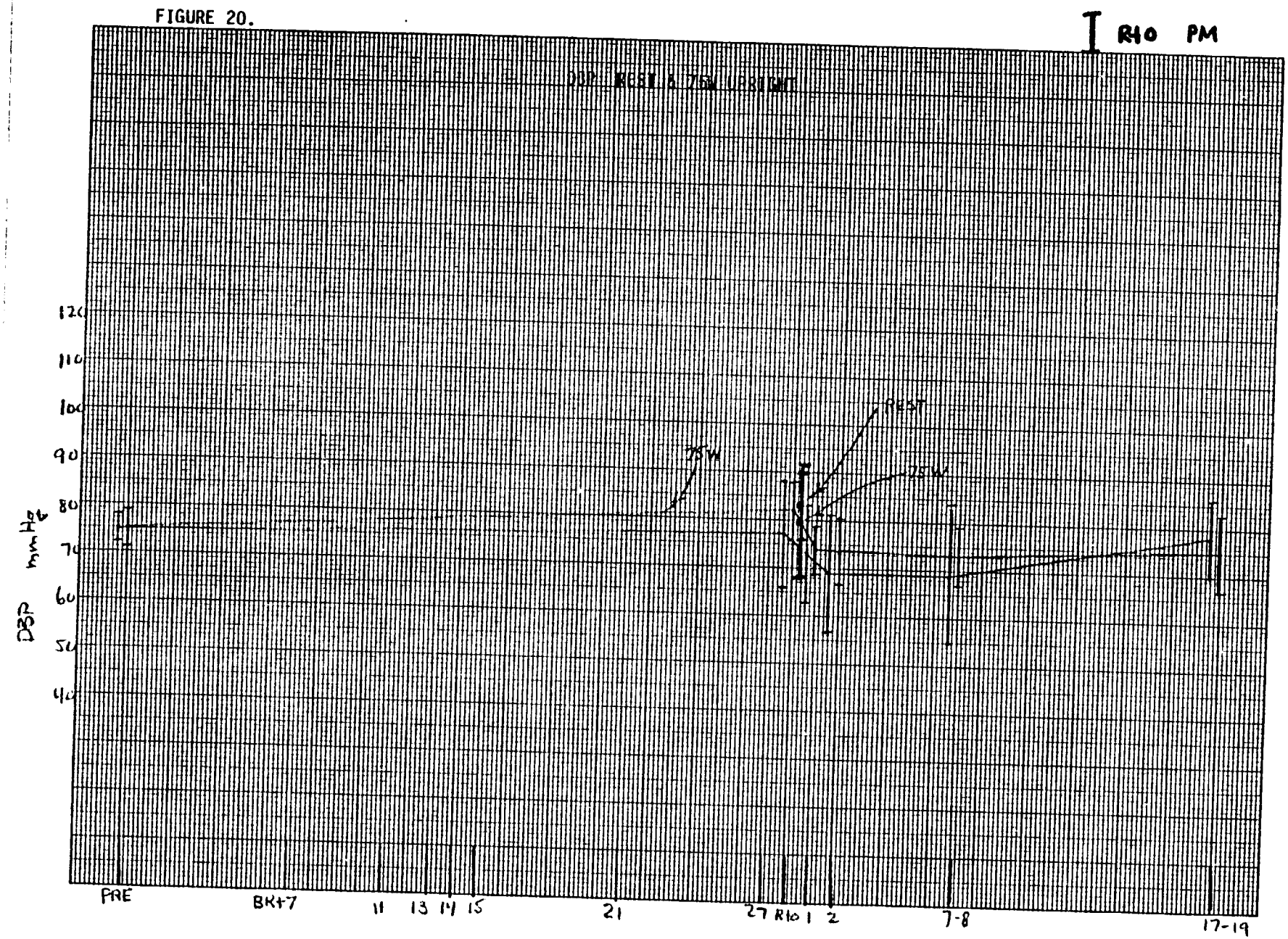


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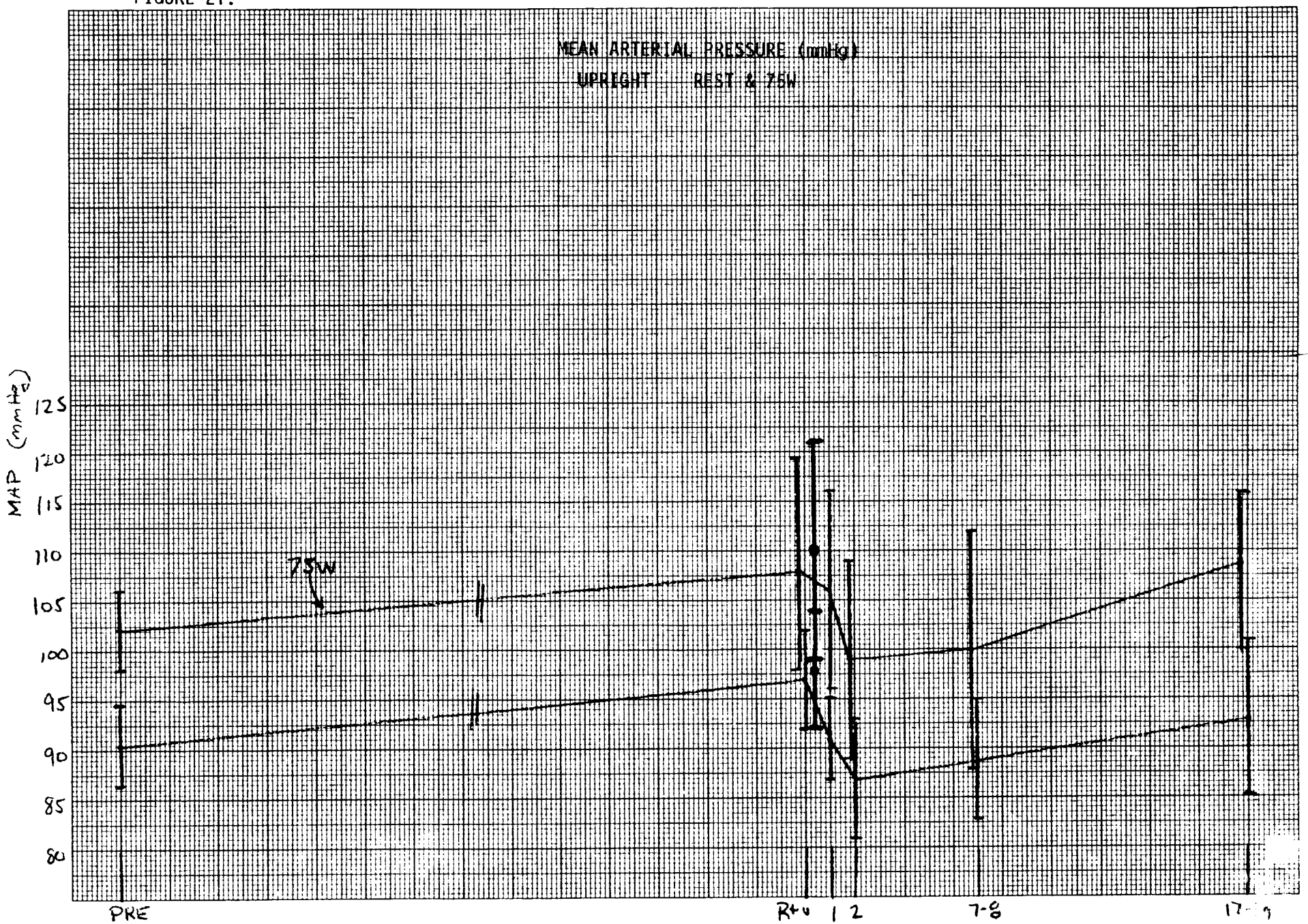
FIGURE 21.



K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 22.

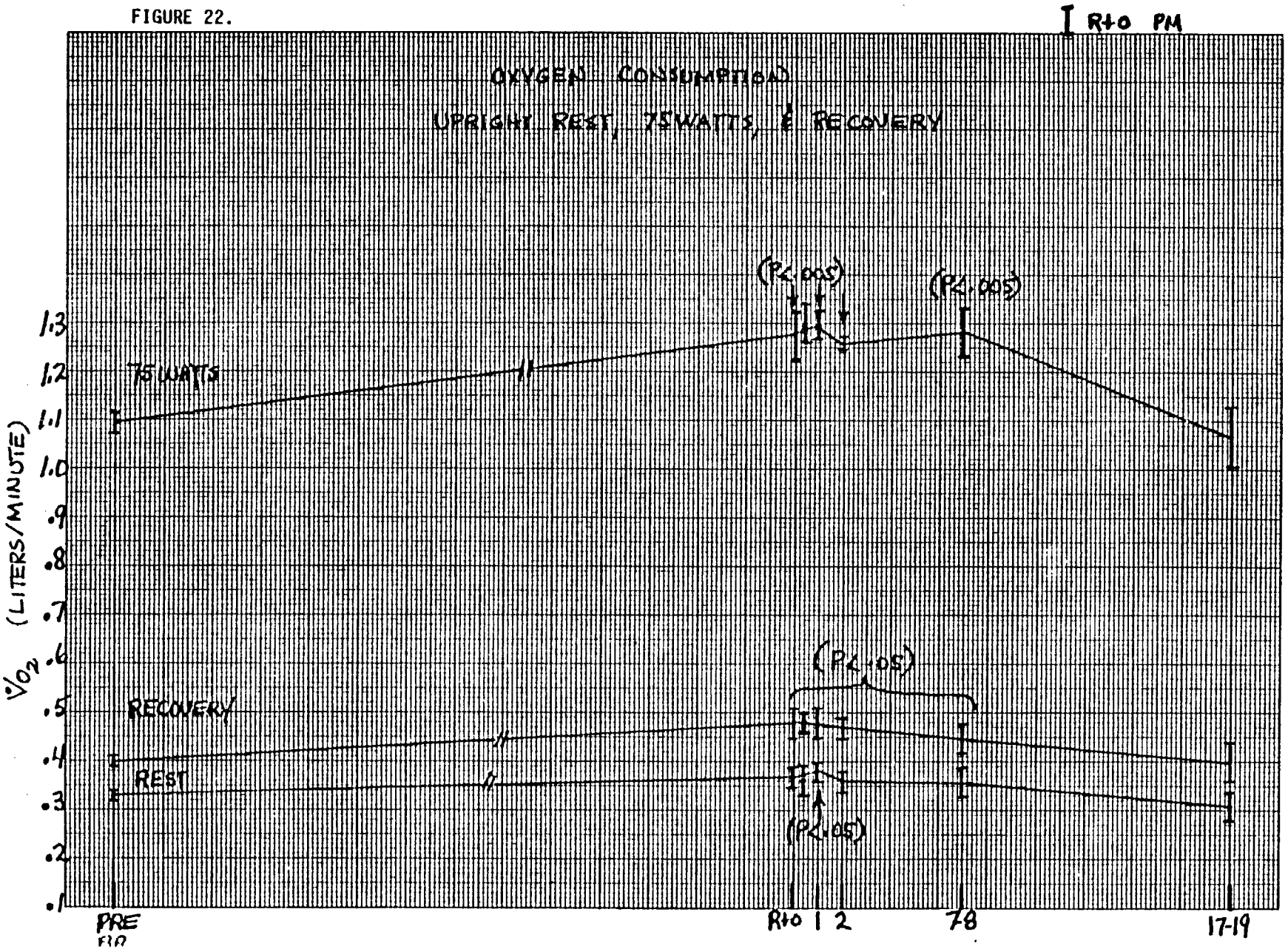


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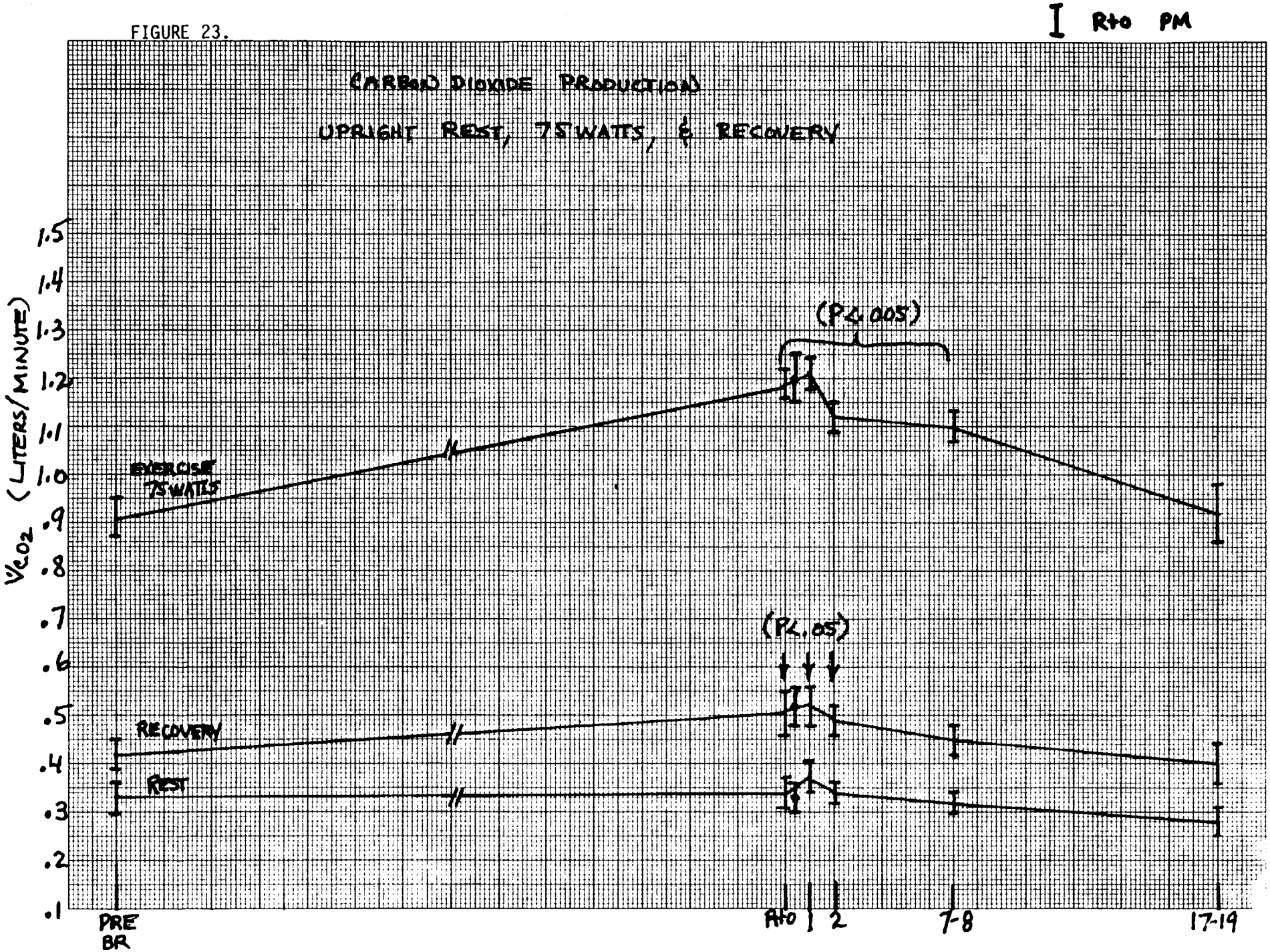
FIGURE 23.



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MADE IN U. S. A.

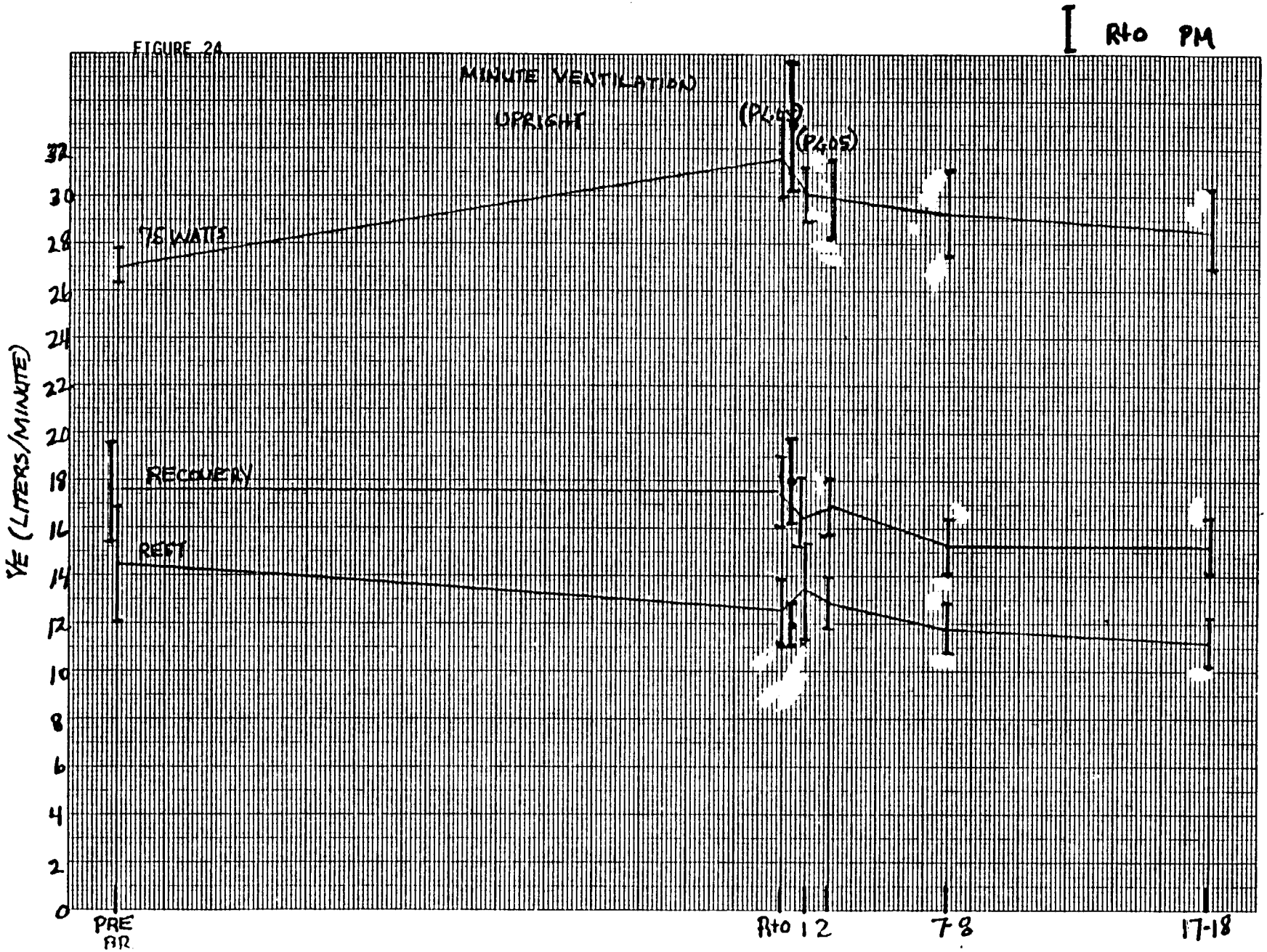
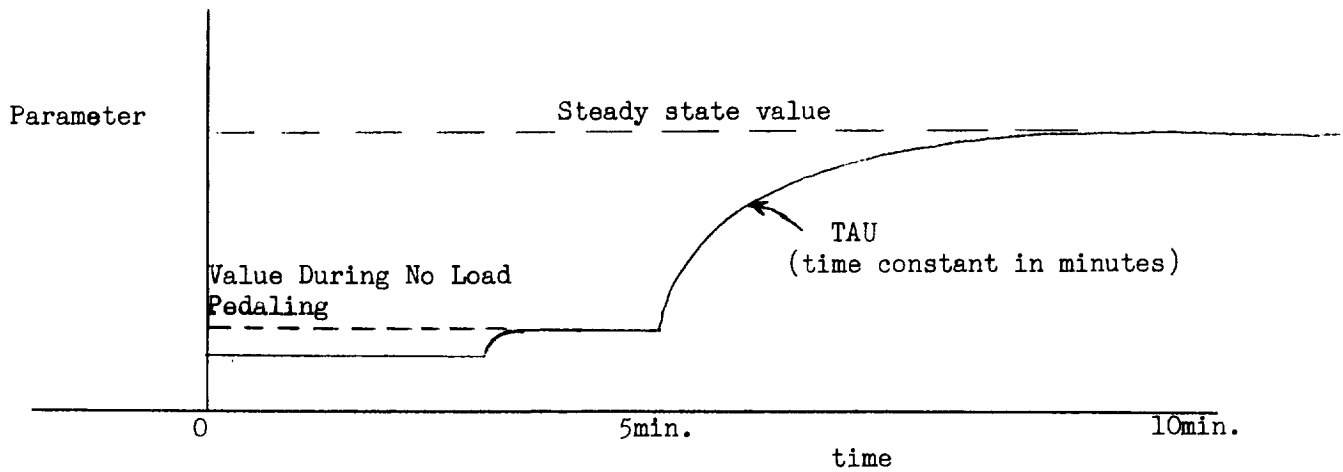


FIGURE 25



Parameters	Units
HR	beats/min
$\dot{V}O_2$	liters/min
$\dot{V}CO_2$	liters/min
$\dot{V}E$	liter/min

APPENDIX C

RESULTS FROM TRANSIENT ANALYSIS OF RESPIRATORY VARIABLES

TABLE C-1 GROUP MEAN RESPONSE TO SUPINE 75W EXERCISE DURING THE BEDREST STUDY

TABLE C-2 IN BEDREST GROUP MEAN RESPONSE TESTED FOR STATISTICAL SIGNIFICANCE RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSE TO SUPINE 75W EXERCISE.

TABLE C-3 POST-BEDREST GROUP MEAN RESPONSE TESTED FOR STATISTICAL SIGNIFICANCE RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSE TO SUPINE 75W EXERCISE

TABLE C-4 GROUP MEAN RESPONSE TO UPRIGHT 75W EXERCISE DURING THE BEDREST STUDY.

TABLE C-5 POST BEDREST GROUP MEAN RESPONSE TESTED FOR STATISTICAL SIGNIFICANCE RELATIVE TO PRE-BEDREST GROUP MEAN RESPONSE TO UPRIGHT 75W EXERCISE.

TABLE C-1

SUPINE EXERCISE

PARAMETER		Pre-br	br+7,11	br+13	br+14	br+15	br+21,27
				TAU			
HR	mean	.658	.587	.879	.761	.417	1.627
	S.D.	±.300	±.228	±.540	±.260	±.095	±2.069
$\dot{V}O_2$	mean	.689	.741	.814	.574	.665	1.142
	S.D.	±.195	±.120	±.331	±.328	±.041	±.467
$\dot{V}CO_2$	mean	1.198	1.655	1.243	1.192	1.256	2.287
	S.D.	±.315	±.482	±.305	±.379	±.261	±.952
$\dot{V}E$	mean	1.239	1.393	1.673	1.654	1.392	2.939
	S.D.	±.138	±.024	±.617	±1.314	±.627	±2.057
				Steady State Value			
HR	mean	98.8	94.5	101.0	107.0	100.7	106.2
	S.D.	±4.1	±.8	±9.8	±2.1	±8.1	±6.8
$\dot{V}O_2$	mean	1.170	1.169	1.088		1.134	1.293
	S.D.	±.088	±.145	±.025		±.054	±.187
$\dot{V}CO_2$	mean	1.050	1.433	1.016	1.038	1.072	1.445
	S.D.	±.069	±.183	±.227	±.432	±.186	±.260
$\dot{V}E$	mean	29.5	31.5	29.8	30.9	29.7	35.6
	S.D.	±1.3	±2.5	±3.6	±3.7	±5.8	±4.6
				Value During No Load Pedaling			
HR	mean	79.5	75.1	78.2	83.3	75.4	86.9
	S.D.	±7.9	±3.8	±4.5	±8.3	±8.0	±8.6
$\dot{V}O_2$	mean	.353	.230	.296	.303	.231	.369
	S.D.	±.074	±.234	±.160	±.010	±.030	±.181
$\dot{V}CO_2$	mean	.259	.257	.257	.245	.183	.337
	S.D.	±.068	±.125	±.110	±.131	±.048	±.143
$\dot{V}E$	mean	8.2	8.1	7.5	9.6	8.6	11.1
	S.D.	±1.5	±4.4	±3.7	±3.8	±4.2	±4.6

TABLE C-1 continued

SUPINE EXERCISE

Parameter		R+0	R+1	R+2	R+7,8	R+17,18
				TAU		
HR	mean	1.091	1.259	1.302	.578	.642
	S.D.	±1.159	±.806	±1.017	±.301	±.162
$\dot{V}O_2$	mean	.660	.842	.976	.913	.766
	S.D.	±.183	±.435	0± .442	± .465	± .138
$\dot{V}CO_2$	mean	1.715	2.246	1.846	2.103	1.290
	S.D.	±1.354	±1.680	±1.440	±1.736	± .142
$\dot{V}E$	mean	1.177	1.292	2.574	1.275	1.197
	S.D.	± .347	± .192	±2.952	± .372	± .333
				Steady State Value		
HR	mean	112.3	111.4	111.0	102.3	109.7
	S.D.	±10.2	±7.9	±1.5	±5.8	± 4.0
$\dot{V}O_2$	mean	1.217	1.283	1.279	1.196	1.047
	S.D.	± .121	± .086	± .094	± .078	±.090
$\dot{V}CO_2$	mean	1.335	1.383	1.325	1.321	1.034
	S.D.	± .225	± .186	± .211	± .326	± .127
$\dot{V}E$	mean	32.0	31.7	30.4	30.1	31.3
	S.D.	±4.7	±1.7	±1.8	±3.4	±1.7
				Value During No Load Pedaling		
HR	mean	89.0	91.5	90.7	83.5	85.6
	S.D.	±6.2	±11.9	±6.4	±7.8	± 12.4
$\dot{V}O_2$	mean	.336	.319	.381	.324	.227
	S.D.	±.083	± .102	±.132	±.158	±.117
$\dot{V}CO_2$	mean	.296	.288	.315	.280	.187
	S.D.	±.046	±.068	±.146	±.181	±.081
$\dot{V}E$	mean	9.7	9.4	12.8	9.5	9.6
	S.D.	±2.2	± 2.7	± 5.1	± 6.3	±3.3

TABLE G-2

SUPINE EXERCISE

PARAMETER		br+7,11	br+13	br+14	br+15	br+21,27
				TAU		
HR	n=		5	5	3	4
	t=		-.97	.19	.82	-.93
	P=					
$\dot{V}O_2$	n=	3	6	5	3	5
	t=	-1.42	-.65	.60	1.46	-2.46
	P=					< .05
$\dot{V}CO_2$	n=	4	6	4	4	5
	t=	-1.82	-.99	-.92	.16	-3.02
	P=					< .05
$\dot{V}E$	n=	3	6	5	6	5
	t=	-1.04	-1.63	-.06	-.06	-1.51
	P=					
				Steady State Value		
HR	n=	3	4	5	3	4
	t=	1.30	-2.07	-6.8	-.55	-3.31
	P=			< .01		< .05
$\dot{V}O_2$	n=	3	3		3	5
	t=	-.57	.62		.39	-1.07
	P=					
$\dot{V}CO_2$	n=	4	4	3	4	6
	t=	-3.73	.52	-.21	.24	-3.60
	P=	< .05				< .01
$\dot{V}E$	n=	3	5	5	6	4
	t=	-1.15	-1.09	-.95	-.12	-2.95
	P=					< .05
				Value During No Load Pedaling		
HR	n=	3	5	5	3	4
	t=	-.27	.43	-1.35	1.23	1.67
	P=					
$\dot{V}O_2$	n=	3	3		3	5
	t=	-.99	-.92		1.35	-.11
	P=					
$\dot{V}CO_2$	n=	4	5	4	4	5
	t=	-.60	.90	-.30	1.31	-.78
	P=					
$\dot{V}E$	n=	3	5	5	6	4
	t=	-.20	.43	-.66	-.30	-.96
	P=					

TABLE C-3

SUPINE EXCERCISE

PARAMETER	R+0	R+1	R+2	R+7,8	R+17,19
			TAU		
HR	n= 6 t= 1.08 P=	5 -1.25	6 -1.37	6 .47	4 -.18
$\dot{V}O_2$	n= 6 t= .29 P=	6 -1.04	6 -.86	6 -.96	4 -1.57
$\dot{V}CO_2$	n= 6 t= -1.01 P	6 -1.33	6 -1.86	6 -1.50	4 -.48
$\dot{V}E$	n= 6 t= -.10 P=	6 -1.98	5 -1.92	5 -1.02	5 -.38
			Steady State Value		
HR	n= 6 t= -4.32 P= <.005	5 -3.22 <.05	6 -9.48 <.005	6 -1.90	4 -3.07 <.05
$\dot{V}O_2$	n= 6 t= -.67 P=	6 -3.22 <.05	6 -1.99	6 -.38	4 1.49
$\dot{V}CO_2$	n= 6 t= -3.60 P= <.01	5 -2.94 <.05	5 -2.14 <.05	6 -2.18 <.05	4 -.54
$\dot{V}E$	n= 6 t= -1.64 P=	4 -1.3	5 -2.18 <.05	5 -1.06	5 -1.76
			Value During No Load Pedaling		
HR	n= 6 t= -5.05 P= <.005	5 2.63 <.05	6 -3.12 <.05	6 -1.04	3 -1.34
$\dot{V}O_2$	n= 6 t= ..48 P=	6 1.34	6 -.65	6 .45	4 1.94
$\dot{V}CO_2$	n= 6 t= -1.11 P=	5 -1.32	5 -.94	6 -2.60 <.05	4 1.44
$\dot{V}E$	n= 6 t= -1.84 P=	5 1.57	6 -1.04	5 -.55	5 -.01

TABLE C-4

UPRIGHT EXERCISE

Parameter		Pre-br	R+0	R+1	R+2	R+7,8	R+17,19
				TAU			
HR	mean	.752	1.476	2.180	1.442	.989	1.033
	S.D.	±.141	±.308	±.822	±.709	±.705	±.720
$\dot{V}O_2$	mean	.569	.688	.568	.639	.573	.536
	S.D.	±.128	±.302	±.177	±.295	±.225	±.173
$\dot{V}CO_2$	mean	1.256	1.472	1.364	1.529	1.454	1.012
	S.D.	±.327	±.596	±.435	±.665	±.804	±.175
$\dot{V}E$	mean	1.085	1.420	1.375	1.591	1.083	.871
	S.D.	±.422	±.892	±.543	±.781	±.567	±.255
				Steady State Value			
HR	mean	102.2	127.9	132.1	123.2	115.0	121.8
	S.D.	±3.3	±10.5	±4.7	±5.9	±5.3	±4.0
$\dot{V}O_2$	mean	1.197	1.293	1.288	1.298	1.249	1.067
	S.D.	±.091	±.130	±.067	±.086	±.064	±.139
$\dot{V}CO_2$	mean	1.013	1.291	1.307	1.259	1.176	1.073
	S.D.	±.067	±.153	±.115	±.108	±.132	±.203
$\dot{V}E$	mean	28.7	32.8	32.9	32.1	30.1	32.5
	S.D.	±1.8	±1.3	±3.7	±2.9	±2.8	±4.5
				Value During No Load Pedaling			
HR	mean	86.9	103.3	103.6	101.1	89.8	94.3
	S.D.	±5.2	±5.0	±13.7	±7.2	±11.8	±11.5
$\dot{V}O_2$	mean	.409	.495	.473	.479	.389	.373
	S.D	±.109	±.130	±.089	±.064	±.121	±.097
$\dot{V}CO_2$	mean	.343	.333	.357	.394	.283	.275
	S.D.	±.064	±.070	±.078	±.155	±.124	±.045
$\dot{V}E$	mean	11.5	11.3	11.6	11.9	9,9	11.7
	S.D.	±2.6	±1.8	±3.0	±1.8	±4.2	±4.2

TABLE C-5

UPRIGHT EXERCISE

PARAMETER	R+0	R+1	R+2	R+7,8	R+17,19
HR	n= 5 t= -4.47 P= <.01	4 -3.02 <.05	5 -2.05	3 - .50	3 -.54
$\dot{V}O_2$	n= 5 t= -1.74 P=	6 .51	5 -1.39	5 -.51	3 .09
$\dot{V}CO_2$	n= 6 t= -1.33 P=	6 -.65	6 -1.08	6 -.56	4 1.72
$\dot{V}E$	n= 5 t= .68 P=	6 -1.50	5 -1.63	6 .94	5 .47
Steady State Value					
HR	n= 5 t= -5.30 P= <.005	4 -13.0 <.005	5 -12.6 <.005	3 - 2.80	3 -16.10 <.005
$\dot{V}O_2$	n= 4 t= -1.39 P=	6 -3.55 <.01	6 -1.93	6 -1.87	3 1.25
$\dot{V}CO_2$	n= 5 t= -4.52 P= <.05	6 -8.39 <.005	5 -15.00 <.005	6 -3.86 <.01	4 -.54
$\dot{V}E$	n= 5 t= -3.12 P= <.05	6 -2.20 <.05	6 -1.58	6 -1.24	5 -1.78
Value During No Load Pedaling					
HR	n= 5 t= -5.98 P= <.005	4 -3.88 <.05	5 -4.34 <.01	3 - .74	3 -1.89
$\dot{V}O_2$	n= 4 t= -.69 P=	6 -1.14	6 -2.10 <.05	6 .74	3 .72
$\dot{V}CO_2$	n= 5 t= -.02 P=	6 -.47	6 -1.00	6 .92	4 1.38
$\dot{V}E$	n= 5 t= .42 P=	6 -.08	5 -.80	6 .68	5 -.67

PRE BEDREST H.R.

Supine Rest

Subject #	BR-24	BR-20	BR-14	BR-7	BR-1	Overall
1	66.0	73.4	76.0	57.6	51.8	61.8
2	78.8	73.2	69.0	62.8	68.2	66.7
3	59.4	66.8	63.8	67.7	54.0	61.8
4	67.8	62.8	68.0	56.8	60.8	61.9
5		54.0	59.4	62.8	60.8	61.0
6		74.0	65.0	65.2	64.5	64.9
	68.0	67.4	66.9	62.2	60.0	63.0
	± 8.0	± 7.9	± 5.6	± 4.2	± 6.2	± 2.2

Supine Exercise

Subject #						
1	98.7	101.7	94.7	91.0	86.3	90.7
2	121.0	106.3	101.0	102.0	101.3	101.4
3	98.0	110.3	102.3	99.0	94.0	98.4
4	105.3	97.3	105.0	91.0	94.7	96.9
5		91.7	93.3	99.7	94.7	95.9
6		107.0	101.7	98.7	96.0	98.8
	105.8	102.4	99.7	96.9	94.5	97.0
	± 10.7	± 6.9	+ 4.6	± 4.7	± 4.8	± 3.6

Upright Rest

Subject #						
1	66.8	69.2	68.5	63.5	60.5	64.2
2	87.5	81.0	83.5	78.5	81.8	81.3
3	74.5	86.0	77.2	76.5	64.5	72.7
4	78.8	66.8	73.2	65.5	66.2	68.3
5		61.5	66.2	79.0	73.2	72.8
6		80.2	81.8	75.8	69.5	75.7
	76.9	74.1	75.1	73.1	69.3	72.5
	± 8.6	± 9.6	± 7.0	± 6.8	± 7.5	± 5.9

Upright Exercise

Subject #						
1	99.0	102.7	93.0	91.7	87.0	90.6
2	126.7	109.3	102.7	102.7	104.7	103.4
3	104.0	113.3	97.0	98.0	96.0	97.0
4	110.3	101.0	112.7	98.3	98.0	103.0
5		95.0	97.7	116.7	101.7	105.2
6		110.7	103.7	102.7	100.0	102.1
	110.0	105.3	101.1	101.7	97.9	100.2
	± 12.1	± 6.9	± 6.9	± 8.4	± 6.1	± 5.5

Heart Rate

Supine Recovery

Subject #	BR-14	BR-7	BR-1	Overall
1	66.0	63.4	56.2	61.9
2	70.2	72.0	72.0	71.4
3	73.0	75.6	59.8	69.5
4	69.0	58.2	59.6	62.3
5	62.8	69.4	66.0	66.1
6	79.2	72.2	69.0	73.5
				67.4
				± 4.8

Upright Recovery

Subject #				
1	68.3	63.4	60.8	64.2
2	77.4	77.6	84.0	79.7
3	78.2	83.0	62.8	74.7
4	78.8	73.0	70.4	74.1
5	72.6	94.2	84.6	83.8
6	82.4	82.2	74.2	79.6
				76.0
				± 6.8

Prebedrest

VO_2

(ℓ/Min)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	0.280	0.310	0.300	0.297	1.080	1.150	1.150	1.127
2	0.240	0.180	0.370	0.263	0.910	0.760	1.330	1.000
3	0.310	0.270	0.260	0.280	1.110	0.770	1.290	1.057
4	0.250	0.170	1.210	0.210	1.056	0.919	1.227	1.067
5	0.230	0.190	0.240	0.220	0.950	0.890	1.160	1.000
6	0.270	0.250	0.300	0.273	1.180	1.040	0.853	1.024
				0.257				1.046
				±0.035				±0.049
				± .01				

Subject #	Supine Recovery BR-14	BR-7	BR-1	Overall	Upright Rest BR-14	BR-7	BR-1	Overall
1	0.410	0.450	0.450	0.437	0.340	0.240	0.400	0.327
2	0.400	0.260	0.510	0.390	0.310	0.260	0.430	0.333
3	0.460	0.340	0.400	0.400	0.390	0.350	0.390	0.377
4	0.400	0.350	0.400	0.383	0.350	0.270	0.320	0.313
5	0.370	0.330	0.440	0.380	0.320	0.230	0.310	0.287
6	0.420	0.410	0.400	0.410	0.370	0.300	0.350	0.340
				0.400				0.330
				±0.021				±0.030

Subject #	Upright Exercise BR-14	BR-7	BR-1	Overall	Upright Recovery BR-14	BR-7	BR-1	Overall
1	1.050	1.100	1.250	1.133	0.410	0.430	0.500	0.447
2	0.930	0.790	1.350	1.023	0.340	0.250	0.470	0.353
3	1.080	0.900	1.370	1.117	0.470	0.330	0.410	0.403
4	1.097	0.965	1.262	1.108	0.410	0.360	0.400	0.390
5	1.100	0.850	1.190	1.047	0.460	0.330	0.420	0.403
6	1.110	1.070	1.244	1.141	0.430	0.390	0.460	0.427
				1.095				0.404
				±0.048				±0.032

Prebedrest

VCO_2

(ℓ/Min)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	0.420	0.350	0.300	0.357	0.990	1.020	0.830	0.947
2	0.260	0.180	0.270	0.237	0.960	0.750	0.970	0.893
3	0.390	0.420	0.200	0.337	0.940	0.720	0.960	0.873
4	0.260	0.180	0.190	0.210	1.035	0.879	1.160	1.025
5	0.240	0.200	0.240	0.227	1.030	0.880	1.140	1.017
6	0.480	0.450	0.440	0.457	1.240	0.990	0.785	1.005
				0.304				0.960
				±0.096				±0.066

Subject #	Supine Recovery				Upright Rest			
1	0.570	0.520	0.470	0.520	0.350	0.250	0.360	0.320
2	0.500	0.330	0.420	0.417	0.320	0.260	0.280	0.289
3	0.590	0.490	0.350	0.477	0.520	0.380	0.380	0.427
4	0.490	0.410	0.450	0.450	0.330	0.260	0.270	0.287
5	0.470	0.400	0.550	0.473	0.300	0.200	0.260	0.253
6	0.710	0.570	0.580	0.620	0.540	0.350	0.400	0.430
				0.493				0.334
				±0.071				±0.076

Subject #	Upright Exercise				Upright Recovery			
1	0.850	0.780	0.790	0.807	0.480	0.470	0.470	0.473
2	0.900	0.700	0.920	0.840	0.350	0.240	0.340	0.310
3	0.860	0.750	0.920	0.843	0.550	0.410	0.320	0.427
4	1.034	0.837	1.103	0.991	0.420	0.360	0.400	0.393
5	1.100	0.820	1.120	1.013	0.510	0.370	0.470	0.450
6	0.950	0.870	0.985	0.935	0.560	0.450	0.530	0.513
				0.905				0.422
				±0.087				±0.067

Prebedrest

RER
(Overall)

Subject #	Supine Rest	Supine Exercise
1	1.202	0.840
2	0.901	0.893
3	1.204	0.826
4	1.000	0.961
5	1.032	1.017
6	1.674	0.981
	1.169	0.920
	SD ± 0.274	SD ± 0.078
	SEM ± .112	SEM ± .03

Subject #	Supine Recovery	Upright Recovery
1	1.190	0.979
2	1.069	0.868
3	1.193	1.133
4	1.175	0.917
5	1.245	0.882
6	1.512	1.265
	1.231	1.007
	SD ±0.149	SD ± 0.159
	SEM ± .06	SEM ± .06

Subject #	Upright Exercise	Upright Recovery
1	0.712	1.058
2	0.821	0.878
3	0.755	1.060
4	0.894	1.008
5	0.968	1.117
6	0.819	1.201
	0.828	1.054
	SD ± 0.093	SD ± 0.108
	SEM ± .04	SEM ± .04

Prebedrest

MV

(ℓ/Min)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	19.3	13.3	11.5	14.7	29.4	31.2	20.8	27.1
2	8.3	7.2	8.9	8.1	28.7	27.2	27.4	27.8
3	13.1	14.5	6.7	11.4	29.0	32.6	26.1	29.2
4	7.6	6.6	5.8	6.7	27.9	28.5	27.6	28.0
5	6.6	6.8	8.4	7.3	26.7	27.7	28.7	27.7
6	18.0	20.6	16.4	18.3	29.3	25.8	18.6	24.6
				11.1				27.4
			SD	± 4.6			SD	± 1.5
			SEM	± 1.88			SEM	± 0.61

Subject #	Supine Recovery BR-14	BR-7	BR-1	Overall	Upright Rest BR-14	BR-7	BR-1	Overall
1	23.6	17.5	14.6	18.6	18.8	12.2	17.7	16.2
2	14.4	14.1	14.2	14.2	11.4	10.3	11.2	11.0
3	17.7	19.5	9.5	15.6	24.2	17.1	14.4	18.6
4	13.3	12.3	12.3	12.6	9.5	8.9	8.4	8.9
5	13.3	13.6	16.4	14.4	9.4	8.9	9.4	9.2
6	24.7	21.4	17.7	21.3	30.6	20.1	18.8	23.2
				16.1				14.5
			SD	± 3.2			SD	± 5.8
			SEM	± 1.31			SEM	± 2.4

Subject #	Upright Exercise BR-14	BR-7	BR-1	Overall	Upright Recovery BR-14	BR-7	BR-1	Overall
1	27.4	24.7	22.7	24.9	27.3	25.9	18.8	24.0
2	30.8	26.5	29.2	28.8	13.3	12.9	13.2	13.1
3	32.9	27.5	25.5	28.6	23.4	20.9	9.3	17.9
4	29.8	27.3	25.6	27.6	12.6	12.5	12.0	12.4
5	24.8	29.4	28.2	27.5	14.1	15.6	15.1	14.9
6	27.1	24.4	24.6	25.4	26.4	22.6	20.8	23.3
				27.1				17.6
			SD	± 1.6			SD	± 5.1
			SEM	±0.65			SEM	± 2.1

Prebedrest

RR

(Breaths/Min)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	15.6	13.6	14.0	14.4	18.0	17.3	12.3	15.9
2	13.2	11.0	14.2	12.8	23.3	20.7	19.7	21.2
3	10.6	8.6	12.8	10.7	15.3	15.7	20.3	17.1
4	9.6	7.0	6.8	7.8	13.7	14.0	13.3	13.7
5	10.2	9.4	11.2	10.3	14.7	13.0	13.3	13.7
6	14.8	16.8	14.2	15.3	14.0	12.7	12.3	13.0
				11.9				15.8
			SD	± 2.8			SD	± 3.1
			SEM	± 1.14			SEM	± 1.3

Subject #	Supine Recovery				Upright Rest			
1	14.6	12.6	9.0	12.1	14.0	11.0	11.0	12.0
2	15.0	15.2	17.8	16.0	13.8	10.3	19.5	14.5
3	10.4	9.2	11.0	10.2	11.0	10.0	7.3	9.4
4	10.8	8.6	8.8	9.4	8.2	7.2	5.1	6.8
5	12.0	11.0	10.4	11.1	10.0	8.2	7.0	8.4
6	19.4	15.6	11.6	15.5	17.2	16.8	12.8	15.6
				12.4				11.1
			SD	± 2.8			SD	± 3.5
			SEM	± 1.14			SEM	± 1.43

Subject #	Upright Exercise				Upright Recovery			
1	17.7	14.0	16.7	16.1	17.8	12.4	9.2	13.1
2	22.3	20.3	22.3	21.6	16.2	12.9	18.0	15.7
3	15.0	17.0	17.7	16.6	11.0	13.0	10.2	11.4
4	13.0	10.7	10.3	11.3	8.2	7.8	6.8	7.6
5	11.7	13.7	14.3	13.2	10.4	9.4	9.4	9.7
6	10.3	10.3	12.3	11.0	15.6	16.8	16.6	16.3
				15.0				12.3
			SD	± 4.0			SD	± 3.4
			SEM	± 1.63			SEM	± 1.4

Prebedrest

SBP
(Torr)

Supine Rest

Subject #	BR-14	BR-7	BR-1	Overall
1	143	141.5	150.0	144.8
2	131	126.8	135.6	131.0
3	124.4	120.0	121.8	122.1
4	115.4	114.0	107.6	112.3
5	129.0	135.0	131.1	131.7
6	120.6	108.4	101.4	110.1
				125.3
			SD	± 13.2
			SEM	± 5.4

Supine Exercise

BR-14	BR-7	BR-1	Overall
188	186.0	190.0	188.0
170	172.7	183.0	175.2
178.0	164.0	162.3	168.1
164.0	173.0	168.7	168.6
180.7	196.0	178.7	185.1
182.7	158.0	140.9	160.5
			174.2
		SD	± 10.6
		SEM	± 4.3

Supine Recovery

Subject #				
1	165.8	164.4	131.8	154.0
2	113.5	140.0	146.0	133.2
3	152.8	134.2	132.8	139.9
4	122.4	130.4	123.5	125.4
5	134.	141.6	136.3	137.4
6	135.2	113.6	111.5	120.1
				135.0
			SD	± 11.9
			SEM	± 4.9

Upright Rest

152.8	132.8	137.5	141.0
126.8	115.7	129.0	123.8
116.0	109.8	114.0	113.3
119.2	113.5	120.0	117.6
114.5	130.5	124.8	123.3
115.2	102.2	104.4	107.3
			121.0
		SD	± 11.6
		SEM	± 4.7

Upright Exercise

Subject #				
1	181.3	167.3	178.0	175.5
2	159.0	155.0	150.0	154.7
3	130.0	136.0	135.3	133.8
4	162.0	160.3	170.0	164.1
5	157.0	180.0	160.7	165.9
6	150.0	148.0	139.9	146.0
				156.7
			SD	± 15.1
			SEM	± 6.2

Upright Recovery

157.2	141.0	144.8	147.7
129.6	123.6	122.0	125.1
113.8	115.0	115.4	114.7
118.8	119.8	130.7	123.1
129.4	132.4	123.5	128.4
122.4	111.8	108.8	114.3
			125.6
		SD	± 12.2
		SEM	± 5.0

Prebedrest

DBP
(Torr)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	91.6	79.5	93.6	88.2	100.3	92.0	102.7	98.3
2	69.5	77.8	85.6	77.6	85.7	71.7	94.0	83.8
3	86.6	77.8	73.8	79.4	107.7	90.0	94.0	97.2
4	60.2	76.4	68.0	68.2	71.0	79.7	80.0	76.9
5	71.5	88.8	86.5	82.3	76.0	92.0	95.3	87.8
6	73.8	62.0	59.2	65.0	71.3	63.7	53.5	62.8
				76.8				84.5
			SD	± 8.7			SD	±13.4
			SEM	± 3.6			SEM	± 5.5

Subject #	Supine Recovery				Upright Rest			
1	60.2	79.6	83.6	74.5	88.8	88.2	86.0	87.7
2	72.8	60.3	87.0	73.4	72.2	77.7	78.0	76.0
3	88.5	77.8	86.8	84.4	72.2	69.5	70.0	70.6
4	71.6	77.8	72.6	74.0	72.0	76.5	65.5	71.3
5	69.6	80.0	82.6	77.4	71.5	88.5	88.6	82.9
6	64.6	55.2	59.0	59.6	62.8	63.8	62.7	63.1
				73.9				75.3
			SD	± 8.1			SD	± 8.9
			SEM	± 3.3			SEM	± 3.6

Subject #	Upright Exercise				Upright Recovery			
1	86.0	73.3	87.3	82.2	90.8	78.4	89.2	86.1
2	74.7	60.0	84.0	72.9	80.2	69.6	82.8	77.5
3	66.7	71.3	74.0	70.7	74.4	75.2	79.6	76.4
4	69.0	74.3	75.3	72.9	72.6	77.8	66.7	72.4
5	79.0	96.7	84.7	86.8	75.4	92.4	94.6	87.5
6	73.0	61.3	60.6	65.0	73.6	63.8	65.6	67.7
				75.1				77.9
			SD	± 8.0			SD	± 7.7
			SEM	± 3.3			SEM	± 3.1

Prebedrest

P P
(TORR)

Subject #	Supine Rest	Supine Exercise
1	56.6	89.7
2	53.4	91.4
3	42.7	70.9
4	44.1	91.7
	49.4	97.3
6	45.1	97.7
	48.6	89.8
	SD ± 5.6	SD ± 9.8
	SEM ± 2.3	SEM ± 4.0

Subject #	Supine Recovery	Upright Rest
1	79.5	53.3
2	59.8	47.8
3	55.5	42.7
4	51.4	46.3
5	60.0	40.4
6	60.5	44.2
	61.1	45.8
	SD ± 9.7	SD ± 4.5
	SEM ± 4.0	SEM ± 1.84

Subject #	Upright Exercise	Upright Recovery
1	93.3	61.6
2	81.8	47.6
3	63.1	38.3
4	91.2	50.7
5	79.1	40.9
6	81.0	46.6
	81.6	47.6
	SD ± 10.8	SD ± 8.2
	SEM ± 4.4	SEM ± 3.4

Prebedrest

MAP
(Torr)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	108.7	100.2	112.4	107.1	130.0	123.3	131.8	128.4
2	90.0	94.1	102.3	95.5	113.9	105.3	123.7	114.3
3	99.2	91.8	89.8	93.6	131.1	114.7	116.9	120.9
4	78.6	88.9	81.2	82.9	102.0	110.8	109.6	107.5
5	90.7	104.2	101.4	98.8	110.9	126.7	123.1	120.2
6	89.4	77.5	73.3	80.1	108.4	95.1	82.6	95.4
				93.0				114.4
			SD	±10.1			SD	± 11.7
			SEM	± 4.1			SEM	± 4.8

Subject #	Supine Recovery				Upright Rest			
1	95.4	107.8	46.3	83.2	110.1	103.1	103.2	102.1
2	86.3	86.9	106.7	93.3	90.4	90.3	95.0	91.9
3	111.9	96.0	102.1	103.3	86.8	82.9	84.7	84.8
4	88.5	95.3	89.5	91.1	87.8	88.8	83.7	86.8
5	46.4	100.5	100.5	82.5	85.8	102.5	100.7	96.3
6	88.1	74.7	76.5	79.8	80.2	76.6	76.6	77.8
				88.9				90.0
			SD	± 8.8			SD	± 8.7
			SEM	± 3.6			SEM	± 3.6

Subject #	Upright Exercise				Upright Recovery			
1	117.8	104.7	117.6	113.4	112.9	99.3	107.7	106.6
2	102.8	91.7	106.0	100.2	96.7	87.4	95.8	93.3
3	87.8	92.9	94.4	91.7	87.5	88.5	91.5	89.2
4	100.0	103.0	106.9	103.3	88.0	91.8	88.0	89.3
5	105.0	124.5	110.0	113.2	93.4	105.7	104.2	101.1
6	98.7	90.2	87.0	92.0	89.9	79.8	80.0	83.2
				102.3				93.8
			SD	± 9.6			SD	± 8.6
			SEM	± 3.9			SEM	± 3.5

Prebedrest

$\dot{Q}$
(ℓ/min)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	--	6.2	--	6.2	9.6	8.6	--	9.1
2	3.8	4.1	--	4.0	9.6	6.8	--	9.2
3	6.3	5.5	--	5.9	9.5	6.6	--	8.0
4	3.4	3.8	3.7	3.6	12.0	11.0	10.4	11.1
5	3.6	3.6	4.0	3.7	10.4	9.3	9.0	9.6
6	6.8	--	--	6.8	10.4	--	7.0	8.7
				5.0				9.3
			SD	± 1.4			SD	± 1.0
			SEM	± 0.6			SEM	± 0.4

Subject #	Upright Rest				Upright Recovery			
1	--	6.1	--	6.1	9.6	7.8	--	8.7
2	5.2	4.9	--	5.0	9.1	7.2	--	8.2
3	--	5.7	--	5.7	10.2	7.4	--	8.8
4	4.6	5.3	5.0	5.0	11.0	9.6	8.0	9.5
5	4.1	4.3	3.7	4.0	9.6	9.2	10.1	9.6
6	9.1	--	--	9.1	11.8	8.6	9.6	10.0
				5.8				9.1
			SD	± 1.8			SD	± 0.7
			SEM	± 0.7			SEM	± 0.3

Prebedrest

S.V.
(mℓ/Beat)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	--	107.6	--	107.6	101.4	94.5	--	98.0
2	55.1	65.3	--	60.2	95.0	66.7	--	80.8
3	98.7	81.3	--	90.0	92.8	66.7	--	79.8
4	50.0	66.9	60.9	59.3	114.3	121.0	109.9	115.1
5	60.6	57.3	65.8	61.2	111.4	93.3	95.1	99.9
6	104.6	--	--	104.6	102.3	--	72.9	87.6
				80.5				93.5
			SD	±23.0			SD	±13.5
			SEM	± 9.4			SEM	± 5.5

Subject #	Upright Rest				Upright Recovery			
1	--	96.1	--	96.1	103.2	85.1	--	94.2
2	62.3	62.4	--	62.4	88.6	70.1	--	79.4
3	--	74.5	--	74.5	105.2	75.5	--	90.4
4	62.8	80.9	75.5	73.1	97.6	97.6	81.6	92.3
5	61.9	54.4	50.5	55.6	98.3	78.9	99.3	92.2
6	111.3	--	--	111.3	113.8	83.8	96.0	97.9
				78.8				91.1
			SD	± 21.0			SD	± 6.3
			SEM	± 8.6			SEM	± 2.6

Prebedrest

TPR
(DYNE-SEC-CM-5)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	--	1293	--	1293	1080	1147	--	1114
2	1895	1837	--	1866	949	1239	--	1094
3	1260	1336	--	1298	1104	1390	--	1247
4	1849	1872	1756	1826	680	806	843	776
5	2015	2316	2027	2119	853	1090	1094	1012
6	1052	--	--	1052	834	--	944	889
				1576				1022
			SD ±	418			SD ±	169
			SEM ±	171			SEM ±	69

Subject #	Upright Rest				Upright Recovery			
1	--	1352	--	1352	982	1073	--	1028
2	1391	1475	--	1433	904	1019	--	962
3	--	1164	--	1164	688	1004	--	846
4	1526	1341	1339	1402	727	858	1069	885
5	1675	1907	2177	1920	875	1082	871	943
6	705	--	--	705	669	839	725	744
				1329				901
			SD ±	396			SD ±	100
			SEM ±	162			SEM ±	41

Prebedrest

A-V O_2
(mℓ/100 mℓ)

Subject #	Supine Rest BR-14	BR-7	BR-1	Overall	Supine Exercise BR-14	BR-7	BR-1	Overall
1	--	5.0	--	5.0	11.3	13.4	--	12.4
2	6.3	4.4	--	5.4	9.5	11.2	--	10.4
3	4.9	4.9	--	4.9	11.7	11.7	--	11.7
4	7.4	4.5	5.7	5.9	8.8	8.4	11.8	9.7
5	6.4	5.3	6.0	5.9	9.1	9.6	12.9	10.5
6	4.0	--	--	4.0	11.3	--	12.2	11.8
				5.2				11.1
			SD ±	0.7			SD ±	1.0
			SEM ±	.3			SEM ±	.4

Subject #	Upright Rest				Upright Exercise			
1	--	3.9	--	3.9	10.9	14.1	--	12.6
2	3.4	5.3	--	4.4	10.2	11.0	--	10.6
3	--	6.1	--	6.1	10.6	12.2	--	11.4
4	7.6	5.1	6.4	6.4	10.0	10.1	15.8	12.0
5	7.8	5.3	8.4	7.2	11.5	9.2	11.8	10.8
6	4.1	--	--	4.1	9.4	12.4	13.0	11.6
				5.4				11.5
			SD ±	1.4			SD ±	0.8
			SEM ±	0.6			SEM ±	.3

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
4	60.4	.261	.237	6.6	7.6	115.4	69.9	85.1	5	82.8	1362	5.2	.908
5	58.3	.203	.203	6.7	6.8	141.6	109.5	120.2	5	85.8	1923	4.1	1.0
6	65.3	.271	.395	13.8	9.2	116.2	70.2	85.5	6.5	100	1052	4.2	1.458
$\bar{X}$	61.33	.25	.28	9.03	7.87	124.4	83.20	96.93	5.50	89.53	1445.67	4.50	1.12
SD ±	3.59	.04	.10	4.13	1.22	74.90	22.78	20.15	.87	9.19	441.49	.61	.29
SEM ±	2.1	.02	.06	2.4	0.7	8.6	13.2	11.6	.50	5.3	255	.35	.17

75W SUP

Subject #													
4	100	1.314	1.299	31	14.7	188.4	81.7	117.3	13.8	138	680	9.5	0.989
5	95	1.02	1.07	26.6	15	218.1	120.3	152.9	14.6	153.7	838	7.0	1.049
6	93.7	1.169	1.088	243	11.7	174.3	78.4	110.3	12.8	136.6	689	9.1-	0.931
$\bar{X}$	96.23	1.17	1.15	27.3	13.8	193.60	93.47	126.83	13.73	142.77	735.67	8.53	.99
SD ±	3.33	.15	.13	3.40	1.82	22.36	23.30	22.84	.90	9.49	88.74	1.34	.06
SEM ±	1.9	.09	.08	2.0	1.05	12.9	13.5	13.2	.52	5.5	51.2	.8	.03

Recovery

Submect #													
4	68.6	.460	.547	14.8	10.8	135.3	70.2	91.9	--	--	--	--	1.189
5	66.6	.389	.506	14.2	10.2	161.2	107.6	125.5	--	--	--	--	1.301
6	67	.434	.539	14.4	8.4	133.9	76.9	95.9	--	--	--	--	1.242
$\bar{X}$	67.40	.43	.53	14.47	9.80	143.47	84.90	104.43	--	--	--	--	1.24
SD ±	1.06	.04	.02	.31	1.25	15.37	19.94	18.35	--	--	--	--	.06
SEM ±	.6	.02	.01	.18	.72	8.87	11.5	10.6	--	--	--	--	.03

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	53.8	.29	.388	16.2	12.4	158.4	105.3	123	--	--	--	--	1.338
2	74	.235	.228	7.8	16	139.2	67.5	91.4	--	--	--	--	.970
3	81.3	.26	.322	10.4	8	101.6	73.9	83.2	9.5	116.8	700	2.7	1.238
$\bar{X}$	69.70	.26	.31	11.47	12.13	133.07	82.23	99.20	--	--	--	--	1.18
SD ±	14.25	.03	.08	4.30	4.01	28.89	20.23	21.02	--	--	--	--	.19
SEM ±	8.2	.02	.05	2.5	2.3	16.7	11.8	12.2	--	--	--	--	.11

75W SUP

Subject #													
1	79	1.18	1.0	26.2	14	196.3	111.6	139.8	--	--	--	--	.847
2	107	1.13	1.1	27.8	23.7	191.4	59.1	103.2	--	--	--	--	.973
3	95.7	1.12	0.95	24.3	17	125.3	71.8	89.6	14.0	146.3	512	8	.848
$\bar{X}$	93.90	1.14	1.02	26.10	18.23	171	80.83	110.87	--	--	--	--	.89
SD ±	14.09	.03	.08	1.75	4.97	39.65	27.39	25.96	--	--	--	--	.07
SEM ±	8.1	.02	.05	1.01	2.9	22.9	15.8	15.0	--	--	--	--	.04

Recovery

Subject #													
1	53.8	.45	.578	19	10.2	167.4	87.2	114	--	--	--	--	1.284
2	80	.373	.448	13.4	19.2	146.8	61.3	89.8	--	--	--	--	1.201
3	73	.416	0.513	14.9	10.2	122.2	70.7	87.9	--	--	--	--	1.233
$\bar{X}$	68.93	.41	.51	15.77	13.2	145.47	73.07	97.23	--	--	--	--	1.24
SD ±	13.57	.04	.07	2.90	5.20	22.63	13.11	14.55	--	--	--	--	0.04
SEM ±	7.8	.02	.04	1.68	3.0	13.1	7.6	8.4	--	--	--	--	.02

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	56.20	.300	.370	15.54	7.40	144.22	95.76	111.91	--	--	--	--	1.23
2	67.20	.220	.190	7.94	15.20	127.92	80.78	96.49	4.5	67.0	1715	4.9	.86
3	70.40	.260	.320	10.66	8.80	123.58	80.18	94.65	5.5	78.1	1377	4.7	1.23
4	55.6	.217	.210	6.40	6.40	92.22	53.36	66.31	9.0	161.9	589	2.4	.97
5	68.00	.250	.27	9.36	10.20	132.26	83.26	99.59	5.8	85.3	1374	4.3	1.08
6	64.8	.206	.283	9.9	5.6	109.8	59.7	76.4	--	--	--	--	1.37
$\bar{X}$	63.70	.24	.27	9.97	8.93	121.67	75.51	90.89	6.20	98.08	1263.75	4.08	1.12
SD ±	6.30	.04	.07	3.12	3.49	18.28	15.88	16.60	1.95	43.21	477.46	1.14	.19
SEM ±	2.6	.02	.03	1.3	1.4	7.5	6.5	6.8	0.8	17.6	195	0.5	.08

75W SUP

Subject #													
1	84.00	1.28	1.08	26.50	9.00	206.97	99.87	135.57	13.2	157.1	822	9.7	.84
2	102.33	1.12	1.03	29.77	20.00	177.93	97.93	124.60	11.8	115.3	845	9.5	.92
3	100.33	1.04	.99	25.90	15.33	159.20	96.83	117.6	12.3	122.6	765	8.5	.95
4	95.67	1.23	1.18	28.37	14.33	155.20	68.03	97.09	16.0	167.2	485	7.7	.96
5	112.33	1.13	1.25	32.40	15.00	214.03	94.60	134.41	13.9	123.7	774	8.1	1.11
6	102.3	.794	.807	22	11	169	70.7	103.5	9.3	90.9	890	8.5	1.02
$\bar{X}$	99.49	1.10	1.06	27.49	14.11	180.39	87.99	118.80	12.75	129.47	763.50	8.67	.97
SD ±	9.34	.17	.16	3.57	3.82	24.73	14.55	15.91	2.24	28.13	144.04	.78	.09
SEM ±	3.8	.07	.07	1.5	1.6	10.1	5.9	6.5	0.9	11.5	58.8	.32	.04

Recovery

Subject #													
1	58.60	.470	.520	15.86	8.20	171.02	91.48	117.99	--	--	--	--	1.11
2	74.00	.390	.430	14.56	18.80	144.26	80.26	101.59	--	--	--	--	1.10
3	77.00	.360	.450	13.64	11.60	140.16	75.48	97.04	--	--	--	--	1.25
4	66.4	.415	.510	14.16	10.60	128.30	62.38	84.35	--	--	--	--	1.23
5	85.20	.450	.570	17.50	11.80	145.34	85.36	105.35	--	--	--	--	1.27
6	75.8	.327	.451	15.2	7.6	136.8	68.5	91.3	--	--	--	--	1.38
$\bar{X}$	72.83	0.40	.49	15.15	11.43	144.31	77.24	99.60	--	--	--	--	1.22
SD ±	9.21	.05	.05	1.39	4.01	14.45	10.75	11.69	--	--	--	--	.11
SEM ±	3.8	.02	.02	.57	1.6	5.9	4.4	4.8	--	--	--	--	.04

BR+14

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	55.4	.210	.310	14.32	6.60	142.9	92.86	109.54	--	--	--	--	1.48
2	67.8	--	--	--	15.2	120.4	67.8	85.3	--	--	--	--	--
3	74.4	.300	.350	10.74	4.20	130.24	86.48	101.07	5.9	79.3	1370	5.1	1.17
4	52	.133	.131	5.92	9.0	104.52	66.64	79.27	5.3	101.9	1197	2.5	.99
5	68.2	.210	.19	9.22	8.80	129.96	83.88	99.24	4.9	71.8	1620	4.3	.91
6	66.2	.224	.297	11.7	4.8	114.2	62.4	79.7	4.7	71.0	1357	4.8	1.33
X	64	.215	.256	10.4	8.1	123.7	76.4	92.4	5.2	81	1386	4.2	1.18
SD ±	8.52	.059	.091	3.11	4.0	13.57	12.33	12.63	0.53	14.43	174.7	1.16	.24
SEM ±	3.5	.02	.04	1.3	1.6	5.5	5.0	5.2	.22	5.9	71.3	.5	.1

75W SUP

Subject #													
1	83.67	.92	.90	25.97	4.67	189.07	102.17	131.14	12.6	150.1	833	7.3	.98
2	108.0	--	--	--	25.2	149	61.6	90.7	--	--	--	--	--
3	108.33	.75	.71	28.50	13.33	176.83	90.03	118.96	10.0	92.3	952	7.5	.95
4	95	.780	.750	27.93	14.00	146.73	71.80	96.78	.4	147.4	553	5.6	.96
5	107.67	.860	.88	32.07	14	196.77	104.33	135.14	11.9	110.5	909	7.2	1.02
6	103.3	.977	.967	26.8	6.3	192.6	64.2	88.1	11.9	115.2	592	8.2	.99
X	101	.857	.841	28.3	12.9	175.2	82.4	110.1	12.1	123.1	767.8	7.2	.98
SD ±	9.88	0.95	.108	2.35	7.28	22.20	19.0	20.89	1.45	24.95	183.8	0.96	.03
SEM ±	4.03	.04	.05	1.05	297	9.06	7.76	8.53	0.65	11.2	82.2	.43	.01

Recovery

Subject #													
1	62.4	--	.48	17.38	6.80	166.22	83.18	110.86	--	--	--	--	--
2	75.2	--	--	--	18.8	135.3	62.9	87	--	--	--	--	--
3	85.6	.29	.39	16.98	10.8	146.36	84.7	105.25	--	--	--	--	1.35
4	61.8	.260	.314	12.84	10.6	118.92	58.98	78.96	--	--	--	--	1.21
5	79.2	.33	.41	17.02	10.4	142.9	83.38	103.22	--	--	--	--	1.24
6 -	78.4	.364	.498	18.1	6	145.2	60.8	88.9	--	--	--	--	1.37
X	73.8	.311	.418	16.5	10.6	142.5	72.3	95.7	--	--	--	--	1.29
SD ±	9.65	0.46	0.74	2.10	4.54	15.45	12.6	12.49	--	--	--	--	.08
SEM ±	3.9	.02	.03	.86	1.9	6.3	5.1	5.1	--	--	--	--	.03

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	51.80	--	--	8.70	7.8	124.44	77.04	92.84	--	--	--	--	--
2	69.2	--	--	7.1	15.2	123.9	84.5	97.6	--	--	--	--	--
3	70.20	--	--	12	9	127.04	82.86	97.59	--	--	--	--	--
4	55.40	.19	.18	5.56	7.0	108.14	78.46	88.35	6.0	108.3	1178	3.2	.947
5	69.40	.25	.25	8.58	11.20	137.92	93.18	108.09	4.8	69.2	1802	5.2	1.0
6	67.4	.282	.375	12.5	5.6	114.7	60.2	78.4	7.8	115.7	804	3.6	1.33
$\bar{X}$	63.9	.241	.268	9.07	9.30	122.7	79.4	93.8	6.2	97.7	1261	4.0	1.092
SD ±	8.11	.047	.099	2.72	3.46	10.3	11	10.0	1.51	2.5	504	1.06	.208
SEM ±		.03	.06	1.1		4.2	4.5		.87	14.4	291	.61	.12

75W SUP

Subject #													
1	79.67	--	--	24.10	10.00	190.33	90.97	124.09	--	--	--	--	--
2	102.7	--	--	23.9	20.0	173.1	54.9	94.3	--	--	--	--	--
3	96.67	--	--	31.63	14.33	162	96.50	118.33	--	--	--	--	--
4	91.67	1.20	1.13	27.60	12.67	173.80	73.30	106.80	15.2	165.8	562	7.9	.942
5	107.67	1.06	1.07	30.33	13.67	200.77	96.90	131.52	--	--	--	--	--
6	103.3	1.043	.984	23.5	5.7	167.2	72.5	104.1	11.5	111.3	724	9.1	.943
$\bar{X}$	97	1.10	1.06	26.8	12.7	177.9	80.9	113.2	13.4	138.6	643	8.5	.965
SD ±	10.1	.09	.07	3.54	4.76	14.7	16.77	13.86	2.62	38.5	114.6	.85	.039
SEM ±		.05	.03	1.4		.6	6.8	6	1.1	16			.02

Recovery

Subject #													
1	59.80	--	--	14.52	7.8	149.3	69.8	96.30	--	--	--	--	--
2	74.4	--	--	11.6	14.0	144.7	67.3	93.1	--	--	--	--	--
3	75.4	--	--	15.28	10.40	147.76	90.94	109.78	--	--	--	--	--
4	61.40	.40	.460	12.40	8.80	117.80	66.34	83.49	--	--	--	--	1.15
5	82.60	.46	.55	17.68	12.0	164.46	89.50	114.49	--	--	--	--	1.20
6	75.2	.420	.539	15.8	5.0	136.7	63.5	87.9	--	--	--	--	1.28
$\bar{X}$	71.5	.427	.516	14.55	9.67	143.4	74.6	97.5	--	--	--	--	1.21
SD ±	8.94	.031	.049	2.45	3.19	15.47	12.30	12.26	--	--	--	--	.066
SEM ±				1.0				5	--	--	--	--	.04

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	71.2	.27	.34	14	9	142.3	87.0	105.5	--	--	--	--	1.26
2	74	.198	.198	8.5	13	124.9	72.1	89.7	--	--	--	--	1.0
3	82.4	.233	.326	16.5	9.6	129.6	93.3	105.4	7.2	87.4	1171	3.2	1.399
4	65.4	.24	.22	6.3	8.2	98	65.6	76.4	5.7	87.2	1072	4.2	.917
5	73.8	.26	.26	8.5	8.8	123.1	86.4	98.6	--	--	--	--	1.0
6	64.6	.241	.304	9.9	5.0	110.7	64.7	80	6.1	94.4	1049	4.0	1.261
$\bar{X}$	71.90	.24	.27	10.62	8.93	121.43	78.18	92.60	6.33	89.67	1097.3	3.80	1.14
SD ±	6.55	.02	.06	3.85	2.57	15.37	12.25	12.62	.78	4.10	64.83	.53	.19
SEM ±				1.6	1.1	6.3	5	5	.45	1.7	26		

75W-SUP

Subject #													
1	99.7	.95	7.0	32.1	13.7	202.7	108.5	139.9	8.8	88.3	1272	10.8	1.053
2	110.7	.665	.661	28.8	22	162.4	68.1	99.5	--	--	--	--	.994
3	109.3	.728	.614	27.9	12.7	160.2	102.1	121.5	13	118.9	748	5.6	.843
4	109	1.31	1.30	30.7	15.7	1443	75.7	98.6	14.2	130.3	554	9.2	1.0
5	105.3	1.12	1.15	28.3	11.7	212.5	95.8	134.7	11.9	113	906	9.4	1.027
6	99	1.116	1.086	22.5	5.3	173.1	64.9	101	12.8	129.3	631	8.7	.973
$\bar{X}$	105.50	.98	.97	28.38	13.52	175.87	85.85	115.87	12.14	115.96	822.20	8.74	.98
SD ±	5.09	.25	.27	3.29	5.45	26.43	18.62	18.71	2.04	17.07	254.30	1.92	.07
SEM ±				1.3	2.2	10.8	7.6	8	1.02	7	104		.03

Recovery

Subject #													
1	80.8	.41	.57	19.5	7.8	184.5	85.2	118.3	--	--	--	--	1.39
2	85.2	.232	.275	14.7	19.8	138.2	70.6	93.1	--	--	--	--	1.185
3	88.2	.434	.56	19.5	7.2	149.1	95.6	113.4	--	--	--	--	1.290
4	73.2	.46	.54	14	10.2	117.9	67.2	84.1	--	--	--	--	1.174
5	94	.874	1.013	28.1	13	205.7	87.6	127	--	--	--	--	1.159
6	73.8	.433	.568	15.1	5.4	132.6	69.9	90.8	--	--	--	--	1.312
$\bar{X}$	82.53	.47	.59	18.48	10.57	154.67	79.35	104.45	--	--	--	--	1.25
SD ±	8.21	.21	.24	5.30	5.23	33.57	11.66	17.38	--	--	--	--	0.09
SEM ±								7					.04

REST

Subject #	HR	O_2	CO_2	MV	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-V_{O2}	RER
1	53.8	.34	.38	12.9	5.4	152.6	104.2	120.3	--	--	--	--	1.12
2	73.8	.228	.26	9.2	16.2	112.2	78	89.4	--	--	--	--	1.14
3	72.4	.3	.395	13.5	7	111.6	76.2	88	9.2	127.1	765	3.3	1.32
$\bar{X}$	66.7	.289	.345	11.9	9.5	125.5	86.1	99.2	9.2	127.1	765	3.3	1.19
SD ±	11.2	.057	.074	2.33	5.83	23.5	15.67	18.26	( )	( )	( )	( )	.11
SEC ±						13.1	6.4	.7					

75W SUP

Subject #													
1	91	1.24	1.28	30.5	9.7	217.9	118.8	151.8	14.3	157.1	849	8.7	1.03
2	106.3	1.079	1.108	28.2	18	167.2	82.5	110.7	--	--	--	--	1.03
3	104.7	1.216	1.093	28.4	16.3	153.9	94.1	114	16.2	154.7	563	7.5	.90
$\bar{X}$	100.7	1.178	1.160	29.0	14.67	179.7	98.5	125.5	15.3	155.9	706	8.1	.99
SD ±	8.41	.087	.104	1.27	4.38	33.77	18.54	22.84	1.34	1.70	202	0.85	.08
SEM ±						.20	7.8	9	1.2				.03

Recovery

Subject #													
1	82	.51	.66	19.4	6.8	176.5	85.6	115.9	--	--	--	--	1.29
2	84	.335	.416	12.4	14.8	134.2	80.5	98.4	--	--	--	--	1.24
3	78.8	.446	.544	15.9	9.2	126.9	80.4	95.9	--	--	--	--	1.22
$\bar{X}$	81.6	.430	.540	15.9	10.3	145.9	82.1	103.4	--	--	--	--	1.25
SD ±	2.62	.089	.122	3.5	4.10	26.78	2.97	10.9	--	--	--	--	.04
SEM ±								4					.02

R&D AM

S. Rest

Subject #	HR	VO_2	V_{CO_2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-VO_2	RER
1	72	.310	.380	14.8	7.4	133.4	94.8	107.7	--	--	--	--	1.23
2	73.8	.250	.228	8.3	15.8	116.8	78.8	91.5	3.7	50.1	1978	6.8	.91
3	77.8	.320	.432	15.3	8.2	122.5	85.4	97.8	8.8	113.0	889	3.6	1.35
4	72.0	.248	.227	6.4	7.2	113.5	80.4	91.4	5.1	70.8	1434	4.9	.92
5	74.6	.261	.254	8.5	12.0	158.4	122.3	134.3	3.9	52.3	2755	6.7	.97
6	78.4	.254	.346	12.2	5.0	113	64	80.3	6.9	88.0	931	3.7	1.34
$\bar{X}$	74.8	.273	.311	10.9	9.3	126.3	87.6	100.5	5.7	74.8	1597	5.1	1.12
SD ±	2.8	.032	.087	3.7	3.9	17.5	16.0	18.8	2.2	26.3	787	1.6	.22
SE													

S. Exercise

Subject #													
1	106	1.26	1.24	32.0	10.7	196.3	98.2	130.9	12.2	115	858	10.3	.98
2	103.7	1.106	1.049	27.9	21.0	157.1	89.0	111.7	9.3	89.7	961	11.9	.95
3	108.3	1.263	1.133	27.9	11.3	146.6	87.8	107.4	11.2	103.4	767	11.3	.90
4	111.3	1.264	1.288	30.1	14.0	159.6	77.3	104.7	12.1	108.7	692	10.4	1.02
5	107.3	1.174	1.164	28.7	12.3	243.5	133.5	1702	10.0	93.2	1362	11.7	.99
6	108.3	1.056	1.008	22.0	5.7	168	79.0	108.7	8.6	79.4	1011	12.3	.95
$\bar{X}$	107.5	1.187	1.147	27.9	12.5	178.4	94.1	122.3	10.6	98.2	942	11.3	.97
SD ±	2.5	.090	.108	3.2	5.0	36.0	20.7	25.3	1.5	13.2	237	.8	.04

S. Recovery

Subject #													
1	86	.46	.58	17.4	7.4	168.5	107.0	127.5	--	--	--	--	1.26
2	75.2	.365	.438	13.2	14.6	135.3	80.1	98.5	--	--	--	--	1.20
3	87.8	.478	.585	15.2	8.4	137.2	89.4	105.3	--	--	--	--	1.22
4	82.8	.412	.481	12.8	9.8	128.5	73.3	91.7	--	--	--	--	1.17
5	82.0	.453	.541	16.4	10.4	186.4	115.1	138.9	--	--	--	--	1.19
6	89.0	.456	.604	16.8	5.8	146	64	91.3	--	--	--	--	1.32
$\bar{X}$	83.8	.437	.538	15.3	9.4	150.3	88.1	106.2	--	--	--	--	1.23
SD ±	5.0	0.42	.066	1.9	3.0	225	19.7	21.4	--	--	--	--	.06

(R&O Supine)

R+O AM

ER Rest

Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	96.3	.44	.37	14.0	12.2	143.4	83.6	103.5	--	--	-	--	.84
2	98.0	.282	.255	11.0	17.0	121.9	79.9	93.9	4.2	42.9	1789	6.7	.90
3	101.3	.420	.453	18.1	8	113.1	72.9	86.3	8.0	79.0	863	5.2	1.08
4	91.5	.321	.292	9.1	7.8	121.9	78.4	92.9	5.0	54.6	1486	6.4	.91
5	96.8	.356	.300	11.4	9.0	137.4	111.9	120.4	4.5	46.5	2140	7.9	.84
6	99.7	.386	.345	12.0	6.3	120	66.	84.0	8.7	87.3	772	4.4	.89
$\bar{X}$	97.3	.368	.336	12.6	10.1	126.2	82.1	96.8	6.1	62.1	1410	6.1	.91
SD ±	3.4	.060	.070	3.1	3.9	11.6	15.8	13.4	2.1	19.9	589	1.4	.09

ER EXC

Subject #													
1	151.7	1.26	1.25	38.3	13.7	199.6	80.7	120.3	11.0	72.5	875	11.4	.99
2	115.3	1.155	1.041	30.7	23.0	149.8	66.2	94.1	9.4	81.5	801	12.3	.90
3	123.7	1.482	1.279	32.3	13.7	129.4	70.8	90.3	10.4	84.1	695	14.2	.86
4	129.0	1.274	1.222	30.8	12.0	160.7	68.5	99.2	10.4	80.6	763	12.2	.96
5	130.3	1.216	1.183	31.1	14.3	211.8	128.2	156.1	9.2	70.6	1357	13.2	.97
6	139.0	1.263	1.188	26.7	7.3	.59	49	85.6	11.1	79.9	617	11.4	.94
$\bar{X}$	131.5	1.275	1.194	31.6	14.0	168.4	77.2	107.6	10.3	78.2	851	12.5	.94
SD ±	12.6	.111	.083	3.8	5.0	31.2	27.0	26.6	.8	5.4	263	1.1	.05

ER Recovery

Subject #													
1	111.4	.47	.49	18.1	7.2	154.4	89.7	111.3	--	--	--	--	1.04
2	99.4	.376	.351	13.4	15.6	129.7	86.3	100.8	--	--	--	--	.93
3	113.0	.551	.600	21.1	10.8	125.9	80.6	95.7	--	--	--	--	1.09
4	110.8	.421	.420	13.3	9.6	132.8	78.2	96.4	--	--	--	--	1.00
5	116.0	.583	.623	21.4	11.2	165.7	119.5	134.9	--	--	--	--	1.07
6	120.0	.487	.556	18.0	7.4	139	75	96.3	--	--	--	--	1.14
$\bar{X}$	116.8	.481	.508	17.6	10.3	141.3	88.2	105.9	--	--	--	--	1.05
SD ±	6.9	.078	.108	3.6	3.1	15.6	16.2	15.4	--	--	--	--	1.07

(R&O Upright)

R + 1

S. Rest

Subject	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	$A-CO_2$	RER
1	69.4	.305	.337	9.7	7.6	118.0	74.2	83.3	5.6	78.7	1376	4.7	1.10
2	93.2	.287	.289	10.0	12.2	.357	76.0	106.0	6.6	81.6	1130	5.2	1.01
3	83.6	.393	.567	6.9	12.6	107.5	80.0	79.8	10.7	91.6	703	3.8	1.44
4	66.6	.231	.232	19.4	9.8	121.9	66.0	94.0	6.1	128.0	1047	3.7	1.00
5	66.2	.280	.333	9.0	7.8	127.6	91.1	93.2	5.4	70.8	1570	4.3	1.19
6	73.6	.273	.320	11.1	5.6	140.6	66.0	96.3	5.8	80.7	1149	5.4	1.17
$\bar{X}$	75.4	.294	.346	11.0	9.3	125.2	75.6	92.1	6.7	88.6	1163	4.5	1.15
SD ±	10.8	.054	.115	4.3	2.8	12.1	9.4	9.4	2.0	20.4	295	.7	.16
SEM ±				1.8			4.9	4	.8	8	120		

S. Exc.

Subject #													
1	104.7	1.241	1.257	23.4	13.3	186.0	102.3	116.7	11.4	86.6	941	12.0	1.01
2	119.3	1.189	1.143	30.8	21.7	198.6	53.2	144.6	9.9	118.5	787	9.4	.96
3	114.0	1.318	1.215	31.3	19.0	154.2	87.5	104.5	13.1	95.6	677	12.0	.92
4	114.0	1.131	1.303	33.0	15.0	157.8	79.7	110.9	10.9	114.9	767	10.1	1.15
5	106.3	1.187	1.256	28.3	12.7	185.7	117.6	97.4	12.6	83.0	918	12.0	1.06
6	112.0	1.165	1.140	29.7	7.0	197.6	82.0	96.3	9.7	108.9	962	10.9	.98
$\bar{X}$	111.7	1.235	1.218	29.4	14.8	180.0	87.1	111.7	11.3	101.3	842	11.1	1.01
SD ±	5.4	.066	.066	3.4	5.2	19.4	21.9	17.9	1.4	1.4	115	1.1	.1
SEM				1.4		7.9	8.9	7	0.6	6	47		

S. Recovery

Subject #													
1	78.8	.467	.604	16.4	7.6	168.6	74.2	105.7	--	--	--	--	1.29
2	94.8	.414	.469	14.0	18.2	142.8	66.3	91.8	--	--	--	--	1.13
3	91.0	.503	.712	25.5	21.2	142.9	84.5	104.0	--	--	--	--	1.42
4	80.6	.434	.535	14.4	11.2	128.2	69.9	89.3	--	--	--	--	1.23
5	73.4	.441	.567	16.0	10.4	141.5	86.9	105.1	--	--	--	--	1.29
6	88.6	.460	.628	16.7	7.0	142.0	64.0	90.0	--	--	--	--	1.37
$\bar{X}$	84.5	.453	.585	17.2	12.6	144.3	74.3	97.7	--	--	--	--	1.29
SD ±	8.2	.030	.083	4.2	5.8	13.2	9.5	8.0	--	--	--	--	.10
SEM ±				1.7				3					

(R+1 Sup)

R+1

Er. Rest

Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	75.7	.451	.455	16.8	7.3	148.3	79.3	1023	5.9	78.0	1387	7.6	1.01
2	105.8	.357	.314	10.8	16.2	130.3	58.3	82.3	5.3	50.1	1242	6.7	.88
3	92.3	.444	.468	21.5	12.0	115.3	68.2	83.9	11.0	119.2	610	4.0	1.05
4	87.2	.304	.283	8.8	--	118.3	72.4	87.7	5.2	59.6	1349	5.8	.93
5	84.2	.382	.346	12.2	8.0	130.0	94.8	106.5	5.3	62.9	1608	7.2	.91
6	85.6	.354	.321	10.2	5.0	111.0	70.0	83.6	7.4	86.4	904	4.8	.91
$\bar{X}$	88.5	.382	.365	13.4	9.7	125.5	73.8	91.1	6.7	76.0	1183	6.0	.95
SD ±	10.1	.056	.078	4.8	4.4	13.6	12.3	10.6	2.3	24.9	363	1.4	.07
SEM ±				2		5.6	5	4	.9	0	148		

Er. Exc.

Subject #													
1	126.7	1.321	1.144	30.7	12.3	190.0	64.3	112.6	9.8	77.4	919	13.5	.87
2	124.0	1.196	1.106	28.4	13.3	202.2	61.8	93.3	8.8	71.0	848	13.6	.92
3	114.3	1.414	1.193	28.9	9.7	142.4	50.8	80.9	12.2	106.7	530	11.6	.84
4	137.0	1.320	1.256	31.1	--	141.1	71.3	95.0	11.9	86.9	639	11.1	.95
5	128.7	1.230	1.333	34.6	12.7	156.2	122.0	148.7	11.2	87.0	1062	11.0	1.08
6	127.3	1.294	1.231	26.6	8.7	209.3	65	106.6	11.3	88.8	755	11.5	.95
$\bar{X}$	126.3	1.296	1.211	30.1	11.3	173.5	72.5	106.2	10.9	86.3	792	12.1	.94
SD ±	7.4	.077	.081	2.8	2.0	30.6	25.1	23.6	1.3	12.1	193	1.2	.08
SEM ±				1.1		12.5	10	10	.5	5	79		.03

Er. Rec.

Subject #													
1	100.6	.479	.522	18.8	5.6	148.6	77.4	101.1	--	--	--	--	1.09
2	106.4	.422	.394	12.6	15.0	134.6	67.4	89.8	--	--	--	--	.93
3	93.2	.544	.574	17.2	6.4	124.8	79.0	94.3	--	--	--	--	1.06
4	107.8	.396	.408	12.5	--	118.1	69.2	85.5	--	--	--	--	1.03
5	103.0	.557	.663	21.4	10.8	159.2	98.9	119	--	--	--	--	1.19
6	104.6	.485	.576	17.4	8.6	136	92.0	106.7	--	--	--	--	1.19
$\bar{X}$	102.6	.481	.533	16.7	9.3	136.9	80.7	99.4	--	--	--	--	1.08
SD ±	5.3	.064	.105	3.5	3.8	15.1	12.5	--	--	--	--	--	.10
SEM ±				1.4									.04

R+1 Erect

R+2

S. Rest Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	66.0	.317	.419	14.7	5.2	136.8	84.8	102.1	--	--	--	--	1.32
2	80.2	.292	.306	9.7	13.4	131.0	64.9	86.9	4.6	57.4	1511	6.3	1.05
3	76.8	.410	.522	17.0	8.6	118.2	85.0	96.1	7.1	92.4	1083	5.8	1.27
4	68.4	.253	.241	7.5	9.4	112.8	81.2	91.7	4.3	62.9	1706	5.9	.95
5	64.4	.241	.224	8.1	7.2	118.9	84.9	96.2	4.1	63.7	1877	5.9	.93
6	73.0	.284	.356	11.2	5.4	112.6	63.0	79.5	6.4	87.7	994	4.4	1.25
$\bar{X}$	71.5	.300	.345	11.4	8.2	121.7	77.3	92.1	5.3	72.8	1434	5.7	1.13
SD ±	6.3	.061	.114	3.8	3.1	10.0	10.5	8.0	1.4	16.0	385	.7	.17
SEM ±				1.6		4.1	4.3	3	.6	7	157		

S. Exc. Subject													
1	105.0	1.316	1.294	33.1	16.0	195.0	98.6	130.7	10.7	101.9	977	12.7	.98
2	112.7	1.157	1.073	27.7	21.7	166.6	50.3	89.1	10.2	90.5	699	11.3	.93
3	105.0	1.300	1.181	29.0	14.7	128.5	60.6	83.2	10.1	96.2	659	12.9	.91
4	107.7	1.302	1.234	29.8	15.7	161.7	79.7	107.0	12.6	117.0	679	10.3	.95
5	106.3	1.173	1.146	29.3	11.3	154.4	102.6	119.9	12.0	112.9	799	9.8	.98
6	109.3	1.212	1.077	24.3	6.7	176.0	75.0	108.7	11.5	105.2	756	10.5	.89
$\bar{X}$	107.7	1.243	1.167	28.9	14.3	163.7	77.8	106.4	11.2	104.0	762	11.3	.94
SD ±	3.0	.071	.087	2.9	4.8	22.2	20.6	18.0	1.0	10.0	118	1.3	.04
SEM ±				1.2		9.1	8.4	7	.4	4	48		

S. Rec. Subject													
1	78.0	.463	.616	15.7	7.4	153.0	72.0	99.0	--	--	--	--	1.33
2	84.4	.409	.481	14.5	18.4	137.9	58.8	85.2	--	--	--	--	1.18
3	83.6	.487	.618	18.8	12.4	108.1	59.4	75.6	--	--	--	--	1.27
4	76.8	.422	.488	13.5	11.4	126.6	77.4	93.8	--	--	--	--	1.16
5	73.2	.452	.535	16.2	9.6	128.4	86.1	100.2	--	--	--	--	1.18
6	85.0	.466	.619	17.6	7.0	140.4	68.1	92.2	--	--	--	--	1.33
$\bar{X}$	80.2	.450	.560	16.1	11.0	132.4	70.3	91.0	--	--	--	--	1.24
SD ±	4.9	.029	.066	2.0	4.2	15.2	10.6	9.3	--	--	--	--	.08
SEM ±				0.8				4					

R+2 Supine

R+2

Subject #	HR	VO_2	V_{CO_2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	78.8	.430	.406	15.7	5.8	139.5	87.0	104.5	--	--	--	--	.94
2	95.0	.339	.324	12.1	14.5	118.8	47.6	71.3	8.6	90.5	663	3.9	.96
3	88.5	.373	.405	15.8	7.8	89.1	64.0	72.4	12.6	142.4	460	3.0	1.09
4	84.8	.300	.260	8.4	6.0	106.3	79.3	88.4	4.1	48.3	1725	7.3	.87
5	86.0	.369	.321	12.6	7.0	117.1	93.9	101.6	6.8	79.1	1195	5.4	.87
6	87.5	.345	.325	12.8	5.5	104.7	74.0	84.2	5.2	59.4	1295	6.6	.94
$\bar{X}$	86.8	.359	.340	12.9	7.8	112.6	74.3	87.1	7.5	83.9	1068	5.2	.94
SD ±	5.3	.044	.057	2.7	3.4	17.0	16.7	14.1	3.3	36.6	508	1.8	.08
SEM ±				1.1	11	6.9	7	6	1.4	15	207		

Er. Exc.

Subject #													
1	122.0	1.284	1.121	33.7	16.3	180.3	58.5	99.1	10.4	85.2	762	12.3	.87
2	119.3	1.225	1.089	30.2	23.3	153.2	42.7	79.5	11.1	93.0	573	11.0	.89
3	113.0	1.315	1.037	26.8	10.7	110.9	56.2	74.4	15.1	133.6	394	8.7	.79
4	122.7	1.258	1.203	31.8	16.3	153.0	80.0	104.4	11.2	91.3	746	11.2	.96
5	126.0	1.271	1.229	32.9	12.7	176.2	124.8	141.9	13.5	107.1	841	9.4	.97
6	123.0	1.221	1.064	24.0	6.8	185.2	50.9	95.7	11.2	91.1	684	10.9	.87
$\bar{X}$	121.0	1.262	1.123	29.9	14.4	159.8	68.9	99.2	12.1	100.2	667	10.6	.89
SD ±	4.5	.036	.077	3.8	5.7	27.6	30.1	23.9	1.8	17.9	161	1.3	.07
SEM ±				1.6	2.3	11.3	12	10	.7	7.3	66		.03

Er. Rec.

Subject #													
1	93.0	.467	.479	17.6	8.2	158.4	92.7	114.6	--	--	--	--	1.03
2	99.5	.443	.430	14.0	17.5	137.4	56.5	83.5	--	--	--	--	.97
3	100.2	.494	.547	20.1	11.4	101.5	59.8	73.7	--	--	--	--	1.11
4	97.0	.376	.373	12.6	10.6	130.0	88.4	102.3	--	--	--	--	.99
5	105.4	.507	.532	18.9	10.0	141.9	105.6	117.7	--	--	--	--	1.05
6	102.2	.513	.602	19.0	8.0	143.8	67.7	93.1	--	--	--	--	1.17
$\bar{X}$	99.6	.467	.494	17.0	11.0	135.5	78.5	97.5	--	--	--	--	1.05
SD ±	4.3	.052	.084	3.0	3.5	19.1	19.9	17.4	--	--	--	--	.08
SEM ±				1.2				7					.03

R+2 Erect

R+7,8

S. Rest Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	69.6	.354	.390	15.0	7.4	147.6	77.9	101.1	--	--	--	--	1.10
2	67.6	.300	.270	8.5	6.4	113.1	73.3	86.5	4.4	65.1	1573	6.8	.90
3	63.8	.300	.310	9.2	8.4	118.5	88.2	98.3	4.9	76.8	1605	6.1	1.03
4	59.0	.219	.202	6.9	6.0	104.2	67.8	79.9	4.1	69.5	1559	5.3	.92
5	55.2	.271	.256	9.2	6.4	134.1	93.9	107.3	4.4	79.7	1951	6.2	.94
6	71.6	.270	.365	12.5	4.6	110.0	70.0	83.3	5.6	78.2	1190	4.8	1.35
$\bar{X}$	64.5	.286	.299	10.2	6.5	121.3	78.5	92.7	4.7	73.9	1576	5.8	1.04
SD ±	6.4	.045	.070	3.0	1.3	16.4	10.4	11.0	.6	6.3	270	.8	.17
SEM ±				1.2		6.7	4.2	4	.2	2.6	110		

S. Exc Subject #												
1	112.0	1.411	.950	27.8	11.4	193.7	108.8	137.1	15.8	141.1	694	8.9	.67
2	102.6	.940	.800	20.9	19.2	146.7	66.1	93.0	9.3	90.6	800	10.1	.85
3	105.4	1.200	1.000	26.2	14.6	142.6	86.0	104.9	13.7	130.0	612	8.2	.83
4	101.7	1.213	1.179	26.7	12.3	139.2	70.5	93.4	12.0	118.0	623	10.1	.97
5	96.3	1.138	1.072	28.1	13.3	174.0	102.2	126.1	10.9	113.2	925	10.4	.94
6	108.0	1.172	1.068	22.5	6.3	176.7	55.3	95.8	9.4	87.0	815	12.5	.91
$\bar{X}$	104.3	1.179	1.012	25.4	12.9	162.2	81.5	108.4	11.9	113.3	745	10.0	.86
SD ±	5.4	.151	.130	3.0	4.2	22.3	21.2	18.8	2.6	21.4	123	1.5	.11
SEM ±				1.2		9.1	8.7	8	1.1	9	50		

S. Rec. Subject #													
1	82.6	.590	.660	22.7	8.6	174.1	80.7	111.8	--	--	--	--	1.12
2	72.2	.330	.370	10.9	12.8	129.8	65.1	86.7	--	--	--	--	1.12
3	79.0	.440	.500	14.2	12.4	140.2	89.2	106.2	--	--	--	--	1.14
4	71.0	.414	.476	13.6	9.4	119.8	58.1	78.7	--	--	--	--	1.15
5	62.2	.431	.454	14.9	12.2	138.9	90.5	106.6	--	--	--	--	1.12
6	82.0	.459	.608	16.9	6.0	137.2	63.7	88.2	--	--	--	--	1.32
$\bar{X}$	74.8	.444	.516	15.5	10.2	140.0	74.6	96.4	--	--	--	--	1.16
SD ±	7.9	.084	.103	4.0	2.7	18.4	14.0	13.5	--	--	--	--	.08
SEM ±				1.6				6					.03

R+7,8 Sup

Er. Rest

Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	79.2	.470	.330	14.2	8.3	141.6	86.6	105.0	--	--	--	--	.70
2	87.3	.260	.240	8.2	9.8	120.7	67.2	85.0	4.0	45.8	1700	6.5	.92
3	78.5	.370	.410	14.0	8.8	113.1	71.0	85.1	7.7	98.1	884	4.8	1.11
4	73.5	.316	.289	10.3	7.5	110.7	57.8	75.4	--	--	--	--	.91
5	66.5	.392	.322	11.3	6.8	134.3	95.1	108.2	7.8	117.3	1110	5.0	.82
6	89.2	.335	.337	13.6	5.2	113.0	59.6	77.4	5.1	57.2	1214	6.6	1.01
$\bar{X}$	79.0	.357	.321	11.9	7.7	122.2	72.9	89.4	6.2	79.6	1227	5.7	.91
SD ±	8.5	.072	.056	2.4	1.6	12.8	15.0	14.0	1.9	33.7	344	1.0	.14
SEM ±				1.0		5.2	6	6	.8	14	140		

Er. Exc.

Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	121.3	1.470	1.120	34.8	16.3	183.4	107.1	132.6	13.0	151.2	816	11.3	.70
2	108.3	1.170	1.01	25.9	14.3	149.4	31.3	70.7	10.7	98.8	528	10.9	.86
3	112.7	1.380	1.14	29.2	14.0	138.3	58.8	85.3	13.0	115.4	525	10.6	.83
4	115.3	1.223	1.101	30.3	10.3	140.5	40.7	74.0	11.3	98.1	524	10.8	.90
5	109.3	1.243	1.206	32.6	11.0	178.8	122.0	140.9	--	--	--	--	.97
6	119.3	1.218	1.037	23.0	7.0	178.6	56.3	97.1	12.0	100.6	647	10.2	.85
X	114.4	1.284	1.102	29.3	12.2	161.5	69.4	100.1	12.0	112.8	608	10.8	.86
SD ±	5.3	.115	.071	4.3	3.4	21.0	36.7	30.0	1.0	22.6	128	.4	.07
SEM ±				1.8		8.6	15	12	.4	9.2	52		.03

Er. Rec.

Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	86.0	.580	.500	18.5	8.8	159.8	88.7	112.4	--	--	--	--	.86
2	93.2	.390	.360	11.1	11.0	125.6	80.1	95.3	--	--	--	--	.92
3	79.6	.430	.460	15.9	12.2	129.6	79.4	96.1	--	--	--	--	1.07
4	83.2	.382	.361	12.8	7.2	119.1	66.1	83.8	--	--	--	--	.95
5	82.0	.483	.479	16.1	8.4	143.9	97.8	113.2	--	--	--	--	.99
6	98.2	.458	.523	17.2	7.4	136.6	61.4	86.5	--	--	--	--	1.14
$\bar{X}$	87.0	.454	.447	15.3	9.2	135.8	78.9	97.9	--	--	--	--	.99
SD ±	7.2	.073	.070	2.8	2.0	14.6	13.6	12.5	--	--	--	--	.10
SEM ±				1.1				5					.04

R+17,19

S. Rest Subject #	HR	VO_2	V_{CO2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	$A-CO_2$	RER
1	59.8	.347	.384	14.0	7.6	139.0	79.8	99.5	--	--	--	--	1.11
2	85.6	.231	.207	8.2	9.8	160.3	76.8	104.6	--	--	--	--	.90
3	70.2	.299	.282	9.6	7.2	109.8	64.1	79.3	4.8	68.4	1322	6.2	.94
4	61.2	.154	.154	5.8	9.2	95.0	61.0	72.3	2.2	35.9	2629	7.0	1.00
5	63.4	.267	.228	8.3	7.4	144.3	97.7	113.2	5.6	88.3	1617	4.8	.85
6	81.6	.257	.312	10.2	5.0	134.6	59.8	93.2	4.7	57.6	1586	5.5	1.21
$\bar{X}$	70.3	.259	.261	9.4	7.7	130.5	73.2	93.7	4.3	62.6	1789	5.8	1.00
SD ±	11.0	.065	.082	2.7	1.7	23.9	14.6	15.6	1.5	21.9	576	.9	.14
SEM ±				1.1		9.8	6	6	.6	9	235		

S. Exc. Subject #												
1	95.0	1.192	.991	28.1	13.3	186.4	87.2	120.3	--	--	--	--	.83
2	114.7	.909	.832	28.6	17.7	196.0	92.2	126.8	--	--	--	--	.92
3	105.3	.968	.850	28.6	17.3	161.6	89.8	113.7	8.4	79.8	1083	11.5	.88
4	105.0	.944	.923	26.7	11.7	137.4	67.7	90.9	7.9	75.2	921	11.9	.98
5	109.0	1.109	1.081	30.8	11.0	200.8	116.3	144.5	10.8	99.1	1070	10.3	.97
6	117.3	1.088	.909	20.6	8.0	196.2	59.8	105.3	9.8	83.5	682	11.1	.84
$\bar{X}$	107.7	1.035	.931	27.2	13.2	179.7	85.5	116.9	9.2	84.4	939	11.2	.90
SD ±	8.0	.111	.093	3.5	3.8	25.1	20.0	18.4	1.3	10.4	186	.7	.07
SEM ±				1.4		10.2	8.2	8	.53	4	76		

s. Rec. Subject #												
1	60.8	.468	.515	16.2	7.2	164.9	76.4	105.9	--	--	--	--	1.10
2	90.0	.300	.307	12.6	12.2	170.5	84.6	113.2	--	--	--	--	1.02
3	80.2	.359	.391	14.8	14.4	125.4	73.4	90.7	--	--	--	--	1.09
4	71.4	.313	.385	12.3	9.2	112.4	55.5	74.5	--	--	--	--	1.23
5	77.8	.475	.545	17.2	10.0	163.3	96.5	118.8	--	--	--	--	1.15
6	94.6	.417	.522	15.4	6.4	154.3	78.4	103.7	--	--	--	--	1.25
$\bar{X}$	79.1	.389	.444	14.8	9.9	148.5	77.5	101.1	--	--	--	--	1.14
SE ±	12.3	.076	.096	2.0	3.0	23.8	13.5	16.2	--	--	--	--	.09
SEM ±				0.8				7					

R+18 SUP

R+17,19

Er. Rest

Subject #	HR	VO_2	V_{CO_2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	61.8	.429	.393	15.4	7.0	141.8	80.5	100.9	--	--	--	--	.92
2	103.0	.280	.239	11.4	13.3	160.8	88.0	112.3	--	--	--	--	.85
3	78.0	.279	.232	10.0	10.5	110.0	56.1	74.1	3.7	47.4	1602	7.5	.83
4	74.0	.230	.209	7.8	5.7	102.0	73.1	82.7	2.7	36.5	2450	8.5	.91
5	79.0	.348	.281	10.7	6.5	134.9	103.6	114.0	7.5	94.9	1216	4.6	.81
6	97.0	.320	.305	12.4	5.2	121.1	49.5	73.4	5.8	59.8	1012	5.5	.95
$\bar{X}$	82.1	.314	.277	11.3	8.0	128.4	75.1	92.9	4.9	59.7	1570	6.5	.88
SD ±	15.3	.069	.067	2.5	3.2	21.7	20.1	18.6	2.1	25.4	636	1.8	.06
SEM ±				1.0		9	8	8	.9	10	260		

Er. Exc

Subject #	HR	VO_2	V_{CO_2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	91.3	1.197	.900	25.6	10.3	175.8	75.3	108.8	--	--	--	--	.75
2	123.0	.860	.744	30.1	22.3	192.6	74.2	113.7	--	--	--	--	.87
3	107.3	1.038	.879	30.5	17.0	143.6	66.3	92.1	8.7	81.1	847	11.9	.85
4	115.7	.947	.838	25.8	10.0	123.3	72.2	89.2	8.6	74.3	830	11.0	.88
5	119.0	1.207	1.192	35.4	12.3	192.1	118.2	142.8	13.0	109.2	879	9.3	.99
6	127.0	1.157	.965	24.2	8.7	184.7	63.0	103.6	9.4	74.0	882	12.3	.83
$\bar{X}$	113.8	1.068	.920	28.6	13.4	168.7	78.2	108.4	9.9	84.7	860	11.1	.86
SD ±	12.9	.143	.152	4.2	5.2	28.7	20.2	19.3	2.1	16.7	25	1.3	.08
SEM ±				1.7		11.7	8	8	.9	7	10		.03

Er. Rec.

Subject #	HR	VO_2	V_{CO_2}	VE	RR	SBP	DBP	MAP	$\dot{Q}$	SV	TPR	A-CO_2	RER
1	58.5	.484	.439	14.5	5.8	158.2	89.5	112.4	--	--	--	--	.91
2	107.4	.319	.289	13.3	14.0	150.6	92.3	111.7	--	--	--	--	.91
3	85.8	.345	.350	16.9	11.8	125.8	74.2	91.4	--	--	--	--	1.01
4	79.8	.308	.296	10.8	8.0	111.0	68.1	82.4	--	--	--	--	.96
5	90.8	.515	.524	17.9	10.0	154.5	95.3	115.0	--	--	--	--	1.02
6	110.6	.434	.479	18.5	7.2	139.4	57.5	84.8	--	--	--	--	1.10
$\bar{X}$	88.8	.401	.396	15.3	9.5	139.9	79.5	99.6	--	--	--	--	.98
SD ±	1.9	.089	.099	3.0	3.1	18.4	15.2	15.1	--	--	--	--	.08
SEM ±				1.2				6					.03

R+18 Erect

R+0 (PM) Post Saline + LBNP

Subject #	HR 1-5	HR 8-10	HR 11-15	HR 17-20	HR 23-25	HR 26-30	$\dot{V}_{O_2}$ 1-5	$\dot{V}_{O_2}$ 8-10	$\dot{V}_{O_2}$ 11-15	$\dot{V}_{O_2}$ 17-20	$\dot{V}_{O_2}$ 23-25	$\dot{V}_{O_2}$ 26-30
1	65.3	96.3	74.0	74.6	133.3	93.4	.272	1.243	.465	.321	1.374	.490
2	80.6	115.7	88.4	96.5	118.0	98.4	.256	1.184	.410	.289	1.135	.460
3	80.2	113.0	91.4	91.3	124.7	107.4	.331	1.247	.453	.436	1.326	.523
4	62.8	106.7	78.0	77.8	118.0	89.7	.218	1.321	.432	.294	1.347	.397
5	64.4	103.3	72.6	79.2	122.0	101.6	.278	1.218	.486	.420	1.369	.561
6	71.6	107.0	84.0	87.0	125.0	105.6	.283	1.156	.413	.387	1.249	.475
$\bar{X}$	70.8	107.0	81.4	84.4	123.5	99.4	.273	1.228	.443	.358	1.300	.484
SD ±	8.0	6.9	7.7	8.6	5.7	6.9	.037	.057	.030	.065	.093	.056
SEM ±	3.3	2.8	3.2	3.5	2.3	2.8	.015	.023	.012	.026	.038	.023

Subject #	$\dot{V}_{CO_2}$ 1-5	$\dot{V}_{CO_2}$ 8-10	$\dot{V}_{CO_2}$ 11-15	$\dot{V}_{CO_2}$ 17-20	$\dot{V}_{CO_2}$ 23-25	$\dot{V}_{CO_2}$ 26-30	MV 1-5	MV 8-10	MV 11-15	MV 17-20	MV 23-25	MV 26-30
1	.313	1.109	.569	.304	1.258	.488	11.0	27.8	16.7	13.6	39.1	17.6
2	.244	1.042	.465	.250	.970	.456	7.9	25.7	13.7	9.5	26.4	14.8
3	.400	1.110	.526	.415	1.258	.603	12.8	28.8	15.1	13.8	40.7	24.9
4	.201	1.316	.547	.270	1.226	.384	6.2	30.7	14.5	9.1	32.0	12.2
5	.343	1.193	.619	.361	1.359	.631	11.6	28.9	17.4	11.9	34.7	20.0
6	.353	1.037	.567	.389	1.149	.580	11.3	21.8	14.6	13.9	24.5	17.8
$\bar{X}$	.309	1.135	.549	.332	1.203	.524	10.1	27.3	15.3	12.0	32.9	17.9
SD ±	.074	.105	.051	.067	.133	.096	2.5	3.1	1.4	2.2	6.6	4.4
SEM ±	.030	.043	.021	.027	.054	.039	1.0	1.3	0.6	0.9	2.7	1.8

R+0 (PM) Post Saline + LBNP

Subject #	R-R 1-5	R-R 8-10	R-R 11-15	R-R 17-20	R-R 23-25	R-R 26-30	SBP 1-5	SBP 8-10	SBP 11-15	SBP 17-20	SBP 23-25	SBP 26-30
1	6.6	10.0	7.4	7.4	15.3	7.6	124.0	178.7	150.2	127.8	207.5	153.8
2	11.4	21.7	17.4	14.5	21.0	11.6	129.4	172.7	147.4	139.6	166.7	145.5
3	8.8	17.7	12.8	10.3	16.3	13.2	117.1	152.8	133.1	117.2	137.0	127.5
4	8.6	14.7	12.2	7.5	15.8	11.2	105.0	139.3	116.6	104.7	131.3	118.6
5	9.0	14.0	10.2	9.2	13.7	9.8	131.5	183.9	146.1	139.2	192.1	154.0
6	4.0	6.3	6.8	6.0	7.0	8.0	112.8	195.0	137.9	134.0	183.3	146.3
$\bar{X}$	8.1	14.1	11.1	9.2	14.9	10.2	120.0	170.4	138.6	127.1	169.7	141.0
SD ±	2.5	5.5	3.9	3.0	4.6	2.2	10.2	20.7	12.5	13.8	30.6	14.6
SEM ±	1.0	2.2	1.6	1.2	1.9	.09	4.2	8.4	5.1	5.6	12.5	6.0

Subject #	DBP 1-5	DBP 8-10	DBP 11-15	DBP 17-20	DBP 23-25	DBP 26-30	MAP 1-5	MAP 8-10	MAP 11-15	MAP 17-20	MAP 23-25	MAP 26-30
1	70.2	98.4	67.1	83.7	81.4	77.3	88.1	125.2	94.8	98.4	123.4	102.8
2	72.2	68.5	66.7	82.0	66.2	81.8	91.3	103.2	93.6	101.2	99.7	103.0
3	73.7	85.5	82.6	81.6	64.4	79.1	88.2	107.9	99.4	93.5	88.6	95.2
4	56.7	68.7	63.1	73.5	68.4	81.6	72.8	92.2	80.9	83.9	89.4	93.9
5	98.7	93.9	89.8	116.2	139.9	119.1	109.6	123.9	108.6	123.9	157.3	130.7
6	64.2	58.0	68.5	62.5	58.8	68.0	80.4	103.7	91.6	86.3	100.3	94.1
$\bar{X}$	72.6	78.8	73.0	83.3	79.9	74.3	88.4	109.4	94.8	97.9	109.8	103.3
SD ±	14.2	16.1	10.7	18.0	30.4	36.6	12.4	12.9	9.1	14.4	26.5	14.1
SEM ±	5.8	6.6	4.3	7.3	12.4	15.0	5.1	5.3	3.7	5.9	10.8	5.7

R&O (PM) Post Saline + LBNP

Subject #	$\dot{Q}$ 1-5	8-10	11-15	17-20	23-25	26-30	SV 1-5	8-10	11-15	17-20	23-25	26-30
1	6.0	11.6	--	--	12.2	--	81.8	120.4	--	--	91.5	--
2	5.0	10.2	--	7.1	9.5	--	62.0	88.2	--	73.6	80.5	--
3	7.9	13.6	--	9.8	17.2	--	98.5	120.4	--	107.3	137.9	--
4	5.2	11.8	--	4.8	12.4	--	82.8	110.6	--	61.7	105.1	--
5	4.8	10.7	--	4.2	11.7	--	74.5	103.6	--	53.0	95.9	--
6	7.2	8.1	--	8.8	10.0	--	100.6	75.7	--	101.1	80.0	--
$\bar{X}$	6.0	11.0	--	6.9	12.2	--	85.0	103.2	--	79.3	89.5	--
SD ±	1.3	1.8	--	2.4	2.7	--	14.9	18.0	--	23.9	21.5	--
SEM ±	.5	.8	--	1.1	1.1	--	6.1	7.4	--	10.7	8.8	--

Subject #	TPR 1-5	8-10	11-15	17-20	23-25	26-30	$A\text{-}V_{O2}$ 1-5	8-10	11-15	17-20	23-25	26-30
1	1175	863	--	--	809	--	4.5	10.7	--	--	11.3	--
2	1461	809	--	1140	840	--	5.1	11.6	--	4.1	11.9	--
3	893	635	--	763	412	--	4.2	9.2	--	4.4	7.7	--
4	1120	625	--	1398	577	--	4.2	11.2	--	6.1	10.9	--
5	1827	926	--	2360	1076	--	5.8	11.4	--	10.0	11.7	--
6	893	1024	--	785	802	--	3.9	14.3	--	4.4	12.5	--
$\bar{X}$	1228	814	—	1289	753	--	4.6	11.4	--	5.8	11.0	--
SD ±	361	159	--	654	230	--	0.7	1.7	--	2.5	1.7	--
SEM ±	147	65	--	293	94	--	0.3	0.7	--	1.1	0.7	--

No Treatment (AM)

Subject	HR Rest	HR Ex	HR Rec	$\dot{V}_{O_2}$ Rest	$\dot{V}_{O_2}$ Ex	$\dot{V}_{O_2}$ Rec	$\dot{V}_{CO_2}$ Rest	$\dot{V}_{CO_2}$ Ex	$\dot{V}_{CO_2}$ Rec	$\dot{V}_E$ Rest	$\dot{V}_E$ Ex	$\dot{V}_E$ Rec
1	51.8	79.7	59.8	--	--	--	--	--	--	8.7	24.1	14.5
2	67.8	108	75.2	--	--	--	--	--	--	--	--	--
3	70.4	100.3	77	.26	1.04	.36	.32	.99	.45	10.7	25.9	13.6
4	55.4	91.7	61.4	.19	1.20	.40	.18	1.13	.46	5.6	27.6	12.4
5	68.2	107.7	79.2	.21	.86	.33	.19	.88	.41	9.2	32.1	17.0
6	64.8	102.3	75.8	.21	.79	.33	.28	.81	.45	9.9	22	15.2
$\bar{X}$	63.1	98.3	71.4	.22	.97	.36	.24	.95	.44	8.8	26.3	14.5
SD ±	7.6	10.9	8.5	.03	.18	.03	.07	.14	.02	2.0	3.8	1.7
SEM ±	3.1	4.4	3.5	.01	.09	.02	.03	.07	.01	.09	1.7	0.8

Subject	RR	SBP	DBP	MAP
1	7.8	124.4	77.0	92.8
2	10	190.3	91	124.1
3	15.2	120.4	67.8	85.3
4	25.2	149	61.6	90.7
5	8.8	123.6	80.2	94.7
6	15.3	159.2	96.8	117.6
	7	108.1	78.5	88.4
	12.7	173.8	73.3	106.8
	8.8	130	83.9	99.2
	14	196.8	104.3	135.1
	10.4	142.9	83.4	103.2
	5.6	109.8	59.7	76.4
	11	169	70.7	103.5
	7.6	136.8	68.5	91.3
$\bar{X}$	8.9	119.4	74.5	89.5
SD ±	14.7	173	83	113
SEM ±	10.8	137.1	71.1	93.1
	3.3	8.7	9.0	8.0
	5.5	18.2	16.8	15.9
	4.2	10.7	7.3	7.2
	1.4	3.5	3.7	3.3
	2.2	7.4	6.9	6.5
	1.7	4.4	3.0	2.9

Subject	Q	SV	TPR	A-V_{O_2}
1	--	--	--	--
2	--	--	--	--
3	--	--	--	--
4	5.5	78.1	1377	4.7
5	12.3	122.6	765	8.5
6	6	108.3	1178	3.2
7	15.2	165.8	562	7.9
$\bar{X}$	4.9	71.8	1620	4.3
SD ±	11.9	110.5	909	7.2
SEM ±	--	--	--	--
	9.3	90.9	890	8.5
	5.5	86.1	1392	4.1
	12.2	122.0	782	8.0
	.6	19.5	221	.8
	2.4	31.7	160	.6
	.4	11.3	129	.5
	1.2	15.9	80	.31

No Treatment (PM)

Subject	HR Rest	HR Ex	HR Rec	$\dot{V}_{O_2}$ Rest	$\dot{V}_{O_2}$ Ex	$\dot{V}_{O_2}$ Rec	$\dot{V}_{CO_2}$ Rest	$\dot{V}_{CO_2}$ Ex	$\dot{V}_{CO_2}$ Rec	$\dot{V}_E$ Rest	$\dot{V}_E$ Ex	$\dot{V}_E$ Rec
1	55.4	86.7	63.4	.21	.93	.36	.23	.87	.47	11.4	28.3	19.3
2	70	106	80.6	--	--	--	--	--	--	6.7	26	12.5
3	67.4	99.7	73.8	.24	.87	.30	.26	.79	.36	9.6	26.2	13.9
4	59.2	98.7	66.4	.21	1.13	.37	.18	1.08	.45	6.7	28.6	14.4
5	59.4	99	66.4	.19	.78	.31	.20	.82	.39	9.1	29.7	16.3
6	58.8	95	69.6	.149	.952	.297	.17	1.0	.43	6.2	24.7	14.3
$\bar{X}$	61.7	97.5	70	.20	.93	.33	.21	.91	.42	8.3	27.1	15.1
SD ±	5.7	6.4	6.3	.03	.13	.03	.04	.12	.04	2.1	1.9	2.4
SEM ±	2.3	2.6	2.6	.01	.06	.02	.02	.06	.02	0.9	0.8	1.0

Subject	RR Rest	RR Ex	RR Rec	SBP Rest	SBP Ex	SBP Rec	DBP Rest	DBP Ex	DBP Rec	MAP Rest	MAP Ex	MAP Rec
1	7.2	9	6.2	131.4	190.5	162.9	76.6	87.7	64.6	94.9	122	97.4
2	16.2	20.3	18	121.6	150.4	143.5	77.6	58	65.8	92.3	88.8	91.7
3	7.4	15.7	12	121.4	157.7	128.3	78.3	87.3	78.5	92.7	110.7	95.1
4	9.6	14	11.8	105.4	149.9	126.5	72.1	75.6	72.3	83.2	100.4	90.3
5	8.4	14	10.2	118.9	166.3	128.3	78.1	100.3	75.3	91.7	122.3	92.9
6	6.2	8.3	6.6	119.7	180.4	149.5	72.7	76.6	70.9	88.4	111.2	97.1
$\bar{X}$	9.2	13.6	10.8	119.7	165.9	139.8	75.9	80.9	71.2	90.5	109.2	94.1
SD ±	3.6	4.5	4.3	8.4	16.6	14.7	2.8	14.4	5.4	4.2	12.9	2.9
SEM ±	1.5	1.8	1.8	3.4	6.8	6.0	1.1	5.9	2.2	1.7	5.3	1.2

Subject	Q Rest	Q Ex	Q Rec	SV Rest	SV Ex	SV Rec	TPR Rest	TPR Ex	TPR Rec	$A\text{-}V_{O_2}$ Rest	$A\text{-}V_{O_2}$ Ex	$A\text{-}V_{O_2}$ Rec
1	7.7	11	--	139	126.9	--	986	887	--	2.7	8.5	--
2	--	--	--	--	--	--	--	--	--	--	--	--
3	4.7	13.4	--	69.7	134	--	1577	661	--	5.1	6.5	--
4	3.2	12.5	--	54	126.7	--	2080	642	--	6.6	9	--
5	4.5	10.6	--	75.8	107	--	1630	701	--	4.2	7.4	--
6	--	12.6	--	--	132.6	--	--	706	--	--	7.6	--
$\bar{X}$	5.0	12	--	84.6	125.4	--	1568	719	--	4.7	7.8	--
SD ±	1.9	1.2	--	37.4	10.8	--	449	97.5	--	1.6	1.0	--
SEM ±	1.0	0.5	--	18.7	4.8	--	225	43.5	--	0.8	0.4	--

Saline (AM)
Crossover Study

		H.R.	VO_2	V_{CO2}	RER	MV	RR	SBP	DBP	MAP	PP	Q	SV	TPR	A-VO_2
Rest		55.4	0.210	0.310	1.48	14.32	6.6	142.9	92.86	109.5	50.0	--	--	--	--
		67.2	0.220	0.190	0.86	7.9	15.2	127.9	80.9	96.5	47.1	4.5	67.0	1715	4.9
		70.2	--	--	--	12.0	9.0	127.0	82.9	97.6	44.2	--	--	--	--
		52.0	0.133	0.131	0.98	5.9	9.0	104.5	66.6	79.3	37.9	5.3	101.9	1197	2.5
		68.0	0.250	0.270	1.08	9.4	10.2	132.3	83.3	99.6	49.0	5.8	85.3	1374	4.3
		67.4	0.282	0.375	1.33	12.5	5.6	114.7	60.2	78.4	54.5	7.8	115.7	804	3.6
	$\bar{X}$	63.4	0.219	0.255	1.16	10.3	9.3	124.9	77.8	93.5	47.1	5.8	92.5	1272	3.8
	SD	± 7.6	0.056	0.097	0.25	3.2	3.4	13.5	12.1	12.2	5.6	1.4	21.0	379	1.0
	SEM	± 3.1	0.025	0.043	0.11	1.3	1.4	5.5	4.9	5.0	2.3	0.7	10.5	190	0.5
Exercise		83.7	0.920	0.900	0.98	26.0	4.7	189.1	102.2	131.1	86.9	12.6	150.1	833	7.3
		102.3	1.120	1.030	0.92	29.8	22.0	177.9	97.9	124.6	80.0	11.8	115.3	845	9.5
		96.7	--	--	--	31.6	14.3	162.0	96.5	118.3	65.5	--	--	--	--
		95.0	0.780	0.750	0.96	27.9	14.0	146.7	71.8	96.8	74.9	14.0	147.3	553	5.6
		112.3	1.130	1.250	1.11	32.4	15.0	214.0	94.6	134.4	119.4	13.9	123.7	774	8.1
		103.3	1.043	0.984	0.94	23.5	5.7	167.2	72.5	104.1	94.7	11.5	111.3	724	9.1
	$\bar{X}$	98.9	0.999	0.983	0.98	28.5	12.6	176.2	89.2	118.2	86.9	12.8	129.5	746	7.9
	SD	± 9.6	0.148	0.183	0.08	3.4	6.5	23.5	13.5	15.0	18.8	1.2	18.1	118	1.6
	SEM	± 3.9	0.066	0.082	0.04	1.4	2.7	9.6	5.5	6.1	7.7	0.5	8.1	53	0.7
Recovery		62.4	--	0.480	--	17.4	6.8	166.2	83.2	110.9	83.0	--	--	--	--
		74.0	0.390	0.430	1.10	14.6	18.8	144.3	80.3	101.6	64.0	--	--	--	--
		75.4	--	--	--	15.3	10.4	147.5	90.9	109.8	56.5	--	--	--	--
		61.8	0.260	0.314	1.21	12.8	10.6	118.9	59.0	79.0	59.9	--	--	--	--
		85.2	0.450	0.570	1.27	17.5	11.8	145.3	85.4	105.4	60.0	--	--	--	--
		75.2	0.420	0.539	1.28	15.8	5.0	136.7	63.5	87.9	73.2	--	--	--	--
	$\bar{X}$	72.3	0.380	0.467	1.22	15.6	10.6	143.2	77.0	99.1	66.1	--	--	--	--
	SD	± 8.9	0.084	0.101	0.08	1.8	4.8	15.4	12.8	12.9	10.1	--	--	--	--
	SEM	± 3.6	0.042	0.045	0.04	0.7	2.0	6.3	5.2	5.3	4.1	--	--	--	--

Saline (PM)
Crossover Study

		H.R.	VO_2	V_{CO2}	RER	MV	RR	SBP	DBP	MAP	PP	Q	SV	TPR	A-VO_2
Rest		52.2	0.180	0.240	1.33	11.6	9.0	146.7	78.9	101.5	67.8	5.1	97.7	1592	3.5
		67.8	--	--	--	5.8	17.2	106.8	69.1	81.7	37.7	--	--	--	--
		71.4	0.311	0.352	1.13	11.9	11.0	87.5	49.2	62.0	38.3	--	--	--	--
		58.6	0.160	0.160	1.00	6.4	9.0	110.7	79.3	89.7	31.4	2.9	49.5	2476	5.5
		61.4	0.191	0.182	0.95	7.8	11.8	121.5	67.2	85.3	54.3	4.4	71.7	1551	4.3
		67.4	0.200	0.256	1.28	9.4	5.2	113.9	60.9	78.6	53.0	--	--	--	--
	$\bar{X}$	63.1	0.208	0.238	1.14	8.8	10.5	114.5	67.4	83.1	47.1	4.1	73.0	1873	4.4
	SD±	7.1	0.059	0.075	0.17	2.6	4.0	19.4	11.4	13.1	13.6	1.1	24.1	523	1.0
	SEM±	2.9	0.026	0.034	0.08	1.1	1.6	7.9	4.7	5.3	5.6	0.6	13.9	302	0.6
Exercise		85.0	0.750	0.700	0.93	25.1	11.3	194.2	104.6	134.5	89.6	10.0	117.6	1076	7.5
		106.0	--	--	--	26.3	24.0	132.9	68.5	90.0	64.4	--	--	--	--
		101.7	1.115	0.989	0.89	25.7	16.7	167.5	82.1	110.6	85.4	12.6	123.9	702	8.8
		105.7	0.680	0.730	1.07	29.7	15.7	146.9	89.2	108.4	57.7	8.7	82.3	997	7.8
		100.7	0.790	0.880	1.11	31.8	15.0	162.9	79.8	107.5	83.1	--	--	--	--
		106.3	1.055	0.994	0.94	24.2	6.3	168.8	58.8	95.5	110.0	10.3	96.9	742	10.2
	$\bar{X}$	100.9	0.878	0.859	0.99	27.1	14.8	162.2	80.5	107.8	81.7	10.4	105.2	879	8.6
	SD±	8.1	0.194	0.139	0.10	3.0	5.9	20.9	16.0	15.4	18.7	1.6	19.1	185	1.2
	SEM±	3.3	0.087	0.062	0.04	1.2	2.4	8.5	6.5	6.3	7.6	0.8	9.5	92	0.6
Recovery		59.0	0.310	0.430	1.39	16.3	7.8	165.7	80.7	109.0	85.0	--	--	--	--
		74.4	--	--	--	12.1	19.8	120.6	72.0	88.2	48.6	--	--	--	--
		76.6	0.371	0.512	1.38	15.0	11.6	114.4	59.7	77.9	54.7	--	--	--	--
		68.8	0.260	0.330	1.27	12.4	12.0	125.2	81.0	95.7	44.2	--	--	--	--
		74.0	0.295	0.449	1.52	16.8	11.4	132.2	67.6	89.2	64.6	--	--	--	--
		75.6	0.377	0.496	1.32	15.4	6.2	128.7	57.9	81.5	70.8	--	--	--	--
	$\bar{X}$	71.4	0.323	0.443	1.38	14.7	11.5	131.1	69.8	90.2	61.3	--	--	--	--
	SD±	6.6	0.050	0.072	0.09	2.0	4.7	18.0	10.0	11.1	15.2	--	--	--	--
	SEM±	2.7	0.022	0.032	0.04	0.8	1.9	7.3	4.1	4.5	6.2	--	--	--	--

Saline + LBNP (AM)

Subject	HR 1-5	HR 6-10	HR 11-15	$\dot{V}_{O2}$ 1-5	$\dot{V}_{O2}$ 6-10	$\dot{V}_{O2}$ 11-15	$\dot{V}_{CO2}$ 1-5	$\dot{V}_{CO2}$ 6-10	$\dot{V}_{CO2}$ 11-15	$\dot{V}E$ 1-5	$\dot{V}E$ 6-10	$\dot{V}E$ 11-15
1	56.2	84.0	58.6	.300	1.280	.470	.370	1.080	.520	15.5	26.5	15.9
2	69.2	102.7	74.4	--	--	--	--	--	--	7.1	23.9	11.6
3	74.4	108.3	85.6	.300	.750	.290	.350	.710	.390	10.7	28.5	17.0
4	55.6	95.7	66.4	.217	1.230	.415	.210	1.180	.510	6.4	28.4	14.2
5	69.4	107.7	82.6	.250	1.060	.460	.250	1.070	.550	8.6	30.3	17.7
6	66.2	103.3	78.4	.224	.977	.364	.297	.967	.498	11.7	26.8	18.1
$\bar{X}$	65.2	100.3	74.3	.258	1.059	.400	.295	1.001	.494	10.0	27.4	13.2
SD ±	7.6	9.2	10.2	.040	.212	.074	.067	.180	.061	3.4	2.2	6.1
SEM ±	3.1	3.7	4.2	.018	.095	.033	.030	.080	.027	1.4	0.9	2.5

	RR			SBP			DBP			MAP		
1	7.4	9.0	8.2	144.2	207.0	171.0	95.8	99.9	91.5	111.9	135.6	118.0
2	15.2	20.0	14.0	123.9	173.1	144.7	84.5	54.9	67.3	97.6	94.3	93.1
3	4.2	13.3	10.8	130.2	176.8	146.4	86.5	90.0	84.7	101.1	119.0	105.3
4	6.4	14.3	10.6	92.2	155.2	128.3	53.4	68.0	62.4	66.3	97.1	84.4
5	11.2	13.7	12.0	137.9	200.8	164.5	93.2	96.9	89.5	108.1	131.5	114.5
6	4.8	6.3	6.0	114.2	192.6	145.2	62.4	64.2	60.8	79.7	88.1	88.9
$\bar{X}$	8.2	12.8	10.3	123.8	184.3	150.0	79.3	79.0	76.0	94.1	110.9	100.7
SD ±	4.2	4.7	2.8	18.7	19.4	15.4	17.3	19.0	14.1	17.6	20.4	14.0
SEM ±	1.7	1.9	1.2	7.6	7.9	6.3	7.1	7.7	5.7	7.2	8.3	5.7

	Q			SV			TPR			$A\text{-}VO_2$		
1	--	13.2	--	--	157.1	--	--	822	--	--	9.7	--
2	--	--	--	--	--	--	--	--	--	--	--	--
3	5.9	10.0	--	79.3	92.3	--	1370	952	--	5.1	7.5	--
4	9.0	16.0	--	161.9	167.2	--	589	485	--	2.4	7.7	--
5	4.8	19.0	--	69.2	176.5	--	1802	554	--	5.2	5.6	--
6	4.7	11.9	--	71.0	115.2	--	1357	592	--	4.8	8.2	--
$\bar{X}$	6.1	14.0	--	95.4	141.7	--	1280	681	--	4.4	7.7	--
SD ±	2.0	3.5	--	44.6	36.2	--	505	197	--	1.3	1.5	--
SEM ±	1.0	1.6	--	22.3	16.2	--	252	88	--	0.7	0.7	--

Saline + LBNP (PM)

Subject	HR 1-5	HR 6-10	HR 11-15	$\dot{V}O_2$ 1-5	$\dot{V}O_2$ 6.10	$\dot{V}O_2$ 11-15	$\dot{V}_{CO2}$ 1-5	$\dot{V}_{CO2}$ 6-10	$\dot{V}_{CO2}$ 11-15	$\dot{V}E$ 1-5	$\dot{V}E$ 6-10	$\dot{V}E$ 11-15
1	59.4	85.3	64.4	.280	1.040	.420	.380	.910	.560	15.2	25.1	18.6
2	67.8	106.3	79.0	--	--	--	--	--	--	6.3	25.3	13.4
3	68.8	104.7	80.8	--	--	--	--	--	--	9.6	28.3	17.6
4	61.6	101.0	71.2	.171	.800	.289	.169	.800	.370	6.4	26.3	12.5
5	38.8	95.7	65.4	.200	.940	.370	.190	.940	.450	6.7	25.1	14.5
6	70.8	105.7	82.0	.250	.950	.349	.328	.921	.473	12.2	25.1	17.1
$\bar{X}$	64.5	99.8	73.8	.225	.933	.357	.267	.893	.464	9.4	25.9	15.6
SD ±	5.2	8.1	7.9	.048	.099	.054	.104	.063	.078	3.7	1.3	2.5
SEM ±	2.1	3.3	3.2	.024	.050	.027	.052	.032	.039	1.5	.5	1.0

	RR			SBP			DBP			MAP		
1	8.1	11	.9	130.4	171.4	151.8	76.1	89	71	94.2	116.5	98
2	11.2	20	14.6	104.1	133.7	123.6	70	69.8	72.8	81.4	91.1	89.7
3	6.6	16.3	12.6	119.5	151	132.7	73.6	83.8	82.7	88.9	106.2	99.4
4	7.2	11.3	9.2	104.8	143	117.1	68.7	77.1	67	80.7	99.1	83.7
5	12	12.7	11.4	128.6	162.4	137.9	96.4	103.9	84	107.2	123.4	101.9
6	6.0	5.7	6.0	118.9	176.2	143.4	60.8	67.7	62.3	80.2	103.9	89.3
$\bar{X}$	8.6	12.8	10.5	117.7	156.3	134.4	74.3	81.9	73.3	88.8	106.7	93.7
SD ±	2.49	4.9	3.0	11.3	16.6	12.8	12.0	13.5	8.6	10.6	11.7	7.1
SEM ±	1.0	2.0	1.2	4.6	6.8	5.2	4.9	5.5	3.5	4.3	4.8	2.9

	$\dot{Q}$			SV			TPR			A-VO_2		
1	--	13.4	--	--	157	--	--	695	--	--	7.8	--
2	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--
4	4.4	12.0	--	71.4	118.8	--	1468	660	--	3.9	6.7	--
5	4.5	15	--	76.5	156.8	--	1905	658	--	4.4	6.3	--
6	7.5	8.6	--	105.9	81.4	--	855	967	--	3.3	11	--
$\bar{X}$	5.5	12.3	--	84.6	119	--	1409	745	--	3.9	8.0	--
SD ±	1.8	2.7	--	18.6	37.7	--	527	149	--	0.6	2.1	--
SEM ±	0.7	1.4	--	10.8	18.9	--	215	74	--	0.3	1.1	--

28-DAY NASA BEDREST STUDY

EFFECTS OF 28 DAYS OF BEDREST IMMOBILIZATION ON THE RESPONSES OF SKELETAL MUSCLE TO ISOMETRIC STRESS

NOVEMBER, 1976

By

Earl V. LaFevers, Ph.D., Johnson Space Center

Cletus R. Booher, Johnson Space Center

William N. Crozier, Technology, Incorporated

and

John Donaldson, Technology, Incorporated

ACKNOWLEDGEMENT

The authors wish to express their sincere appreciation to Drs. George W. Hoffler and Stuart A. Bergman, Jr., NASA Lyndon B. Johnson Space Center and to Joseph Baker, Technology, Incorporated for their support of this study project.

INTRODUCTION

Laboratory research has shown that muscle inactivity, or disuse, is associated with various muscle dysfunctions including heightened excitability, atrophy, reduced tension capabilities, et cetera (Eccles, 1941, 1944; Fischbach, et al, 1969; Jewell, et al, 1954). The Skylab II investigation of skeletal muscle changes accompanying 59 days of weightlessness provided evidence that skeletal muscles were significantly affected by that lengthy period of weightlessness, the effects including increased excitability and heightened fatigability (LaFevers, et al, 1975).

Skeletal muscle function was also found to be significantly altered by the shorter period of weightlessness (9 days) of the Apollo-Soyuz mission. Those changes included increased excitability, decreased muscle electrical efficiency, and increased fatigability (LaFevers, et al, 1976).

The purpose of this experiment was to investigate the effects of bedrest disuse on the characteristics of the electrical activity of skeletal muscles. This experiment is one of a series of studies to comprehensively study skeletal muscle function as modified by immobilization or disuse.

The specific objectives of this study were:

1) Evaluate skeletal muscle electrical changes resulting from 28 days of bedrest recumbency.
2) Compare the results with those of past spaceflight studies.
3) Investigate the relationship between changes in muscle electrical function and changes in blood flow to muscles.
4) Investigate muscle electrical changes as they occurred during the period of recumbency.

METHODS

Instrumentation

A Supine Skeletal Muscle Stress Apparatus (SSMSA) was used to provide controlled muscle isometric testing while the subject was in a supine position. The device was adjustable to accommodate a wide range of persons and permitted measurement of force exerted by the subject's arm or leg. A second apparatus was used during the prebedrest and postbedrest phases of the study to provide the same type of controlled testing while the subject was

in a sitting position. A force transducer was mounted on each stress apparatus. Calibration of the force signals was accomplished by coupling a known amount of weight to the transducer. A small meter provided feedback of force levels to the test subject. A two-channel EMG detector was used to record the muscle electrical activity sensed by surface-type electrodes. An occlusion-cuff apparatus was used to collect flood flow responses to the isometric stresses.

All data were recorded at 9.53 cm/sec (3.75 in/sec) on magnetic tape by a four-channel instrumentation recorder (two channels of EMG, one channel each of force signals and IRIG-B time code. Blood flow data were recorded on a second instrumentation recorder. Figure 1 is a diagram of the instrumentation setup (does not include blood flow apparatus).

Procedures

Data were taken from six subjects on two prebedrest days: B-20 and B-10. Inbedrest measurements were taken on one group of three subjects (the 50% MVC group) on B+0, B+12, B+22, and B+26 days. On the second group of three subjects (the 35% MVC group) inbedrest measurements were taken on B+0, B+16, and B+27 days. The percentage MVC's for inbedrest identified above are based on the values used prebedrest and postbedrest for the calf muscles which were 60% and 50% MVC, respectively. However, MVC's from the leg were larger in the supine position than in the sitting position, thus the effective percentage MVC's for inbedrest compared with pre- and postbedrest were less. Postbedrest measurements were made on R+3 and R+10 days. Force capabilities of the arm remained fairly constant from sitting to recumbent positions, thus the 25% and 50% MVC's used were not altered.

For each subject, two muscles of the calf, the m. gastrocnemius and m. soleus, and two muscles of the arm, the m. biceps brachii and m. brachioradialis (see Figure 2). Surface electrodes, 7/16 inch in diameter, were used with spaceflight-type electrode paste to record muscle electrical signals.

Experiment protocols were as follows:

	Task	Rest
ARM	25% MVC for 60 seconds	5 minutes
	50% MVC for 60 seconds	5 minutes
	MVC	

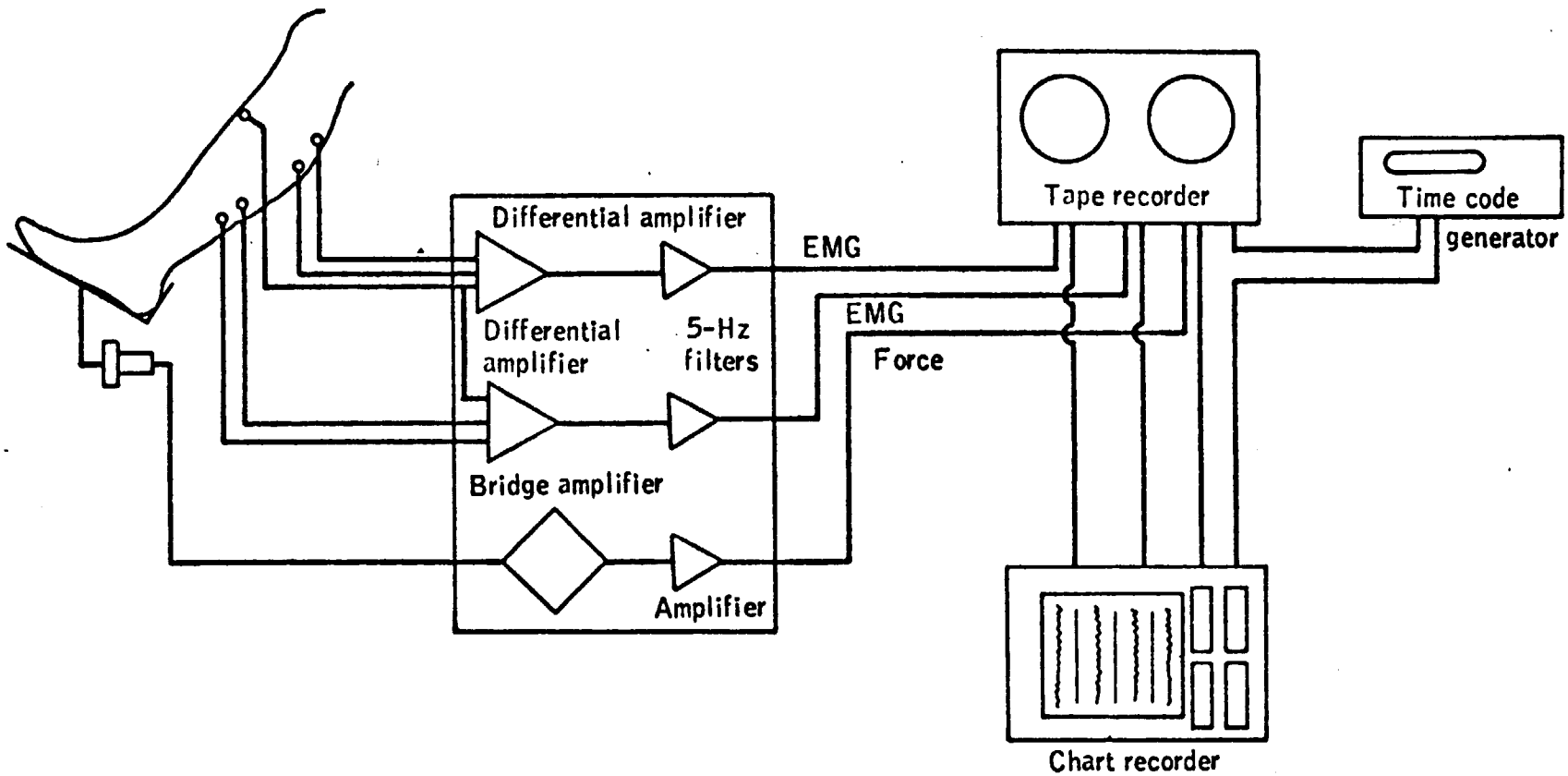


FIGURE 1. **Experiment Hardware Configuration**

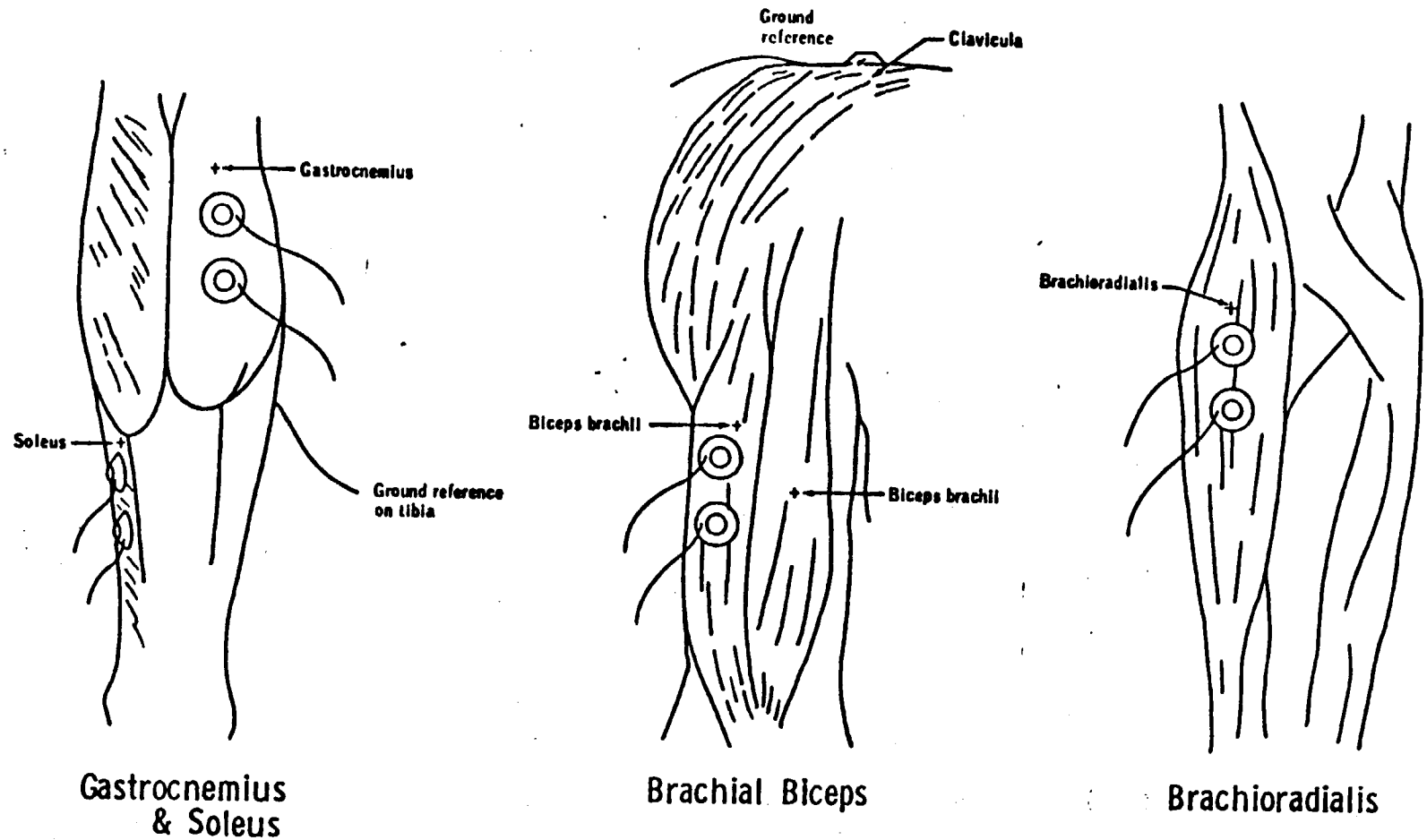


FIGURE 2. Surface Electrode Positions

CALF	20% MVC for 10 seconds	20 seconds
	30% MVC for 10 seconds	20 seconds
	40% MVC for 10 seconds	20 seconds
	50% MVC for 10 seconds	2 minutes
	50% MVC for 90 seconds	5 minutes
	MVC	

The above measurements on the calf were for one group of three subjects. The second group of three subjects started at 30% of MVC and finished at 60% of MVC.

Blood flow was measured immediately prior to and following each of the constant hold tasks (60 seconds for the arm and 90 seconds for the calf). Measurement was accomplished by occluding the active arm or leg segment and measuring the change in volume of the segment distal to the occlusion.

Data Processing

The analog force and electromyographic (EMG) signals were digitized for processing on a computer. The analog force signals were high-pass filtered at 10 hertz and sampled at 20 samples/second. A 400-hertz upper frequency limit was selected for EMG power spectral density (PSD) analysis. Consequently, the analog EMG data were low-pass filtered at 400 hertz and digitized at 1000 samples/second. Force data were calibrated into pounds and averaged over 1-second intervals. The EMG signals were analyzed in 4-second segments. The data were calibrated into microvolts and the integrated value for each segment was found.

A cosine taper was applied to the first and last tenths of each data segment, the discrete Fourier transform was taken, and the magnitude of the PSD was calculated. To reduce random error, the PSD was smoothed over approximately 10-hertz intervals. The integrated value of the PSD was also calculated.

Experimental Design

The experimental design used in this study was the repeated measures design (Edwards, 1960, Myers, 1966). Bruning and Kintz (1968) refer to this design as the treatments-by-treatment-by-subjects design in which each subject is tested under all combinations of treatments.

The treatments were: 1) conditions, i.e., prebedrest versus post-bedrest, and 2) muscle stress measured in terms of the fatigue index associated with the amount of time the stress was maintained. Fatigue index was defined as the percentage of total spectral power residing in the 10 to 60 hertz band for the calf muscles and the 10 to 40 hertz band for the arm muscles.

RESULTS

The results of the analyses of variance on individual subject's data generally show that the period of bedrest significantly altered muscle electrical activity especially in the frequency bads related to muscle fatigability. Tables 1 and 2 show the results of the analyses. Eleven of of the 18 tests on three muscles, the gastrocnemius, soleus, and biceps brachii, showed statistically significant main effects between the prebedrest and postbedrest sessions. Three of the seven tests showing insignificant conditions main effect demonstrated a statistically significant interaction between the fatigue index and contraction time for the two conditions. Thus, 14 of 18 statistical tests showed significant effects associated with the period of bedrest. Eight of the eleven significant main effects for conditions were in the expected direction, i.e., postbedrest muscle fatigue index greater than prebedrest. One subject accounted for 2 of the 3 "wrong direction" effects.

The main effect for stress was statistically significant in all cases showing the highly reliable spectral power shift into lower frequencies as a stressful contraction was maintained over time. The significant conditions by stress interactions show that the fatigue index was differentially affected by conditions, i.e., the postbedrest fatigue index was lower than prebedrest at the beginning of the contraction but finished higher at the end of the contraction. Figures 3 thru 7 are data plots of the results of the analyses of variance

The t-test statistic was used on grouped data to determine the general significance of change in the magnitude of the fatigue index from prebedrest to postbedrest. The first and last spectral power values derived from EMG data during stress periods were used to compute the t-test values. Table 3 shows the results of these analyses. The 50% MVC group showed significantly greater postbedrest fatigue indexes on both calf muscles, whereas the 60% MVC group did not. However, the 60% MVC group had significant fatigue index by time interactions for the gastrocnemius which indicated greater postbedrest effects (see Figure 3). Combining the data for the six subjects on the 50% MVC stress on the arm resulted in a statistically significant

TABLE 1. Summary of Analyses of Variance for the 60% MVC Group.

SOURCE	DF	MS	F	MS	F	MS	F
SUBJECT		1		2		3	
GASTROCNEMIUS							
CONDITIONS (Prebed vs Postbed)	1	1.9	<1	0.2	<1	17.1	8.1*
STRESS (Fatigue Index)	1	89.5	21.3*	95.1	158.5**	57.5	27.4**
COND X STRESS	1	46.4	11.1*	5.2	8.7*	7.3	3.5
ERROR	4	4.2	-	0.6	-	2.2	-
SOLEUS							
CONDITIONS (Prebed vs Postbed)	1	21.8	36.3**	305.0	108.9**	49.3	123.3**
STRESS (Fatigue Index)	1	152.9	254.8**	44.1	15.8*	37.5	93.8**
COND X STRESS	1	4.8	8.0*	1.0	<1	0.8	2.0
ERROR	4	0.6	-	2.8	-	0.4	-
BICEP BRACHII							
CONDITIONS (Prebed vs Postbed)	1	82.7	31.8*	35.7	1785.0**	9.7	32.3*
STRESS (Fatigue Index)	1	172.5	66.4*	26.7	133.5**	651.2	2170.7**
COND x STRESS	1	1.4	<1	21.1	105.5**	7.7	25.7*
ERROR	2	2.6	-	0.02	-	0.03	-

(*) = $p < .05$
(**) = $p < .01$

TABLE 2. Summary of Analyses of Variance for the 50% MVC Group.

SOURCE	DF	MS	F	MS	F	MS	F
SUBJECT		4		5		6	
			GASTROCNEMIUS				
CONDITIONS (Prebed vs Postbed)	1	20.4	25.5*	64.8	54.0**	6.6	2.6
STRESS (Fatigue Index)	1	85.7	107.1**	107.7	89.8**	26.2	10.5*
COND X STRESS	1	0.2	0.3	43.8	36.5**	2.7	1
ERROR	4	0.8	-	1.2	-	2.5	-
			SOLEUS				
CONDITIONS (Prebed vs Postbed)	1	2.7	2.1	14.3	7.2	14.8	14.8*
STRESS (Fatigue Index)	1	30.3	23.3**	104.4	52.2**	106.7	106.7**
COND X STRESS	1	0.3	<1	0.1	<1	0.3	<1
ERROR	4	1.3	-	2.0	-	1.0	-
			BICEP BRACHII				
CONDITIONS (Prebed vs Postbed)	1	0.05	<1	56.8	20.0*	3.3	12.2
STRESS (Fatigue Index)	1	170.3	549.2**	283.2	100.0**	342.4	1268.1**
COND X STRESS	1	1.1	3.5	8.5	3.0	4.7	17.4
ERROR	2	0.3	-	2.8	-	0.3	-

(*) = $p < .05$
(**) = $p < .01$

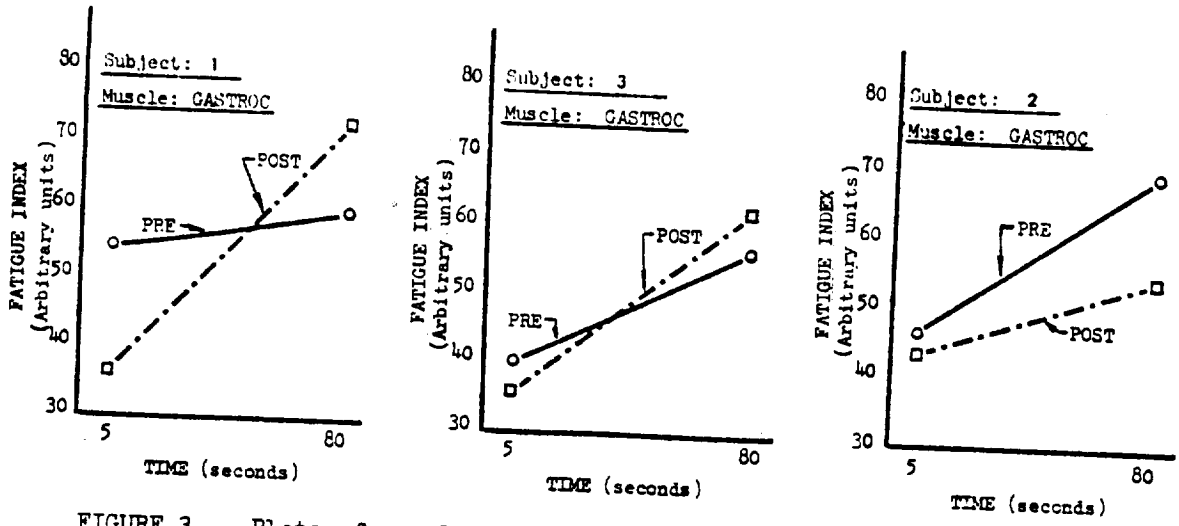


FIGURE 3. Plots of muscle fatigue index data showing the relationship between prebedrest and postbedrest isometric stress responses for the gastrocnemius muscle at 60% of MVC.

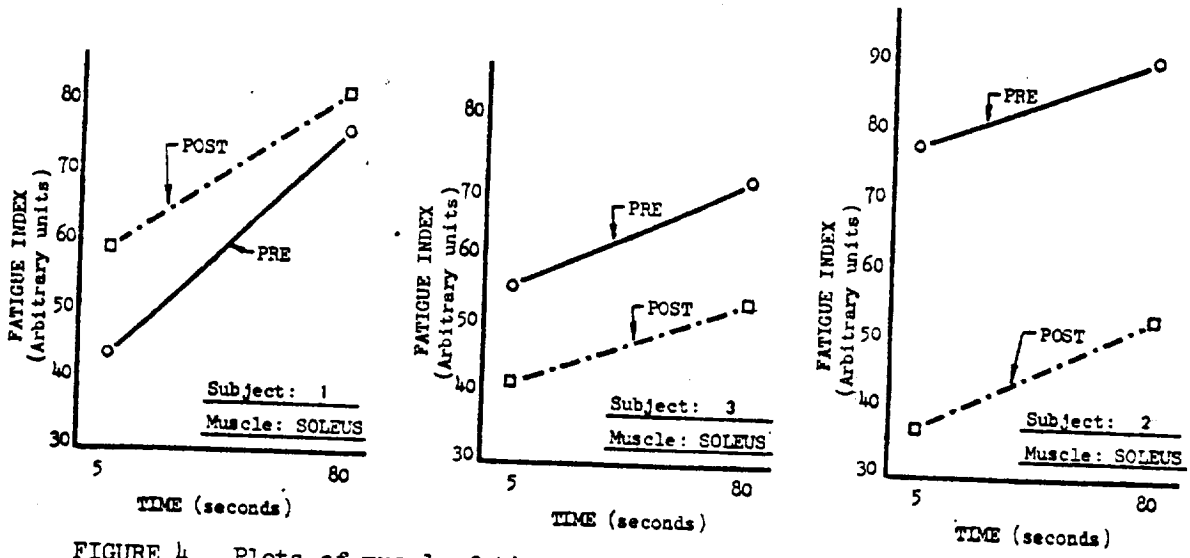


FIGURE 4. Plots of muscle fatigue index data showing the relationship between prebedrest and postbedrest isometric stress responses for the soleus muscle at 60% of MVC.

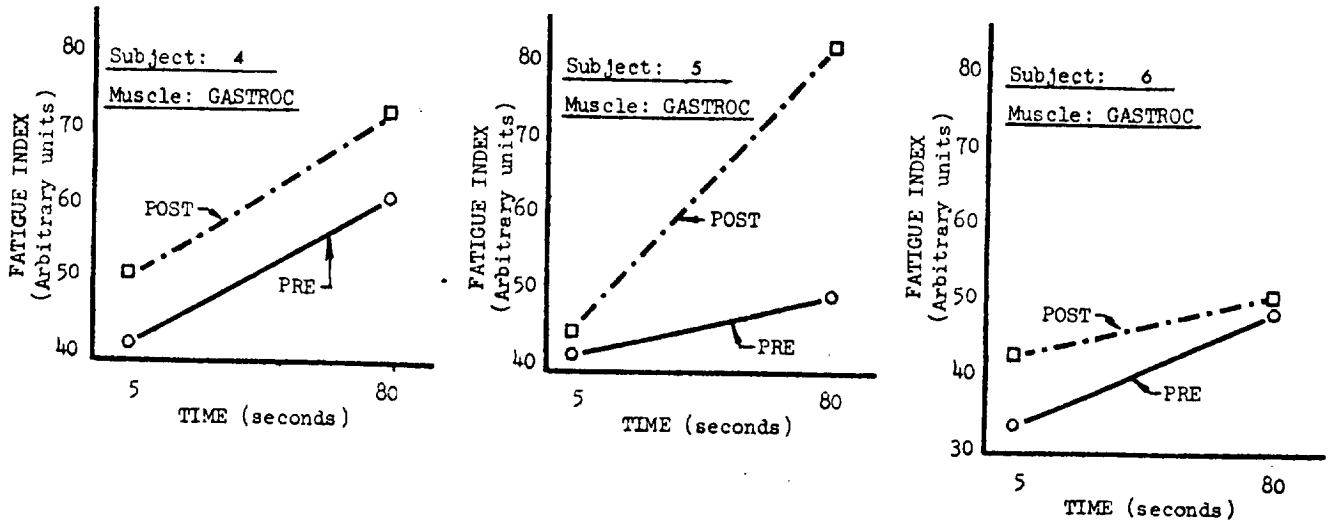


FIGURE 5. Plots of muscle fatigue index data showing the relationship between prebedrest and postbedrest isometric stress responses for the gastrocnemius muscle at 50% of MVC

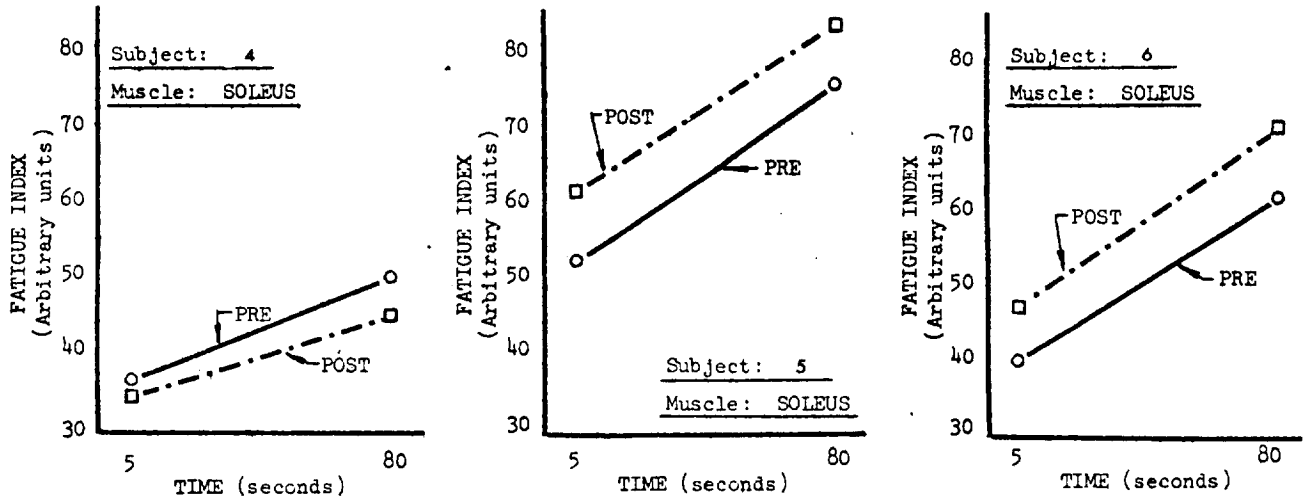


FIGURE 6. Plots of muscle fatigue index data showing the relationship between prebedrest and postbedrest isometric stress responses for the soleus muscle at 50% of MVC.

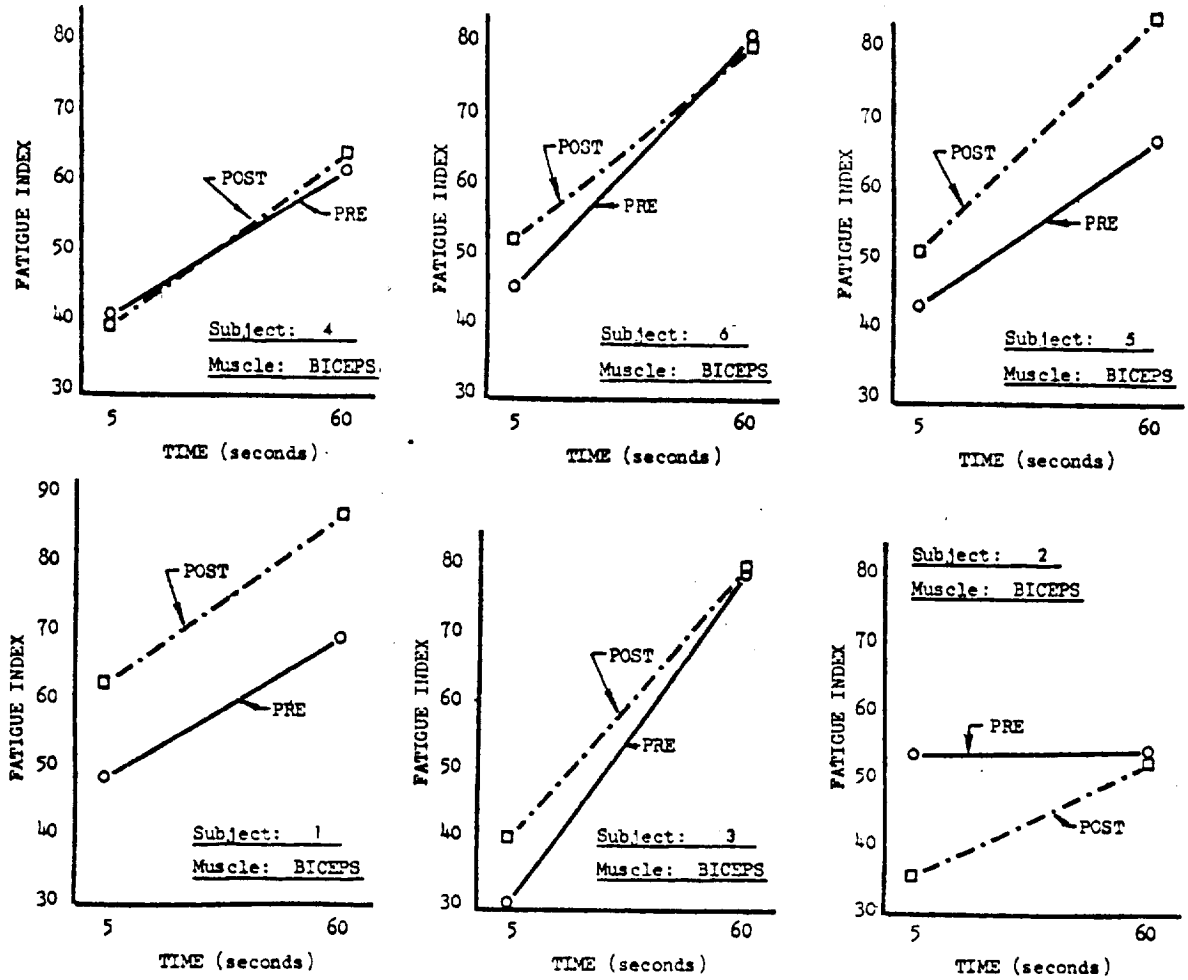


FIGURE 7. Plots of muscle fatigue index data showing the relationship between prebedrest and postbedrest isometric stress responses for the biceps brachii at 50% of MVC for each of six subjects.

TABLE 3. Analysis by t-tests of differences in prebedrest and postbedrest fatigue indexes in grouped data for three skeletal muscles.

	GROUP 1 - 60% MVC (3S's)	GROUP 2 - 50% MVC (3S's)
GASTROCNEMIUS	0.87 (p = n.s.)	-2.48* (p <.05)
SOLEUS	1.48 (p = n.s.)	-2.89* (p <.05)
	6 S's - 50% MVC	
BRACHIAL BICEPS	-2.32* (p <.05)	

Note: Negative value denotes postbedrest fatigue index greater than prebedrest.

difference between prebedrest and postbedrest fatigue indexes for both of the muscles measured, with the postbedrest being greater.

Tables 4 and 5 show the results of the analyses of variance performed on the EMG data collected at the beginning and end of the bedrest phase of the study. Data used in these analyses were collected on the day the subjects began bedrest (B+0 days) and on the last day of bedrest (B+27 days). All muscle measurements were taken with the subjects in a supine position.

The three subjects shown in the analysis of leg muscle data represented the 50% MVC stress level. Just two tests showed a significant difference in the fatigue index response between the early and late periods of the recumbent phase of the study, with both occurring in the gastrocnemius muscle, and only one of the two differences in the expected direction, i.e., the late period producing the larger increase to the fatiguing stress. The brachial biceps data for the recumbent phase, shown in Table 5, give comparable results. Just two of the six subjects produced significantly different fatigue index responses between early and late periods of recumbency and only one of these was in the expected direction. Also lacking was the usually highly reliable spectral power shift into the lower frequencies, except in the case of the gastrocnemius. Only 6 of 12 tests showed a significant shift in the fatigue index. Results from the 35% MVC group, not shown, were comparable to the 50% MVC

TABLE 4. Summary of Analyses of Variance for the 50% MVC Group (Inbedrest Phase) for Leg Muscles.

SOURCE	DF	MS	F	MS	F	MS	F
SUBJECT		1		3		5	
			GASTROCNEMIUS				
CONDITIONS (B+0 vs B+27)	1	10.2	6.4	40.0	28.6**	107.7	34.7**
STRESS (Fatigue Index)	1	38.9	24.3**	11.7	8.4*	37.5	12.2*
COND X STRESS	1	0.5	<1	0.6	<1	12.5	4.0
ERROR	4	1.6	-	1.4	-	3.1	-
			SOLEUS				
CONDITIONS (B+0 vs B+27)	1	10.5	4.8	2.9	3.2	10.7	3.3
STRESS (Fatigue Index)	1	0.4	<1	5.0	5.6	10.4	3.3
COND X STRESS	1	75.7	34.2**	0.03	<1	1.3	<1
ERROR	4	2.2	-	0.9	-	3.2	-

TABLE 5. Summary of Analyses of Variance for the 50% MVC Group (Inbedrest Phase) for the Bicep Brachii.

SOURCE	DF	MS	F	MS	F	MS	F
SUBJECTS		1		2		3	
			BICEP BRACHII				
CONDITIONS (B+0 vs B+27	1	99.2	5.9	247.5	55.0*	14.7	5.1
STRESS (Fatigue Index)	1	61.2	3.7	22.1	4.9	321.7	110.9**
COND X STRESS	1	9.9	<1	0.6	<1	8.2	2.8
ERROR	2	16.7	-	4.5	-	2.9	-
SUBJECTS		4		5		6	
			BICEP BRACHII				
CONDITIONS (B+0 vs B+27)	1	38.5	15.4	20.4	20.5*	38.9	6.4
STRESS (Fatigue Index)	1	355.3	142.1**	115.9	115.9**	90.8	14.9
COND X STRESS	1	2.1	<1	9.3	9.3	6.7	1.0
ERROR	2	2.5	-	1.0	-	6.1	-

(*) = $p < .05$ (**) = $p < .01$

group shown above, i.e., few significant differences.

Changes in the electrical efficiency of muscles as a result of 28 days of bedrest are plotted in Figures 8 and 9 for the leg muscles and the arm muscles respectively. Muscle electrical efficiency (MEE) is defined as the ratio of force to electrical activity, or newtons/microvolts squared. The t-test for related measures was used to evaluate the differences in electrical efficiency between the prebedrest and postbedrest periods.

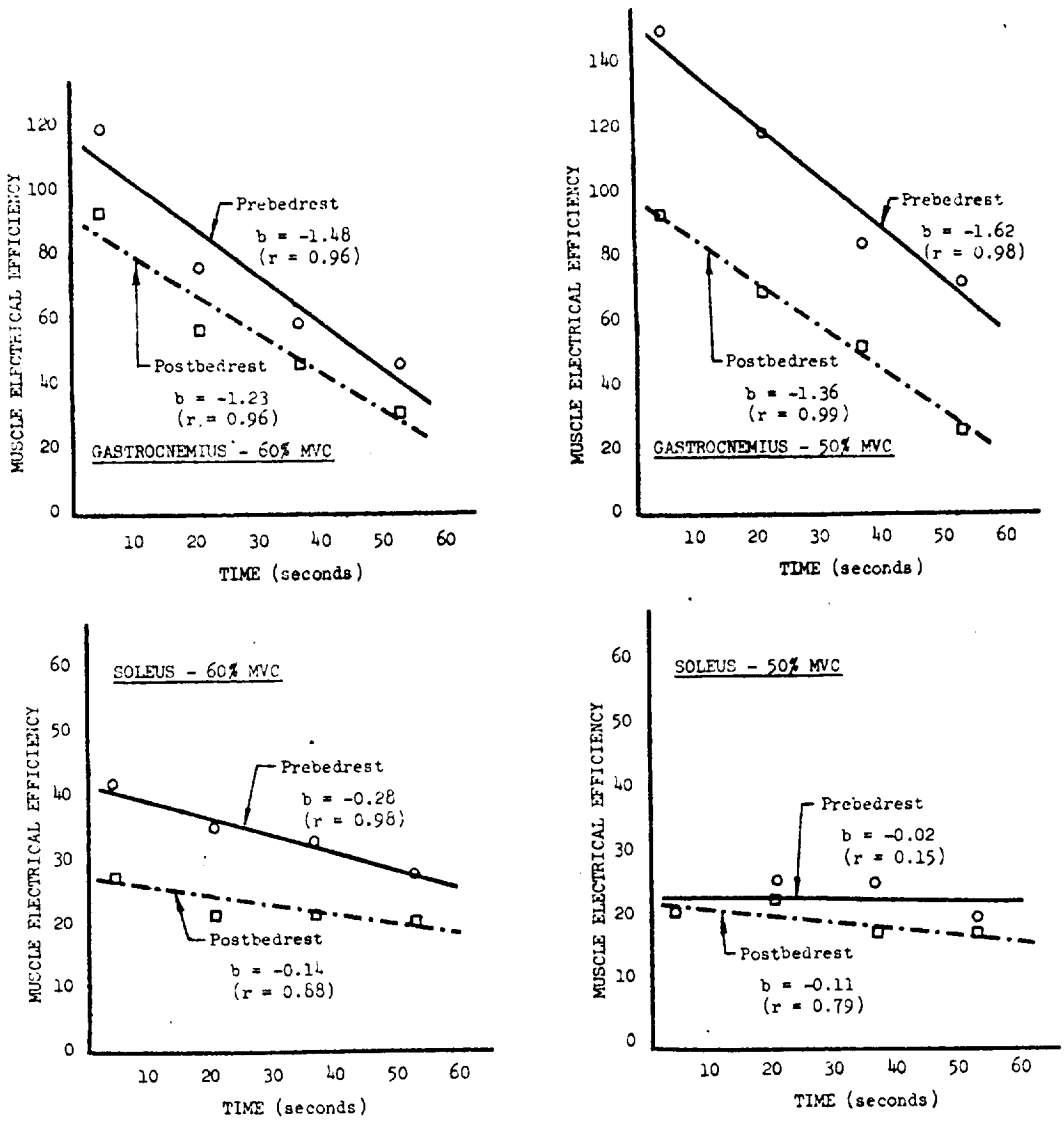


FIGURE 8. Plots of muscle electrical efficiency (MEE) for both the gastrocnemius and soleus muscles showing the general trend for decreased efficiency postbedrest for both groups of subjects.

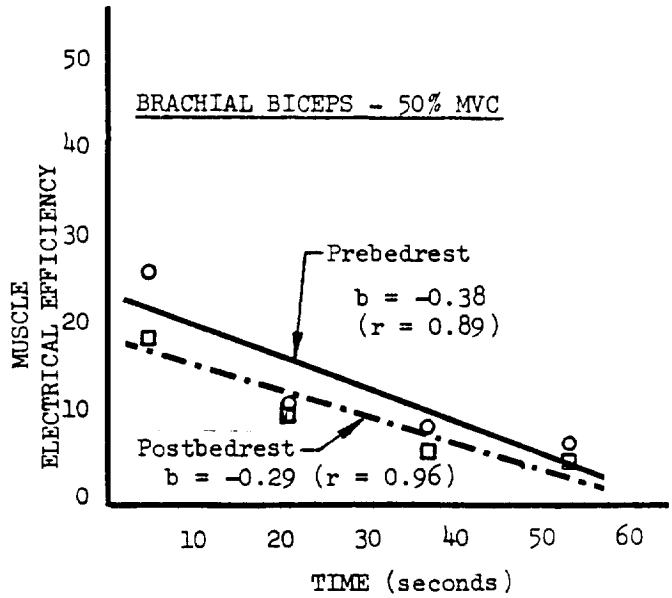


FIGURE 9. Plot of muscle electrical efficiency (MEE) for the brachial bicep showing the general trend for decreased efficiency postbedrest.

The 60% MVC group did not show a statistically significant reduction in MEE from the gastrocnemius muscle after bedrest ($t = 1.15$, p = n.s.), however, inspection of the data revealed that one of the three subjects responded in the opposite direction to the other 2 subjects, i.e., he had increased electrical efficiency after the bedrest period. A subsequent evaluation of the data for the two subjects resulted in a highly significant reduction of the MEE ($t = 3.25$, $p < .01$). The 50% MVC group showed a significant reduction in the MEE from the gastrocnemius ($t = 2.80$, $p < .02$).

From the soleus muscle, the 60% group showed a significant reduction in the MEE ($t = 4.68$, $p < .01$), but the 50% MVC group did not ($t = 1.90$, p = n.s.). Again, one subject was found to show increased MEE rather than decreased. Subsequent analysis of the data from the 2 subjects yielded a highly significant reduction in the MEE ($t = 5.94$, $p < .01$) in response to the 28 days of bedrest.

The analysis of the bicep brachii data for the total group of six subjects yielded a t value of 1.12 indicating insignificant reduction in MEE. But, again, one of the six subjects exhibited increased rather than decreased MEE. Subsequent analysis of the data from the 5 subjects yielded

a t value of 2.59 which is significant beyond the .02 level.

Analysis of changes in blood flow in response to muscle stress were hampered by the loss of data due to recurring equipment problems. However, sufficient data were recorded on the arm to permit some analysis.

The results were in general agreement with those of Lind (1974). Reliably large increases in blood flow were registered poststress when compared to prestress. Also, it was found that blood flow in the arm was greater in the recumbent than sitting posture when measured immediately before and after a stressful contraction. Relating this latter finding to the fatigue indexes for the bicep muscle across all six of the subjects did not show a significant difference in the magnitude of the fatigue index between prebedrest and postbedrest measurements and inbedrest measurements. However, inspection of individual data showed that four of the six subjects had a lower effective fatigue index during bedrest than before or after. These data are shown in Table 6. Effective blood flow was computed as the

TABLE 6. Comparisons of blood flow data with effective fatigue indexes across conditions by subjects.

	SUBJECTS											
	1		3		2		4		5		6	
	BF	FI	BF	FI	BF	FI	BF	FI	BF	FI	BF	FI
PRE-	+0.4	+28.1	+1.7	+54.4	+3.0	+1.4	+3.2	+30.4	+4.8	+26.0	+3.5	+42.2
IN-	+3.5	+16.7	+3.2	+36.3	+3.9	+33.2	+5.2	+30.6	+9.5	+18.3	+7.4	+17.7
POST-	+2.0	+34.3	+1.8	+47.6	+2.1	+15.2	+5.3	+25.7	+0.6	+46.7	+2.3	+35.0

Note: BF = Blood Flow and FI = Fatigue Index

difference between prestress and poststress blood flow levels and effective fatigue index was computed as the increase in spectral power in the low frequencies resulting from the constant isometric contraction for one minute.

DISCUSSION

Previous research has shown that significant changes occur in skeletal muscle electrical function after periods in a weightless state in spaceflight (LaFevers, et al, 1975, 1976). The question addressed in this study was whether or not comparable results could be obtained from skeletal muscles subjected to 28 days of bedrest disuse.

In general, the results of this study agree with those of the previous spaceflight studies mentioned, and with a number of laboratory studies that have shown significant relationships between the stress of contraction, muscle electrical activity, and the functional states of skeletal muscle.

Skeletal muscle fatigability, as defined by increases in spectral power in the lower frequencies (Chaffin, 1969a, 1969b), was significantly altered by the bedrest period. The data in Tables 1, 2 and 3 provide evidence that lengthy recumbency was associated with increased fatigability to isometric stress. These findings, being in general agreement with the results from spaceflight studies, suggest a correlation between the changes in muscle in spaceflight and the changes that occur in bedrest recumbency.

The exact mechanisms that cause this are unknown, but appear to be comparable for both conditions. These mechanisms include alterations in effective blood flow, decreased calcium and potassium supply at the muscle level, and greater potential potassium leakage from active fibers of disused muscles. Fenn (1937) showed that potassium leakage occurs from active fibers of muscle under normal conditions which is associated with greater electrical activity, and Glaser, et al (1958) showed that potassium deficiency diminishes muscle excitability which, in frequency terms, means that spectral power is shifted toward lower frequencies. Of course, alterations in the biochemical constituents in the body precipitated by recumbency, as well as spaceflight, may change the internal milieu of the muscle sufficiently to intensify the effects found for the normal condition. However, the idea of one factor being responsible for the results obtained is questionable.

The restriction of blood flow to muscle has long been recognized as a factor in fatigue buildup during muscular stress (Lippold, et al, 1960; Myers, et al, 1968; Lind, 1959). Lind and collegues (1974) have shown that during a muscle contraction, blood flow is greater when the subject is in

a sitting position rather than recumbent. Assuming that diminished blood flow contributes to the buildup of fatigability during a contraction and therefore is a contributing factor to differential increases in spectral power in the low frequencies of the spectrum (fatigue index), it should follow from the Lind findings that low frequency band spectral power should be generally smaller for the prebedrest and postbedrest measurements in this study than for the inbedrest measurements because of better blood flow during the seated condition. This was statistically confirmed in the case of the gastrocnemius muscle. Inbedrest measurements of spectral power in the low frequencies showed significantly higher levels than did either the prebedrest or postbedrest measurements ($\chi_r = 11.6$, $p < .05$). However, the other three muscles did not show significant differences in the fatigue index between conditions.

Several things could be responsible for the absence of expected differences. First, blood flow during contraction was not measured in this study so the assumption of greater flow in the sitting position may not have been correct. Second, the muscle stress task performed in the supine position may have been sufficiently different from the sitting task to negate more positive comparisons. Thirdly, the confounding effects of bedrest may have been contributory.

A comparison of Tables 1 and 2 with Tables 4 and 5 provide evidence that the inbedrest condition was different from the pre- and postbedrest conditions. The inbedrest isometric stress simply did not provide as much change in the fatigue index as did the non-recumbency conditions. Table 6 shows that the majority of subjects registered lower levels of effective fatigue index during bedrest and this was related to an increased level of blood flow as indicated by the change in blood flow immediately pre- to immediately post-contraction. This suggests that changes in muscle electrical activity associated with the disuse of recumbency may not have shown their effects until a non-recumbency condition was assumed. It is possible that the same suggestion is appropriate for spaceflight effects.

The finding that the effective fatigue index from the brachial biceps was generally less during bedrest than before or after bedrest is interesting because it appears to be in opposition to what would be expected from blood flow results of the Lind investigation. In this study, there was the

tendency for the fatigue index measured during contraction to be correlated with blood flow measured immediately pre- and post-contraction. For example, from prebedrest to early bedrest, all six subjects registered an increase in effective blood flow, measured pre- and post-contraction, and five of the six subjects also registered a decrease in the effective fatigue index, measured during the contraction. Four of five subjects registered a decrease in blood flow from early bedrest to later bedrest with three registering an increase in the fatigue index. From late bedrest to postbedrest, four of five subjects registered further decreases in effective blood flow with three also registering further increases in effective fatigue index. This suggests, without statistical verification, that blood flow was a determinant of the magnitude of the fatigue index and that pre- and post-contraction measures of blood flow were representative of blood flow status during the submaximal contractions.

The results also suggest that bedrest effects may have altered vascular efficiency in the muscle during contraction. Blood flow occlusion has been shown to be related to onset of fatigue (Lippold, et al, 1960; Myers, et al, 1968; Naess, et al, 1955). However, other research has shown that occlusion due to intramuscular pressure during submaximal muscle contractions probably does not occur (Lloyd, et al, 1970). Therefore, the increased blood flows registered early in the recumbent phase of this study should have and did result in decreased indexes of fatigue. However, as the recumbency progressed, effective blood flow decreased and the effective fatigue index increased which carried over into the postbedrest period.

The decreases in electrical efficiency with bedrest are in agreement with previous studies that have shown these effects after spaceflight. The principal cause for decreases in electrical efficiency is motor unit recruitment. As the fatiguing contraction is maintained, motor units in use begin to fatigue. Central processes then intervene to command additional motor units into action to maintain the tension on the muscle. The recruitment process results in increasingly greater electrical activity and therefore a decreasing electrical efficiency index for the constant force being held. Figures 8 and 9 show this process to be intensified after muscles have been subjected to 28 days of bedrest disuse.

Previous studies have shown a negative relationship between muscle electrical efficiency and the spectral power fatigue index, that is, the better the electrical efficiency, the smaller the fatigue index. As cited above, continued recruitment attests to the fact that more and more motor units are called upon to maintain the level of contraction which is related to the incidence of synchronous firings among motor units as well as the recruitment of larger, slower firing motor units. This assortment of effects results in an increase of spectral power in low frequencies, i.e., a higher fatigue index. Of 36 statistical tests conducted across three of the muscles correlating muscle electrical efficiency with the magnitude of the fatigue index, 31 were in the negative direction and 18 of the 31 correlations were significant beyond the 5% level.

These results coupled with the analyses of variance cited previously provide strong support for the conclusion that bedrest disuse was instrumental in degrading the normal capabilities of the skeletal muscles measured in this study. There was the general trend for increased fatigability and decreased electrical efficiency.

SUMMARY

The electromyograms (EMG) from four skeletal muscles, the m. gastrocnemius, m. soleus, m. biceps brachii, and m. brachioradialis, on each of six subjects were recorded during periods of isometric contraction under recumbency and non-recumbency conditions. The recumbency period lasted for 28 days. Consonant with EMG measures were measures of limb blood flow registered immediately pre- and post-contraction. The general findings were as follows:

1. Lengthy recumbency was associated with increased muscle fatigability to isometric contraction as measured by quantity of spectral power in the low frequencies.

2. Lengthy recumbency was associated with decreased muscle electrical efficiency which, in turn, was negatively related to magnitude of fatigability, i.e., the less the electrical efficiency, the greater the fatigability. Recumbency seemed to intensify the process of decreasing electrical efficiency with continued contraction.

3. Changes in muscle electrical activity associated with recumbency may not show their effects until a non-recumbency condition is assumed. The fatigue index was simply not as great during recumbency as before or after recumbency in response to isometric stress. Although there was in increase in maximum strength capability in the recumbent position, it amounted only to 10% and this is not considered sufficient to explain the differences noted.

4. Blood flow measured immediately pre- and post-contraction was found to be greater during recumbency than before or after recumbency.

5. The data suggest blood flow to be a determinant of the magnitude of the fatigue index. The greater the blood flow, the smaller the fatigue index.

6. In this study, at least, pre- and post-contraction blood flow apparently mimicked rather closely the dynamic state during contraction. The fatigue index measured during contraction was negatively related to the pre- and post-contraction measures of blood flow.

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THE EFFECT OF 28-DAYS SUPINE BEDREST ON VESTIBULAR SYSTEM FUNCTION

Jerry L. Homick
Millard F. Reschke
Maurus J. Moore
David J. Anderson *

November 15, 1976

* Kresge Hearing Research Institute
University of Michigan

INTRODUCTION

Pre-, in- and postflight observations and data obtained during the Skylab missions revealed a number of interrelated clinical, behavioral and sensory-physiological responses presumably caused by exposure to the weightless space flight environment. Alterations in susceptibility to motion sickness were among the most significant of the changes manifested (Graybiel et al,1974). Upon initial entry into weightlessness, five of the nine Skylab crewmen experienced symptoms characteristic of motion sickness. Symptoms ranged from mild (stomach awareness) to severe (vomiting) and in most cases persisted for three to five days. Adaptation to the weightless environment occurred by approximately mission day seven for all of the crewmen and subsequent tests utilizing the Skylab M131 Rotating Litter Chair showed surprisingly that all of the crewmen had become virtually immune to experimentally induced motion sickness. Of particular relevance to the present study were the results of motion sensitivity tests conducted postflight. These tests revealed that relative to their preflight baseline levels, all of the crewmen were somewhat less susceptible to motion sickness during the postflight period. Although considerable variability was present among the crewmen, the magnitude and duration of this change was related in a slightly positive fashion to the duration of 0-g exposure. Also, in crewmen who did not take anti-motion sickness medication prior to splash-down, a brief period (8-24 hours)

during which symptoms spontaneously occurred with head movements, preceded the measured increase in tolerance to vestibular stress. In all cases, continued post-flight testing indicated that a return to approximate preflight levels of susceptibility to Coriolis motion sickness did eventually occur. A number of hypotheses have been advanced to explain the Skylab motion sickness findings, however, it is generally agreed that available data are inadequate to unequivocally define the mechanism or mechanisms underlying the changes which occurred.

Related to the above findings was the observation that all of the Skylab crewmen experienced a marked postflight deficit in postural stability (Homick and Reschke, 1976). Quantitative measurements indicated that the change was most pronounced when the crewmen were deprived of visual cues and were required to maintain a stable, upright posture solely on the basis of vestibular and proprioceptive sensory inputs. In all cases, complete recovery to preflight levels of postural equilibrium performance and locomotor ability occurred within approximately ten days after splashdown. It has been postulated that these changes were most likely the manifestation alterations in the central nervous system integration of sensory inputs from the visual, vestibular, and proprioceptive sensory modalities which had occurred during the weightless space flight exposure. An increase in the Achilles tendon

reflex and gastrocnemis muscle potential, as well as decreased muscle strength and leg volume loss, may also have contributed to the postflight changes observed in postural equilibrium (Nicogossian et al, 1974; Thornton and Rummel, 1974).

Data obtained from the Skylab neurophysiology experiments were generally limited and fell short of providing explanations for the phenomena observed. It is recognized that much additional research using various experimental approaches is needed to develop the information necessary to resolve the significant questions raised by Skylab.

Among the experimental approaches that have received attention is the use of prolonged bedrest which in some respects may represent a physiological analog of weightlessness. In a recently completed bedrest study it was found that thresholds for susceptibility to Coriolis motion sickness and postural equilibrium were not significantly altered when measured immediately following 14-days of continuous supine bedrest (Homick et al, 1975). The same study did reveal a slight hyperflexia of the gastrocnemis muscle on the first post-bedrest test day. In general, however, the results of the 14-day study bore meager resemblence to the Skylab postflight findings and it was tentatively concluded that supine bedrest does not produce the type of peripheral and central nervous system adaptation processes induced by exposure to zero-g. Such a conclusion must be

tempered by the fact that the Skylab missions against which the bedrest findings were compared ranged in duration from 28 to 84 days. Therefore the 14-day bedrest exposure may simply have been of insufficient duration to produce changes like those observed following Skylab. In order to investigate the effects of bedrest on sensory and neuromuscular system function under exposure conditions which more closely approximate Skylab, three separate but related experiments were performed in conjunction with the 28-day NASA-Baylor College of Medicine bedrest study.

EXPERIMENT 1: MOTION SICKNESS SUSCEPTIBILITY

Procedure

This portion of the study utilized procedures and hardware identical to those developed for Skylab Experiment M131, Human Vestibular Function.

Approximately one week prior to the first pre-bedrest test each of the six subjects completed a motion experience questionnaire. This questionnaire provided needed information concerning the subject's motion sickness history, and was used to calculate the rotating chair velocity for his first test. Immediately prior to the first experimental session each subject was given instructions on how to recognize and report his symptoms. During the test, the blindfolded subject was

seated in the chair and rotated at the predetermined constant velocity. While rotating, the subject executed standardized head movement in the four cardinal directions (front, right, back and left). These head movements were performed in sets, each set consisting of five head movements. Each set was separated by a 20 second period of no head movements. During the test, the subject was carefully monitored for signs and symptoms indicative of early motion sickness. A diagnostic categorization of different levels of severity of experimentally induced acute motion sickness (Graybiel et al, 1968) is presented in Table 1.1. Head movements were terminated when the subject manifested a low grade motion sickness (referred to as Malaise IIa) or after the performance of 150 head movements, whichever occurred first. The entire test procedure was typically completed in 20 minutes or less. Additional details on the hardware and procedures used to ascertain motion sickness symptomatology are available in previously published reports (Miller and Graybiel, 1970, 1973).

Immediately following the completion of head movements and in conjunction with stopping the rotating chair an additional simple measurement was made to ascertain the subjects sensitivity to angular motion. The procedure was analogous to that used for post-rotary sensation cupulograms. The subject, with his head stationary and tilted slightly forward, was required to verbally report the onset and cessation of

of perceived counter-rotation associated with the chair deceleration stimulus. The duration of the after-sensation was timed with a stop watch and recorded. The chair deceleration was fixed at $4^0/sec^2$.

A minimum of four pre-bedrest tests were performed on each subject. With the exception of minor scheduling variations identified in the results section of this report, these tests were conducted at BR-24, BR-20, BR-14 and BR-7 days. Post-bedrest data were obtained only on BR+1 and BR+7 (BR+8 for Group II). In order to avoid possible confounding of other test results the motion sickness susceptibility test was always performed following the daily completion of other biomedical investigations included in the bedrest study.

Results

Pre- and post-bedrest test results for subjects 1-6 are summarized in Tables 1.2-1.7 respectively. Dependent variables included in each table are test day, chair velocity and direction and the number of head movements required to reach the MIIa level of motion sickness. Independent variables for which data are listed include signs/symptomatology, total symptom points, the Coriolis Sickness Susceptibility Index (CSSI) and duration of the after-sensation of rotation.

The signs/symptomatology shown are those which were present at the time the test was terminated on any given test

day. They are listed from left to right in their approximate order of appearance during the course of a test session. The total point values (i.e., the level of severity of induced motion sickness) associated with the signs/symptoms experienced are derived from the scheme presented in Table 1.1. The CSSI, which is a normalized value indicating the individual's susceptibility to motion sickness on a scale of 0-100 (low values indicate higher susceptibility), is obtained by multiplying N x E where N is the number of head movements required to reach M IIa and E is the relative stressor effect (E-Factor) of a single head movement designed to evoke M IIa as a function of rotational velocity. Supportive data and details on the rational for the CSSI scoring procedure are available elsewhere (Miller and Graybiel, 1970).

Evaluation of the pre-bedrest CSSI scores indicates somewhat higher than usual within subject variability. This variability was most likely due to changes in criteria used by the subjects to estimate the level of severity of symptoms experienced. However, with the exception of subject 1, this group as a whole demonstrated average levels of susceptibility to motion sickness relative to the general population of individuals tested by this method.

As indicated by the CSSI scores, when tested on BR+1 four of the subjects (subjects 3,4,5 and 6) showed slightly

greater susceptibility to motion sickness relative to their pre-bedrest base lines. This change was greatest in subject 5. When tested again on BR+7 (BR+8 for Group II) subjects 2 and 6 were unexpectedly more susceptible than they had been on BR+1 or at any time pre-bedrest; subjects 3 and 5 were basically unchanged from BR+1 and subject 4 had returned to his pre-bedrest level of susceptibility. Possible reasons for response variations observed post-bedrest will be discussed.

Within subject comparisons of pre- and post-bedrest motion sickness symptomatology indicate that there were no appreciable alterations in the type of symptoms expressed by each subject. As would be expected subjective body warmth, dizziness, sweating and symptoms of an epigastric origin (epigastric awareness, epigastric discomfort and nausea) were dominent symptoms for most of the subjects. However, epigastric symptoms were never reported by subject 1 and subject 5 experienced epigastric awareness only on BR+7. It is also of interest to note that on BR-7, BR-1 and particularly on BR+1, subject 1 reported a "head fullness" or increased pressure sensation in the head and ears when executing forward head movements. On BR+1 this individual also reported a mild popping sensation in his ears with forward head movements. An, apparently similar sensation (head fullness) was reported by subject 2 on BR+8.

Subjective reports elicited from each of the subjects on BR+0 indicated that none experienced any type of spatial disorientation while in bed or post-bedrest. Three of the subjects (subjects 1, 2 and 4) reported experiencing very slight dizziness with rapid head turns on BR+0. One subject (number 3) experienced mild motion sickness while being transported by motor vehicle from the bedrest facility at the Baylor College of Medicine to the test laboratory at the Johnson Space Center. This malaise, sometines apparently bordering on nausea, was present until approximately BR+2.

In figure 1.1 the duration of after-sensation of rotation is plotted as a function of test day for each subject. Visual inspection of these data indicates no overall trends. It will be noted that compared to the group as a whole, subject 4 consistently reported longer after-sensation durations.

Subject 1 proved to be almost totally resistent to the development of motion sickness. This immunity is apparently due to pronounced degradation of normal vestibular function caused by the adminsitration of the ototoxic drug streptomycin sulfate to treat a middle ear infection earlier in his life. This subject did consent to several diagnostic tests of inner ear function which were performed following the conclusion of the standard post-bedrest test protocols. These special tests included a pure tone audiogram, a cupulogram and caloric

irrigation. A description of the test protocols and the results obtained are provided in Appendix A.

Discussion

Not unlike the results of the 14-day bedrest study, the post-bedrest increase in susceptibility to Coriolis motion sickness measured in four of the subjects in the present study were small in magnitude and of questionable significance. Indeed, the changes observed may be accounted for in part by normal response variablilty encountered with testing of this type. Also, the possibility that one or more of the subjects may have over stated symptoms post-bedrest in order to terminate the test prematurely cannot be overlooked. Finally, in considering the significance of the subject's post-bedrest responses a distinction must be made between symptoms of motion sickness having their etiology in the vestibular system and symptoms characteristic of motion sickness, but not of vestibular origin. For example the symptoms experienced by subject 3 on BR+0 and BR+1 may not have been the result of vestibular hypersensitivity, but instead the result of a generalized autonomic nervous system response to the various physical stresses encountered during the first 24-28 hours after termination of bedrest. Such non-vestibular influences may also account for some of the response change observed in several of the other subjects. Despite these uncertainties the results of this experiment do indicate rather clearly that 28-days supine bedrest does not significantly alter ones susceptibility

to experimentally induced motion sickness.

A direct comparison between the present study and the Skylab 2 post-flight results is not entirely valid for several reasons. First, it must be remembered that the Skylab crew was recovered at sea under conditions condusive to the production of motion sickness. Secondly, the post-exposure test times were not identical for the two situations. Finally, the Skylab crewmen had periodic inflight exposure to the rotating chair test, as well as other vestibular stimulation, and therefore had opportunities to acquire or at least maintain some degree of vestibular adaptation during flight. The bedrest subjects had no such opportunities. With these facts in mind it may be only generally stated that the post-bedrest tests did not yield results like those typically obtained following the Skylab missions. Most notably, the striking post-flight decrease in susceptibility seen in most of the Skylab crewmen was not exhibited by the bedrest subjects.

Aside from the dissimilarities between the two test situations, these findings are not unexpected if one accepts the postulation that alterations in otolith function were primarily responsible for the post-flight changes in the Skylab crewmen. In the absence of gravity, the otoliths, or the CNS intergration of otolith generated sensory input, could be expected to undergo significant change. Such would not be the

case in individuals bed-rested in a 1-g environment.

To conclude unequivocally at this time, that supine bed-rest does not result in sensory physiological alterations like those produced by prolonged exposure to weightless space flight would be premature. The Skylab missions ranged from 28 to 84 days duration, whereas, the exposure to supine bedrest in the present study was only 28-days in duration. It is conceivable that longer supine bedrest might result in alterations more analogous to those seen following Skylab. Also, because of the potential etiological significance of fluid shifts in space motion sickness, the effects of weightlessness might be better simulated by head-down tilt bedrest rather than horizontal bedrest. Such a study has yet to be done.

EXPERIMENT 2: VESTIBULO-SPINAL REFLEX

Method

Instrumentation

A one millisecond pulse was generated by a Grass Model S 44 stimulus generator, and delivered to the subject's leg through a Grass photo electric stimulus isolation unit (Model PSiV6B). Stimulus current was limited to 10 ma. Pulse amplitude was between 10 and 150 V, delivered at three second intervals. This pulse was negative going with respect to a silver plate anode (3 x 5 cm) placed over the patella. The cathode was a 1 cm silver disc (Beckman 16 mm electrode)

placed over the tibial nerve in the popliteal fossa. The general arrangement used for both stimulation and recording was that described by Hugon (1973).

Recording electrodes (Beckman, Ag/AgCl: 16 mm) were placed over the soleus muscle, on the mid dorsal surface of the leg, above the junction of the achilles tendon and gastrocnemius muscle. The active electrode was uppermost, and the reference was placed about 3 cm below. The leg was restrained using an inflatable splint, and the foot fixed in a restraint. The subject lay in a supine position, with the head and neck horizontal. The myographic potential was delivered to a high impedence probe (Grass Model 741P5D) and amplified by a Grass Model 7P511G EEG amplifier. Individual responses were monitored on a Tektronix Model 7313 storage oscilloscope, triggered by an independent synch signal generated by the Grass stimulator. This trigger signal, the myographic response, and time signals were recorded on analog magnetic tape. A Systron-Donner Model 8150 time-code generator/reader provided the time signals.

Procedure

The recording electrodes and the stimulus anode plate were placed in position, and the signal from soleus activity visualized while a probe was used to locate the optimum location for the cathode in the popliteal fossa. Once this location was determined, the stimulus electrode was placed in position. Soft rubber straps attached to a rigid plate over the electrode were passed around the leg to apply pressure and

improve contact with the nerve trunk.

Once a satisfactory response was obtained, a rapid scan was made to determine the range of intensities to be used for data collection. The magnitude of voltage increment used during any series was chosen to provide an adequate sampling of the dynamic range of the response, from just below visual threshold to saturation of the response.

Ten samples were recorded at each stimulus level used, with the first two in any series discarded, and the remaining eight used for subsequent analysis. Six complete data sets were obtained for each subject, three before, and three after bedrest. For the first group these were: BR-8, -7, -1, +0, +2, +8; and for the second group: BR-14, -7, -1, +0, +2, +7. These data were digitized from analog tape, and analyzed on a Varian 620F computer.

Results

A typical response series is shown in Figure 2.1. Each trace represents the averaged response to eight successive stimulus presentations at the same level. Seventeen such traces are presented, representing the full dynamic range of the response from below threshold to saturation of the M component, using 4V increments from 24V to 56V. These data may be conveniently summarized in a recruitment plot, Figure 2.2. It can be seen from these figures that the H component has the lower

threshold, recruits rapidly with increases in stimulus level, and decreases in amplitude with further increases in stimulus level, once the threshold for direct stimulation of the efferent motor units is achieved. Figure 2.3 summarizes the individual data for each test day and subject, in the form of recruitment curves. Amplitudes of the H component are expressed throughout as a percentage of the peak amplitude of the M component.

Peak values of H (in M-max percentage units) for each subject and test day are presented in table 2.1. These are summarized in table 2.2 as averages for each subject before and after bedrest. A small decrease in the mean amplitude of peak H was observed after bedrest but this was not significant, ($t=1.699$, $df=5$; $p>.05$).

An analysis of the trading relationship between H and M was made, using a regression of H on M. This may be visualized by plotting H against M - Figure 2.4. The recruitment of H in the absence of M produces in these plots a steeply rising line, followed, in a typical case, by a negative slope produced by the trading relationship between H and M. The slope reflects relative changes in the amplitudes of H and M, and so deviations from a linear trading relationship is reflected in slope changes. Correlation performed on the data lying between H max and M max provide a convenient measure of these deviations, while slope changes from test-day to test-day provide a means for monitoring changes in the H-M trade-off. Individual linear regression analyses were computed on each data set (subjects

x days) for those values between H max and M max. The slopes computed from these are presented in table 2.3. Examination of this table together with Figures 2.3 and 2.4 will show that subject #3 (R.T.) produced responses unlike any of the other subjects. In general the correlation coefficients and slopes of the regression lines were negative while this subject produced positive slopes and correlations. A t-test on the slopes of the regression lines revealed no significant change in the nature of the trade-off before and after bedrest ($t=1.177$, $df=4$; $p=>.05$). The data from subject #3 was not included in this computation. Table 2.4 presents the correlations obtained from the regression analyses.

Discussion

The results of this experiment were inconclusive. It was our intention to demonstrate changes in vestibulo-spinal reflex patterns, and relate these to postural ataxia problems and other myographic observations obtained following the Skylab flights.

Long term space flight and exposure to prolonged periods of weightlessness, as experienced during Skylab, tend to generate a hyper-reflexia. This finding observed together with an increase in postural instability following Skylab support a concept which suggested that central neural reorganization occured in response to environmental change. That is, a modification of a 1-g environment dependent memory store may have

occured that required restructuring of the vestibular "pattern center" upon return from weightlessness.

The previous 14-day bedrest investigation indicated a direct and immediate increase in amplitude of an evoked Achilles tendon reflex on BR+0. While this finding was in agreement with the Skylab myographic studies, it did not permit, as was hoped, further explanation of the Skylab postural ataxia data, nor did it allow for evaluation of bedrest as a method to study physiological changes which may be analogous to those induced through exposure to prolonged periods of weightlessness.

To overcome some of these objections, and to allow for further evaluation of the questions which came from the Skylab postural ataxia data, the Hoffman reflex was chosen as a quantitative tool for the 28-day bedrest test. However, the results were inconsistent and suggest that two basic conclusions be considered. First, methodolgies for long term studies of selected individuals with the H-reflex must be well standardized. Electrode placement is difficult both in the soleus muscle and over the tibial nerve. Small differences between each experimental run could account for vast differences in the recorded data. So while the methodology is sufficient for acute experimentation, careful consideration will be necessary for more longitudinal work. Second, these data support the conclusion from Experiment 1 (Motion Sickness Susceptibility) that supine

bedrest does not produce sensory physiological alterations like those which may result from prolonged exposure to weightless space flight. Based on our parabolic flight data, and the projected response of the spinal vestibular motoneuron pool response to long term zero-g exposure, it would be premature to view bedrest as an appropriate analog for prolonged exposure to weightlessness or as an adequate method of inducing vestibular adaptation and subsequent sensory relearning.

EXPERIMENT 3: POSTURAL EQUILIBRIUM

Methods

Pre- and post-bedrest postural equilibrium performance was assessed simultaneously by two different methods. Each is described separately.

Rail Balancing

The primary method used was a modified version of a standard laboratory test procedure developed by Graybiel and Fregly (1966) and was identical to the approach used to evaluate pre- and post-flight postural equilibrium of Skylab astronauts. The test employed a set of narrow metal rails on which the subject was required to balance while maintaining an upright posture with his feet tandomly aligned and arms folded across his chest. The rails were .75, 1.25, 1.75, and 2.25 inches wide. In addition, a 4" x 30" section of tape served as the foot-guide alignment when the subject was required to

stand on the floor. Each subject was fitted with military-type shoes for this test, to rule out differences in footwear as a variable. Performance on this task was measured under two sets of conditions. In the first, the subject was required to balance on the rail (or floor) with his eyes open. In the second condition, he attempted to balance with his eyes closed. In both cases, performance was scored in terms of time (in seconds) on the rail before losing balance. On a given rail size, three test trials with a maximum required duration of 50 seconds each were allowed. If the time limit was reached in the first two trials, a third was not performed, and a perfect score of 100 seconds was recorded. If the subject failed to obtain a perfect score, the two largest time values for the three trials were summed to obtain the final score. Elapsed time for each trial was registered on a digital clock which was started, stopped and reset by the experimenter. Trial duration was also recorded on a 3-channel Brush strip chart recorder. During a test session, a minimum of two rail sizes were used in both the eyes open and eyes closed conditions.

Sway Measurement

Postural sway has long been recognized as a phenonmenon which could potentialy yield information on the complex reflex pathways which govern motor function. Sway testing of patients with suspected disruptions in proprioception and vestibular function has been conducted since the days of Romberg with

increasing sophistication. Most commonly these measurements are used to map the projection of the subject's center of gravity on his base of support without regard to the position of individual body links.

Concomitant with the rail balancing test a special sway measurement technique was used to assess possible mechanisms by which the subjects maintained balance on the test rails before and after bedrest. As the subject attempted to maintain his balance on the rails, the position of his hips and shoulders were monitored in the plane perpendicular to the rail. With this information, the mechanism used by each subject to keep his center of gravity over his base of support could be analyzed. It was hypothesized that two major methods would be observed.

1. The body would remain rigid and act as an inverted pendulum with the major forces for correction coming from torques applied around the ankles.
2. The hips would thrust from side to side moving the center of gravity to the side opposite the deviation from the upright thus producing a corrective torque around the base of support.

The instrumentation chosen for this study was the Reticon Corporation digital line scan camera. The heart of the camera is a high density monolithic linear array of silicon photodiodes.

Depending on the amount of light falling on them, the photodiodes pass varying amounts of current into capacitors integrated into the device. The voltage on each capacitor was read of sequently by a sense amplifier multiplexed to the array members. For the present application, there were 512 diodes in the array and each capacitor was read every .01 sec. The camera electronics provided for logic compatibility by a threshold detection of the capacitor voltage readouts, a logic level which defined the beginning of the sweep, and a clock pulse which defined the time at which the multiplexer stepped to the next diode. When a subject appeared as a silhouette against a light background, the threshold output of the camera was in one state when scanning the background and in the other when viewing the subject. The interface for the camera consisted only of a logical circuit which identified the subject image in the scan and calculated the average position between the leading and trailing edges of the subject image. The resolution of this determination was 1 part in 1024. To obtain analog tape recorder compatibility and portability, a digital to analog converter was used to convert the average position count to an analog voltage.

With two cameras mounted over one another, one viewing a line at the level of the hips and the other at shoulder level, we were able to record movements of two body links as the subject (standing erect with arms folded) attempted to maintain his balance on the rails. After each test session, the data were digitized and analyzed using digital signal processing

techniques. These techniques were applied to the data to determine individual subject differences and changes in postural mechanisms between the pre- and post-bedrest testing sessions.

For each of the six subjects the combined rail balancing-sway measurement test procedure was conducted four times pre-bedrest and three times post-bedrest. Test days were as follows- Group I: BR-24, -20, -7, -1, +0, +2 and +7; Group II: BR-26, -20, -7, -1, +0, +2 and +8. The total duration of this test did not exceed 25 minutes. This test procedure typically immediately followed the vestibulo-spinal reflex measurement procedure.

Results

Rail Balancing

Pre- and post-bedrest rail test data for subjects 1-6 are presented in Figures 3.1 - 3.6, respectively. In these figures, eyes open and eyes closed postural equilibrium performance on each of the rail sizes used, plus the floor, is plotted as a function of test day. The standard error of the mean was selected as a descriptor of the variance in the pre-bedrest data and is indicated by the dashed lines in the figures. The solid horizontal line in the figures is the mean of the pre-bedrest performance scores. Where there is obviously little variance in the pre-bedrest data neither the mean nor the standard error are shown.

During the pre-bedrest test period this group of subjects, with the exception of subject 1, exhibited exceptional postural equilibrium performance. Subjects 4 and 6 showed particularly outstanding ability to balance on the test rails during the eyes closed condition. Visual inspection of the figures indicates that during the pre-bedrest period four of the subjects (2, 3, 4 and 6) showed an overall trend toward better performance on successive test days suggesting that learning was occuring.

Subject 1 demonstrated remarkably poor performance on this task. In fact he was almost unable to stand on the floor with his eyes closed. His performance was reminescent of the difficulty Skylab astronauts had with this task immediately after they returned from 59 or 84 days in weightlessness. As noted earlier, it may be assumed that this individual's poor balancing ability is the direct result of streptomycin destruction of vestibular sensory epithelium.

When tested on BR+0 subjects 4 and 5 showed a moderate deficit and subject 6 a slight deficit on both the eyes open and eyes closed balancing tasks. Subjects 2 and 3 demonstrated a very slight deficit on only the eyes open portion of the task. Subject 1 showed no change relative to his pre-bedrest performance. Despite some variability, particular in subject 2, it may be seen that there was a general trend toward improved performance on BR+2. On the last post-bedrest test day this

trend continued for subjects 2 and 4, while curiously subjects 1, 3 and 5 demonstrated a reversal toward somewhat poorer performance. In no case, however, did their BR+7 (or BR+8) score fall below their worst pre-bedrest score for a given rail size.

Sway Measurement

Data analysis was applied only to data obtained in trials where successful balance was maintained for time periods over 25.5 seconds. These records were analyzed for three factors:

1. The standard deviation of the shoulders over the test period.
2. The standard deviation of the hips over the test period.
3. The cross-correlation function between the shoulders and the hips over the test period.

The two standard deviation quantities were calculated on an arbitrary scale but was consistent among all of the trials and sessions. The cross-correlation functions were broken into three categories.

a) Positive at or near the zero shift value.
b) Negative at or near the zero shift value.
c) Passes from negative to positive at or near the zero shift value.

Examples of these three types of cross-correlation functions are shown in Figure 3.7. Although other patterns might be imagined they did not appear. The significance of these three cross-correlation function types are respectively: a) inverted pendulum action, b) out of phase thrusting of the hips and

c) 90 degree phase movement which could be subjectively described as a snaking motion.

Once the important parameters were calculated for all trials which lasted for at least 25.6 seconds, they were tabulated into a single computer file which allowed access to the entire sway measurement data base. Table 3.1 is a reproduction of the data base. The important information given in the table for each trial is:

1. Subject number.
2. Day relative to start and finish of bedrest.
3. Eyes open or closed.
4. Rail width.
5. Standard deviation of shoulders.
6. Standard deviation of hips.
7. Type of cross-correlation.
8. Time of cross-correlation.

The last item on the list was not used in the analysis of these data but may be of some significance as more is understood about the dynamics of postural control.

By careful examination of the data base, one can observe that the trends in the rail score data apparently caused by learning also appear in the camera data. Exact tabulation of these trends were not attempted for this analysis because insufficient trials over 25.6 seconds existed to seperate out individual sessions and still leave a large enough statistical

sample for each stimulus condition. If the pre-bedrest and the post-bedrest days are reduced to just two classes (pre and post) then the total number of experimental conditions is only 16 obtained from:

a) Four rail sizes.

b) Eyes open and eyes closed.

c) Pre- and post-bedrest

Table 3.2 is an analysis of which condition classes among these 16 condition classes are most populated.

If one examines Table 3.2 and ignores subject 1, then it appears that the most significant quantity of data fall into just eight conditions:

1-4) Rail width 1.25 and 1.75 inches with eyes open pre- and post-bedrest.

5-8) Rail width 2.25 and 4.00 inches with eyes closed pre- and post-bedrest.

These conditions are bracketed in Table 3.2 under "Summary of Stimulus Conditions for all Subjects."

Figures 3.8 and 3.9 summarize all of the analyzed data for the eight conditions identified above. The data in the graphs are arranged in histogram form with all of the subjects combined into one data base. The abscissa of each graph is the standard deviation of shoulder or hip movement. The ordinate is the number of trials within the class which are in a given standard deviation interval. Each individual trial

has been recorded with a symbol which indicates the type of cross-correlation function which was calculated from the data.

+ - positive

0 - alternate

- - negative

Below each histogram the subject numbers are positioned to indicate the average standard deviation for the subject. A "T" is positioned at the average value for the entire condition class.

There are a number of general observations which can be made with the aid of figures 3.8 and 3.9.

1. Hip movement is generally smaller than shoulder movement.
2. No significant difference could be detected between pre- and post-bedrest data classified as they are.
3. Large deviations were generally associated with the negative type of cross-correlation function.
4. The best control with eyes open on the narrow rails was with the alternating cross-correlation function type.
5. The best control with eyes closed on the wide rails was with the positive cross-correlation function type.
6. From the standpoint of success at staying on the rail, large deviations and negative type cross-correlation does not mean failure. It only indicates the type of stabilization used.

In addition to the rail balancing and sway measurement data, subjective experiences reported by the subjects are noteworthy. Several of the subjects reported mild dizziness with rapid head turns on R+0 and most of them indicated experiencing a tendency to lean to the outside when walking around corners. Similar R+0 experiences were reported by Skylab astronauts, as well as subjects who participated in the 14-day bedrest study. Also all of the subjects complained, especially on the BR+2 test day, of sore feet and calf muscles. This condition appeared not to have affected their ability to balance on the test rails, however.

Discussion

The static rail balancing test procedure used in this experiment revealed only short-lived and functionally insignificant alterations in post-bedrest postural equilibrium performance. As might be expected from previous situations where the rail test was used, observed changes tended to be somewhat greater when the subject was deprived of visual cues.

No firm conclusions regarding the comparability of supine bedrest and weightlessness in producing neuro-muscular system modification can be drawn from this experiment. This is true in part because of the significantly longer duration of the Skylab missions from which data are available. Twenty-eight days supine bedrest may be insufficient time for the sensory and particularly neuro-muscular system alterations presumed

responsible for the Skylab postflight postural disturbances to occur. More importantly, however, it must be recognized that sensory system modification during bedrest should include little if an otolithic contribution regardless of the duration of bedrest. Assuming this to be true, the total patterning of sensory system modification should be different for periods of exposure to bedrest and weightlessness of equal duration. Therefore, even if equal periods of bedrest and weightlessness produced highly similar changes in postural responses the underlying causes could be quite different.

The addition of sway measurement to the basic rail test did not significantly increase the yield of this experiment as organized. These measurements did, however, support the finding of the basic rail test. That is, no significant post-bedrest changes were detected.

When considering the value of the body sway measurement, one must keep in mind that no special modification of the rail test was made to accommodate this additional measurement procedure. The basic strategy of test condition presentation in the rail test was to span the range between low time totals (where the subjects were challenged) and long total times (where the subjects were not challenged). The best strategy for sway measurements however, would be to present conditions which allow good balance for at least 20 seconds for almost all trials. A number of trials could then be taken in a smaller time

interval then was required for the rail test. Also, for the present experiment no instructions were given which caused the subjects to minimize their total body sway. This may very well have biased subject 2 to appear to have poorer performance on the narrow rails than the other subjects. He did a good job of staying on the rails but he did it with significantly more motion of a negative cross-correlation nature.

It is evident from these sway test results that the mechanism of balance is a function of what the subject has available to him in terms of sensory cues and possibilities for torque application. Testing with eyes closed on a wide base of support allows the subject to use torque applied at the ankle to control his balance. If that ankle torque possibility is taken away from him, there will be thrusting of the hips to dynamically accomplish the same goal. It also appears that better control is maintained on narrow rails by using a mode of control which produces the alternating cross-correlation function type. This makes sense from a control theory point of view because 180 degree phase shifts between shoulders and hips can only perpetuate themselves where as a 90 degree phase shift situation tends to damp out the instabilities.

Finally, as previously noted, all of the subjects in this experiment did exhibit some ataxia on BR+0 even though rail performance was generally good. This finding indicates that the static rail balancing test may have been insensitive to a

change that was present. It is suggested therefore that in future test situations of this type a dynamic balancing task (e.g., balancing on an unstable platform) should be utilized. The assessment of postural equilibrium under dynamic test conditions, particularly with the use of quantitative body sway measurement techniques, should yield more meaningful results.

SUMMARY AND CONCLUSION

The three experiments included in the present study were designed primarily to determine if prolonged supine bedrest produces neuro-sensory and neuro-muscular functional alterations like those observed in Skylab crewmen following their long duration exposure to weightless space flight.

Experiment 1, which examined pre- and post-bedrest susceptibility to motion sickness, revealed only small and insignificant increases in susceptibility in a majority of the subjects on the BR+1 test day. These changes could be largely accounted for by factors other than alterations in vestibular system function. Experiment 2 demonstrated a slight trend toward increased vestibulo-spinal reflex excitability in approximately half of the test subjects on BR+0, but the data were inconclusive. Experiment 3, which was designed to assess pre- and post-bedrest posture equilibrium, revealed that five of the six subjects had a slight deficit in rail balancing ability on BR+0. However, there was generally no sharp distinction between the eyes open and eyes closed test conditions and in most cases recovery

was nearly complete by BR+2. Also, the sway measurements which utilized the digital scan cameras indicated no significant changes post-bedrest.

On the basis of data obtained from each of the three experiments it may be tentatively concluded that with regard to sensory physiological processes supine bedrest does not provide a valid analog of weightlessness of equivalent duration. Whether or not this conclusion could be applied to all human sensory physiological processes is a matter of conjecture, but it would appear to apply to those responses investigated in the present series of experiments.

As suggested earlier in this report, the lack of any meaningful correlation between these bedrest study results and the Skylab post-flight findings is not surprising if one considers the mechanisms presumably responsible for the Skylab postflight changes. During the Skylab missions it is most probable that significant adaptive changes involving the otolith receptors occurred. Included, as a result of altered otolith activity, would have been modifications in the central nervous system processing of sensory information which were appropriate for the zero-g environment. Such modifications, however, were inappropriate for normal functioning in 1-g. Hence, upon return to 1-g, the crewmen manifested response changes, most notably altered motion sickness susceptibility and postural instability, which gradually diminished and disappeared as

they re-adapted to the 1-g environment.

Such adaptive changes involving the otoliths and other gravi-receptors would not be expected in subjects undergoing supine bedrest in a 1-g environment. Therefore, the lack of significant changes following bedrest should not be too unexpected. Even if significant sensory physiological response changes did occur following bedrest of durations greater than 28-days, it is unlikely that the underlying causes would be the same as those associated with exposure to weightless space flight. A possible, but unlikely exception to this line of reasoning, might be head-down tilt bedrest where vestibular function may be influenced by body fluid shifts.

Aside from any comparisons with Skylab findings, the failure to detect any meaningful post-bedrest alteration in sensory physiological function is perhaps by itself of some significance. In other words, contrary to what one may intuitively think about possible debilitating effects of being continuously confined to bed for one month, normal, healthy individuals are resilient and not too adversly affected by the experience.

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ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation to Kenneth Jones, Bryant McPherson and Richard Simmons for their outstanding assistance with the collection, reduction and analysis of the data reported in this study.

A special note of gratitude is offered to Mary Pat Stitsinger for her patience and care while typing this manuscript.

List of Figures

Figure 1.1 Duration of post-rotary after-sensation plotted as a function of test day for each subject.

Figure 2.1 Each trace represents the averaged response to eight stimulus presentations. Stimulus range used was 24 volts (below threshold) to 56 volts, in two volt increments.

Figure 2.2 Recruitment curve plotted from the data of Figure 2.1. H and M amplitudes are plotted as function of stimulus voltage level. Amplitudes of both H and M are expressed as a percentage of the maximum H amplitude.

Figure 2.3 Recruitment curves summarizing the data from each subject on each day, plotted as in Figure 2.2.

Figure 2.4 Plot of H amplitude against M amplitude for each voltage level. The plots emphasize the nature of the tracking relationship between H and M amplitudes, from H-max to M-max. A straight line with a negative slope indicates a smooth proportional reduction in H amplitude, as M amplitude increases with increases in stimulus voltage. This may be seen to be the typical. In some cases, deviations from a straight line occur, indicating an irregular

trading relationship. The correlation coefficient associated with the regression of H or M provides an index of the magnitude of this deviation.

Figure 3.1 Pre- and post-bedrest rail balancing performance for subject 1.

Figure 3.2 Pre- and post-bedrest rail balancing performance for subject 2.

Figure 3.3 Pre- and post-bedrest rail balancing performance for subject 3.

Figure 3.4 Pre- and post-bedrest rail balancing performance for subject 4.

Figure 3.5 Pre- and post bedrest rail balancing performance for subject 5.

Figure 3.6 Pre- and post-bedrest rail balancing performance for subject 6.

Figure 3.7 Illustration of the three type of cross-correlation functions derived from the sway measurement data.

Figure 3.8 Histograms of the number of test trials which occurred within a given standard deviation interval for the pre- and post-bedrest eyes open test conditions on the 1.25" and 1.75" wide rails. Hip and shoulder data are shown separately. The symbols used represent

the type of computed cross-correlation function for each trial (+ : positive, - : negative, 0: alternating). Subject numbers are positioned to represent the average standard deviation for that subject. A "T" is positioned at the average value for the entire condition class.

Figure 3.9 Histograms of the number of test trials which occurred within a give standard deviation interval for the pre- and post-bedrest eyes closed test conditions on the 2.25" and 4.0" (floor) test rails. Other descriptors are the same as those in Figure 3.8.

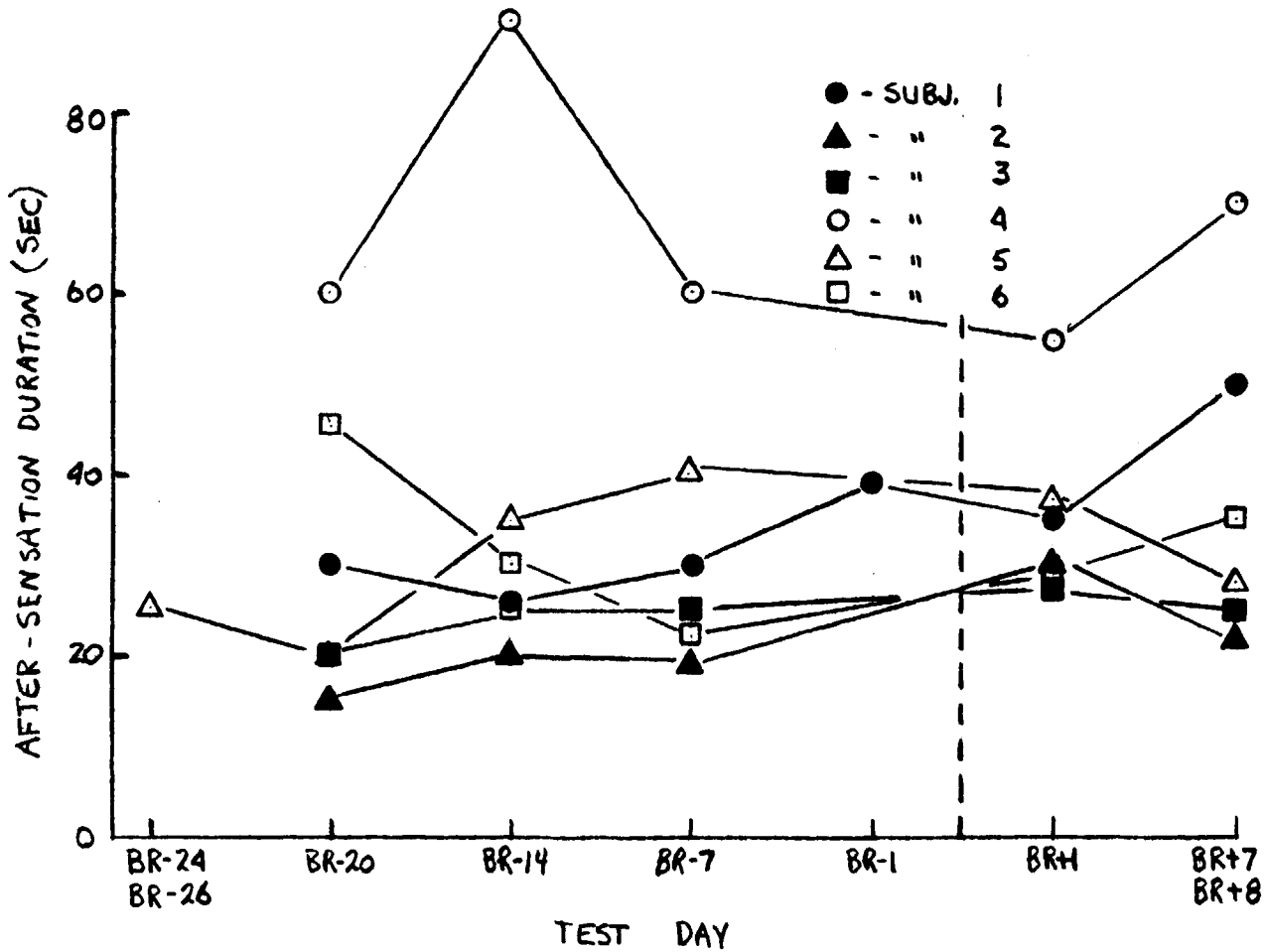
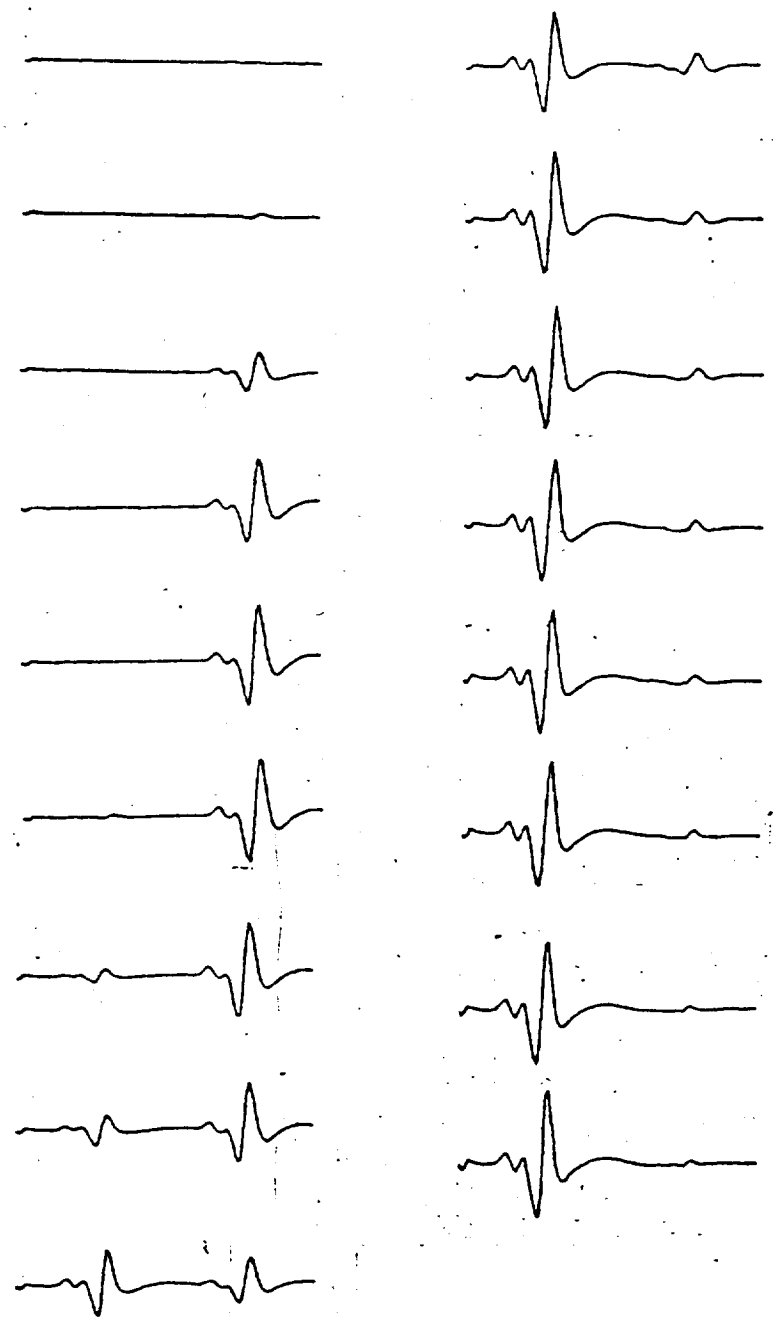

● - SUBJ. 1
▲ - " 2
■ - " 3
○ - " 4
△ - " 5
□ - " 6
AFTER - SENSATION DURATION (SEC)
80
60
40
20
0
BR-24
BR-26
BR-20
BR-14
BR-7
BR-1
BR+1
BR+7
BR+8
TEST DAY

FIG. 1.1

FIG. 2.1



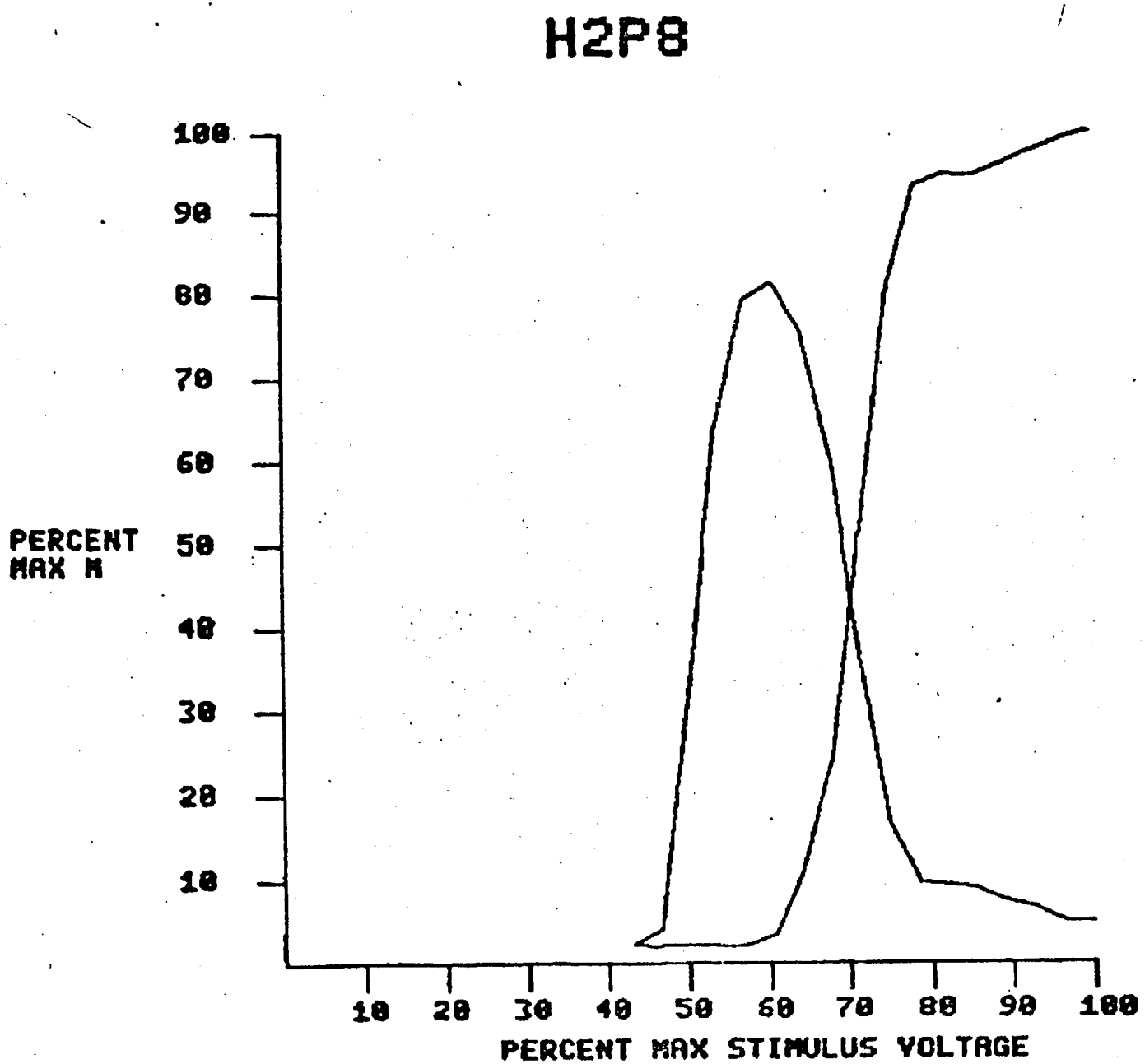

H2P8
PERCENT MAX M
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
PERCENT MAX STIMULUS VOLTAGE

FIG. 2.2

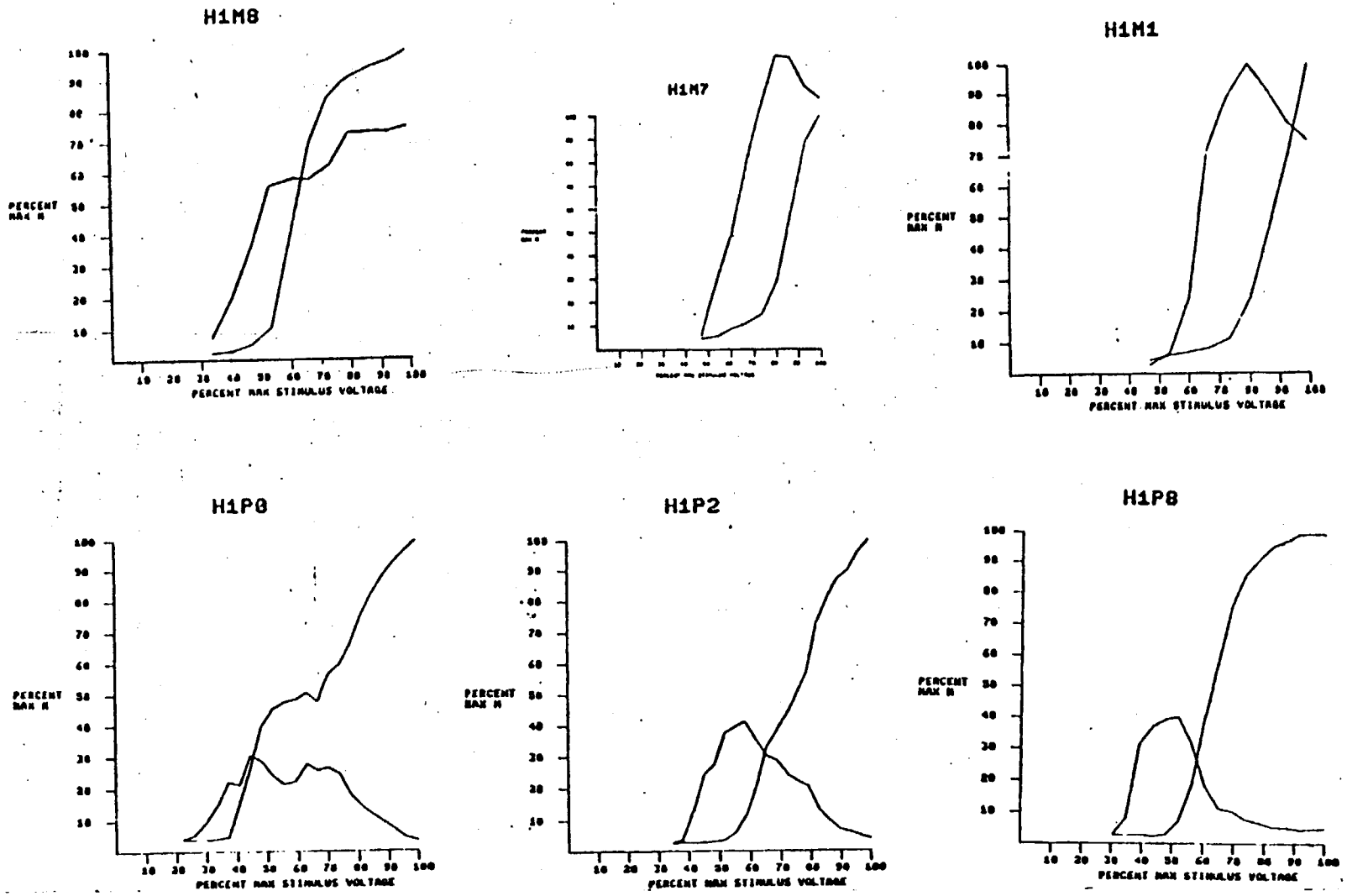

H1M8
H1M7
H1M1
H1P0
H1P2
H1P8
PERCENT MAX M
PERCENT MAX STIMULUS VOLTAGE

FIG. 2.3a

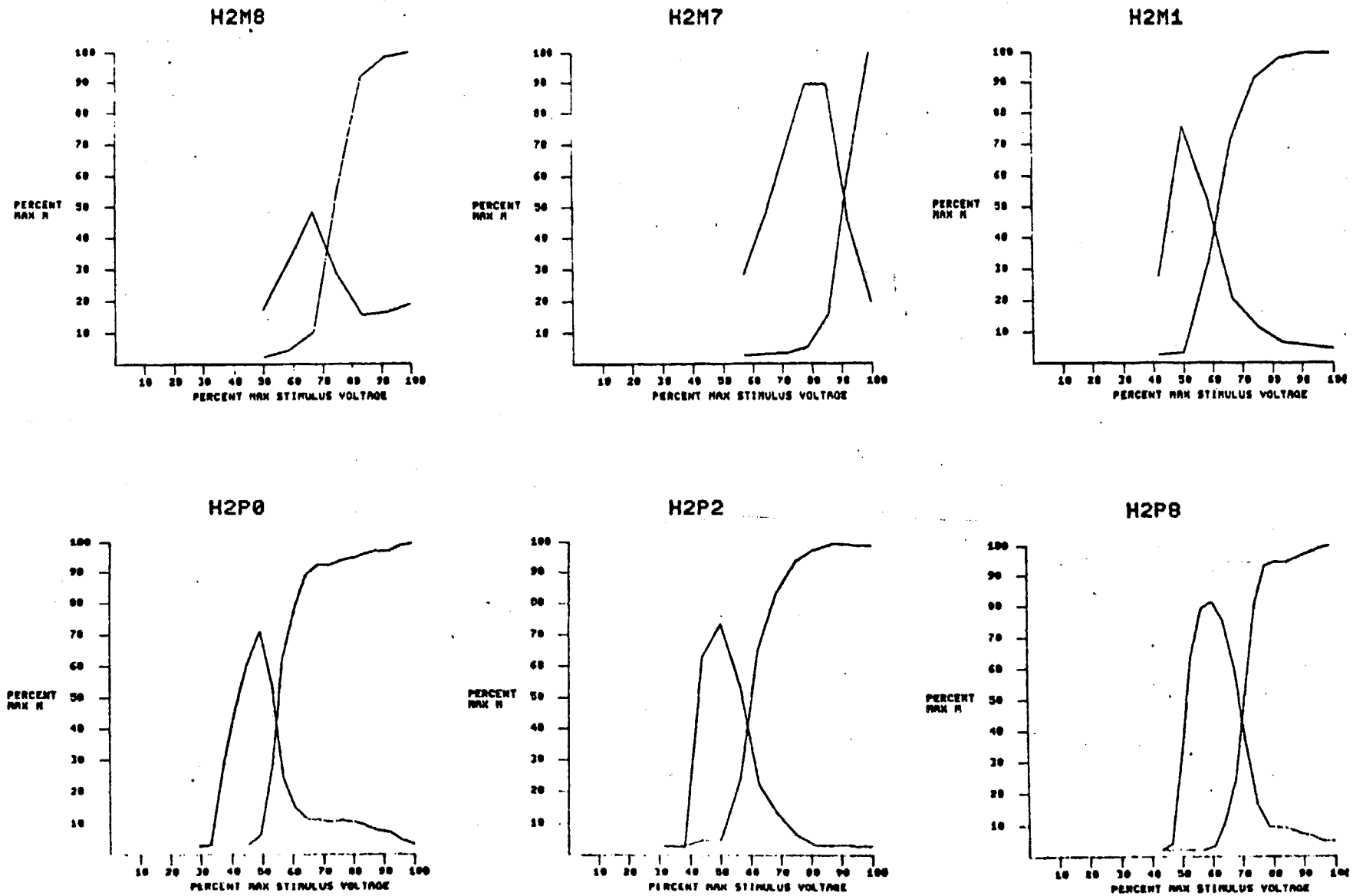
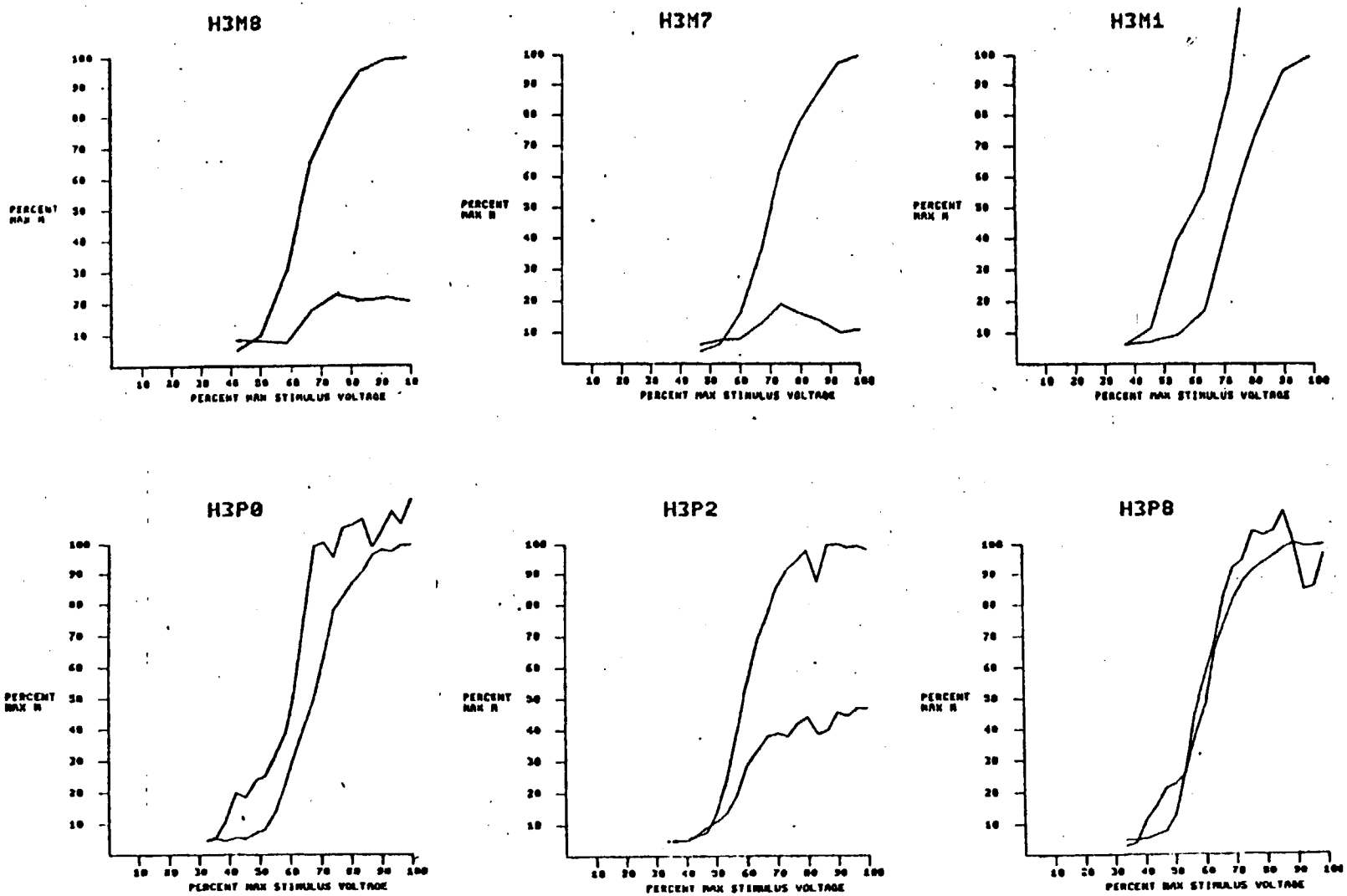

H2M8
H2M7
H2M1
H2P0
H2P2
H2P8
PERCENT MAX M
PERCENT MAX STIMULUS VOLTAGE

Fig. 2.3b


H3M8
H3M7
H3M1
H3P0
H3P2
H3P8
PERCENT MAX R
PERCENT MAX STIMULUS VOLTAGE

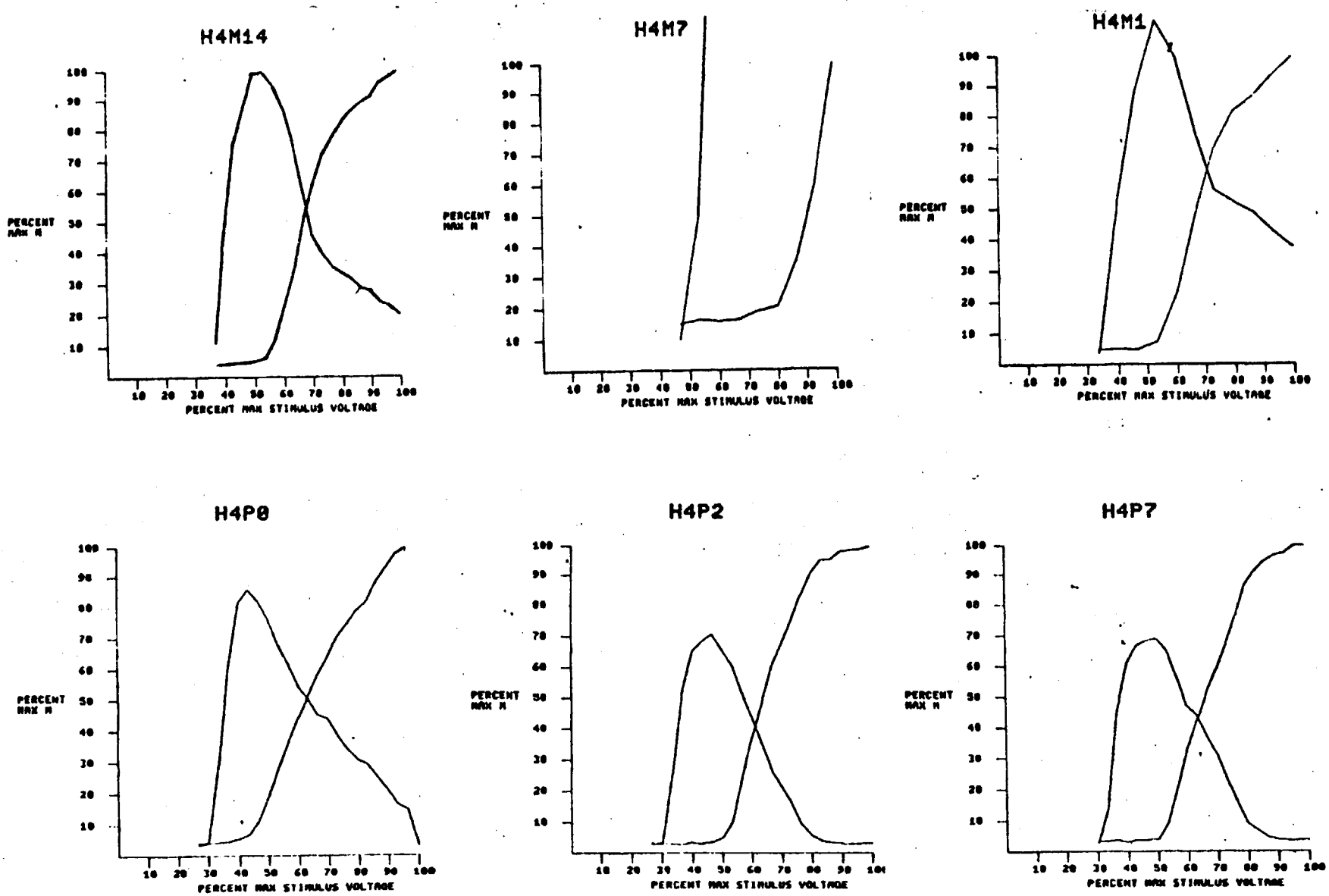

H4M14
H4M7
H4M1
H4P0
H4P2
H4P7
PERCENT MAX R
PERCENT MAX STIMULUS VOLTAGE

FIG. 2.3d

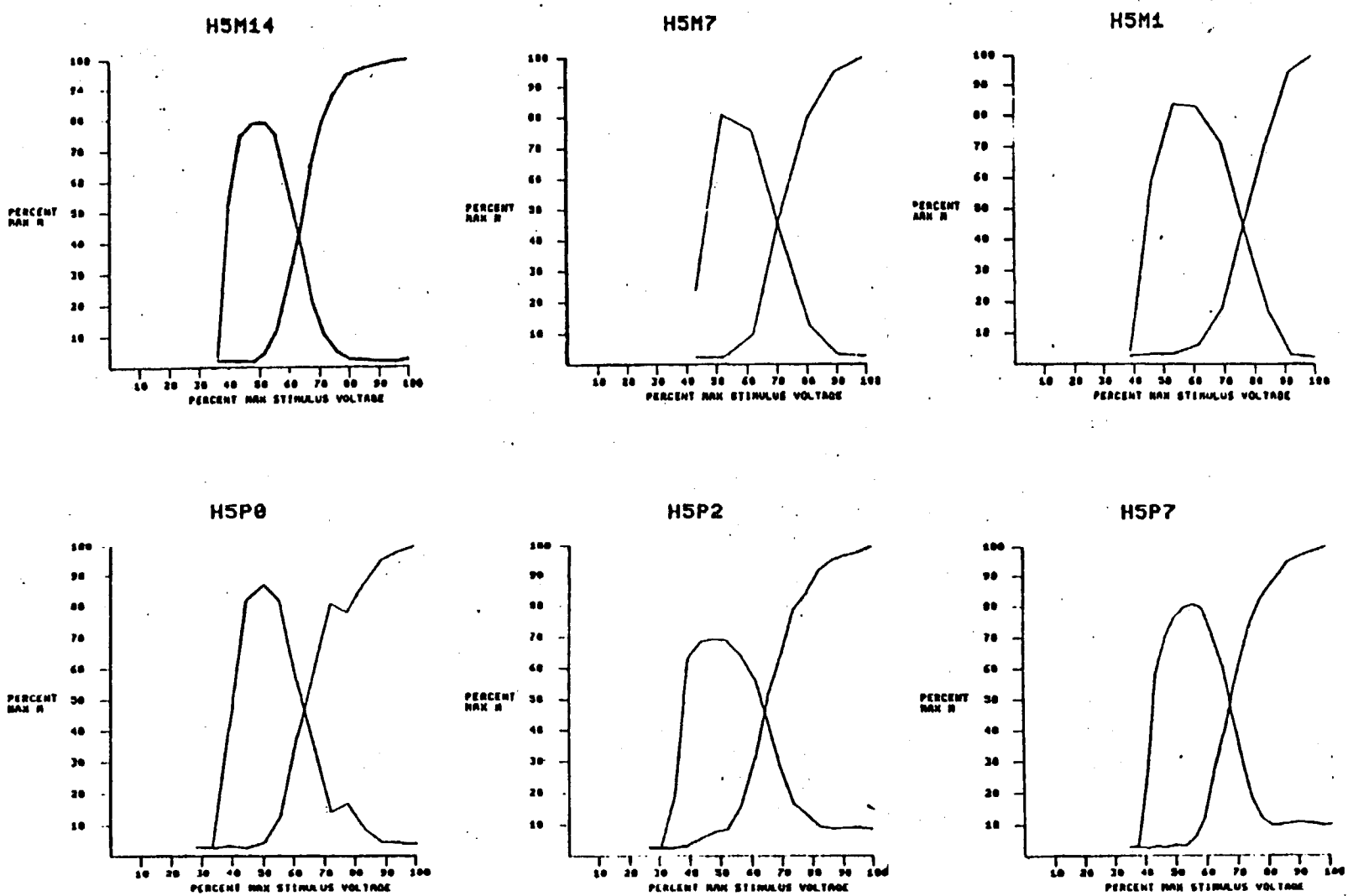

H5M14
H5M7
H5M1
H5P0
H5P2
H5P7
PERCENT MAX R
PERCENT MAX STIMULUS VOLTAGE

FIG. 23a

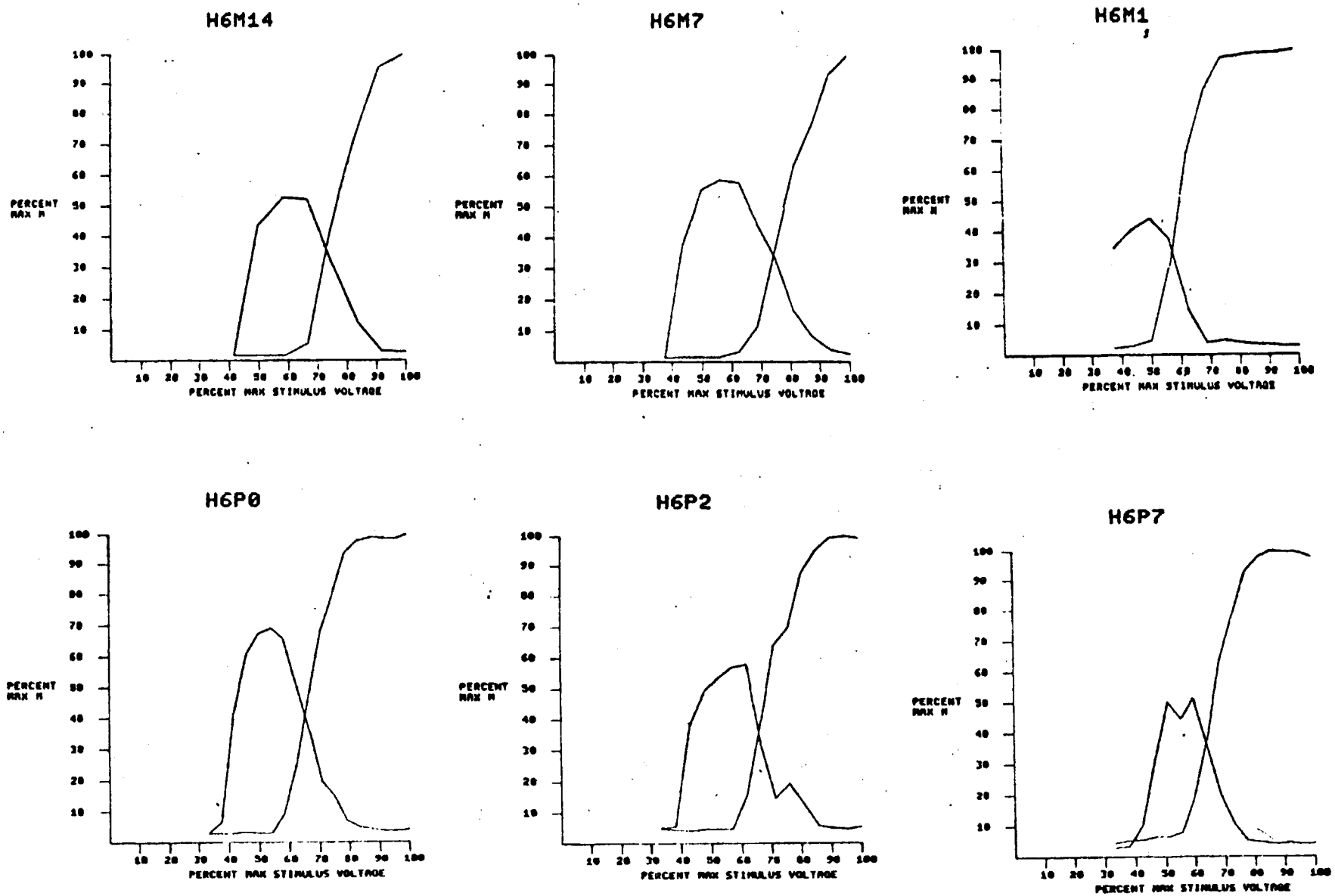

H6M14
H6M7
H6M1
H6P0
H6P2
H6P7
PERCENT MAX M
PERCENT MAX STIMULUS VOLTAGE

FIG. 2.3f

Figure 4.1-6

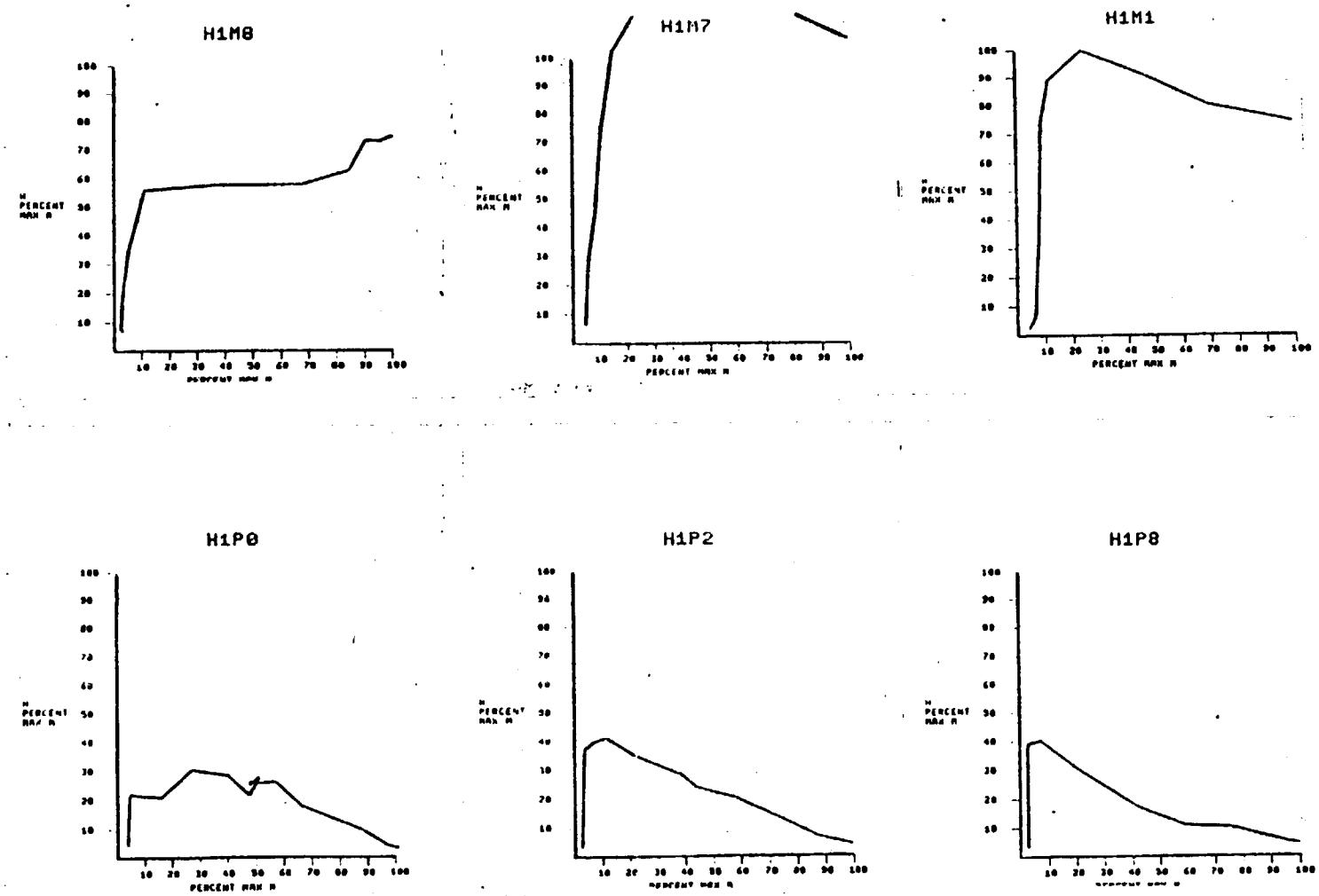


FIG. 2.4a

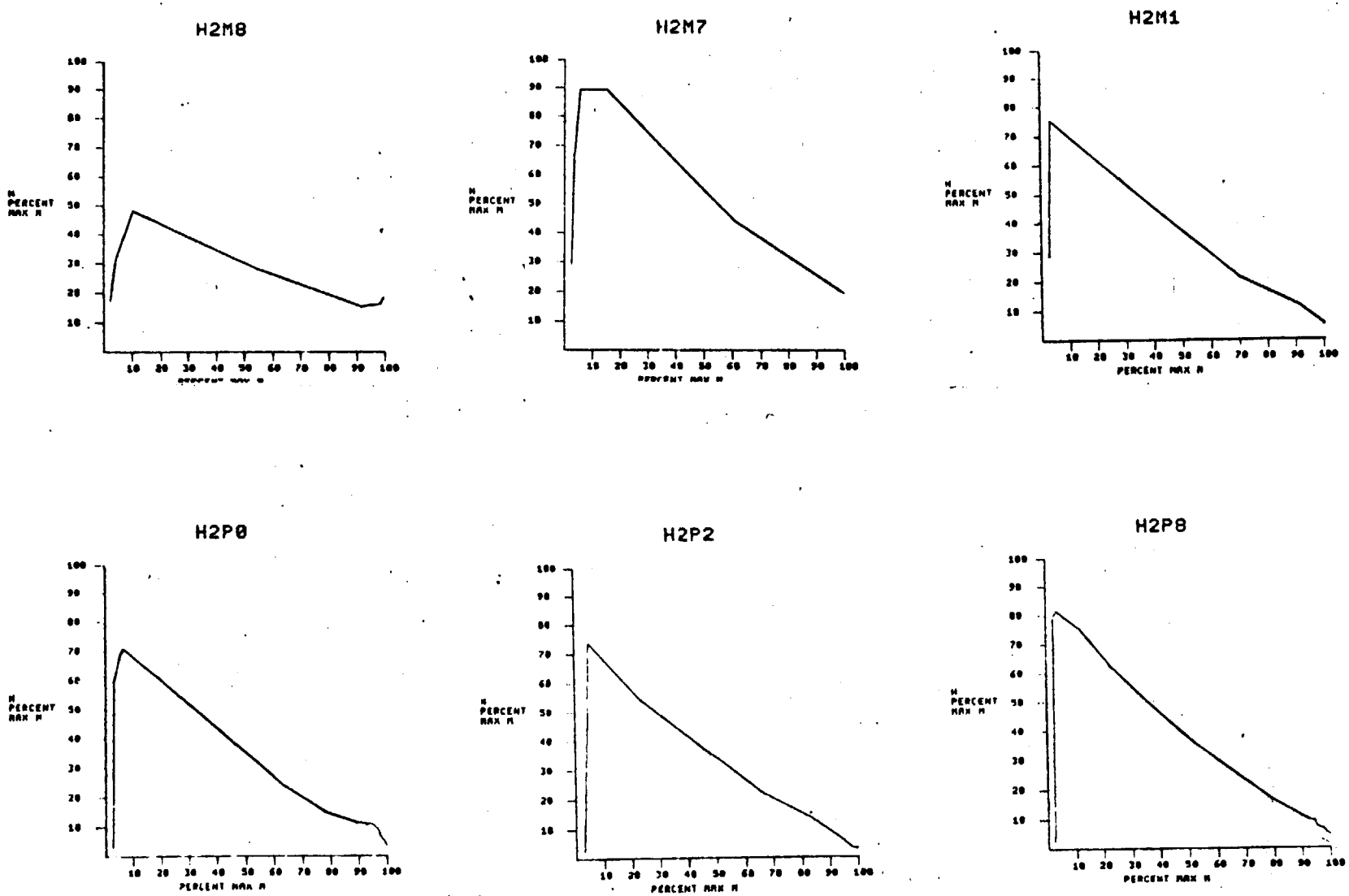


FIG. 2.4b

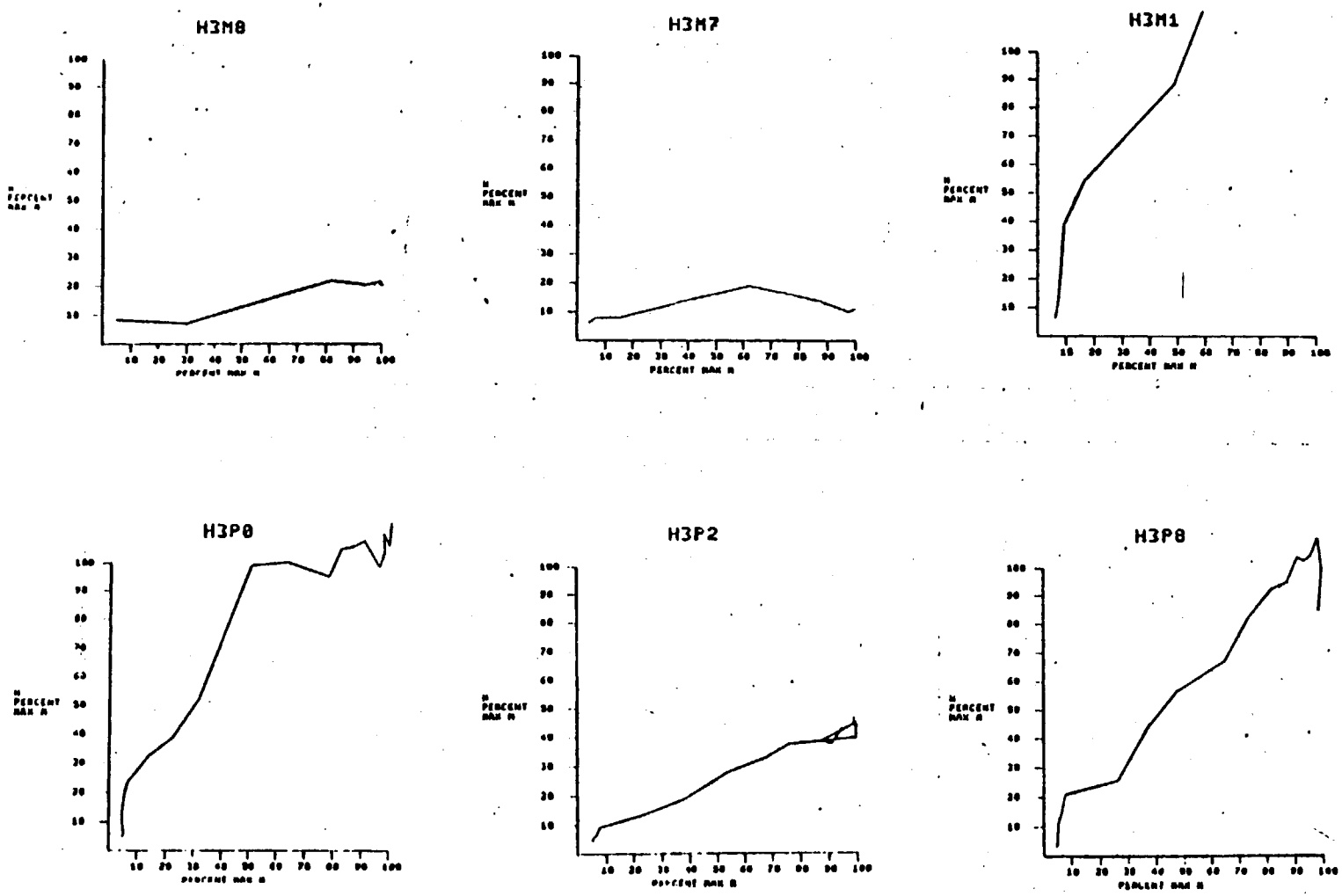


Fig. 2.4c

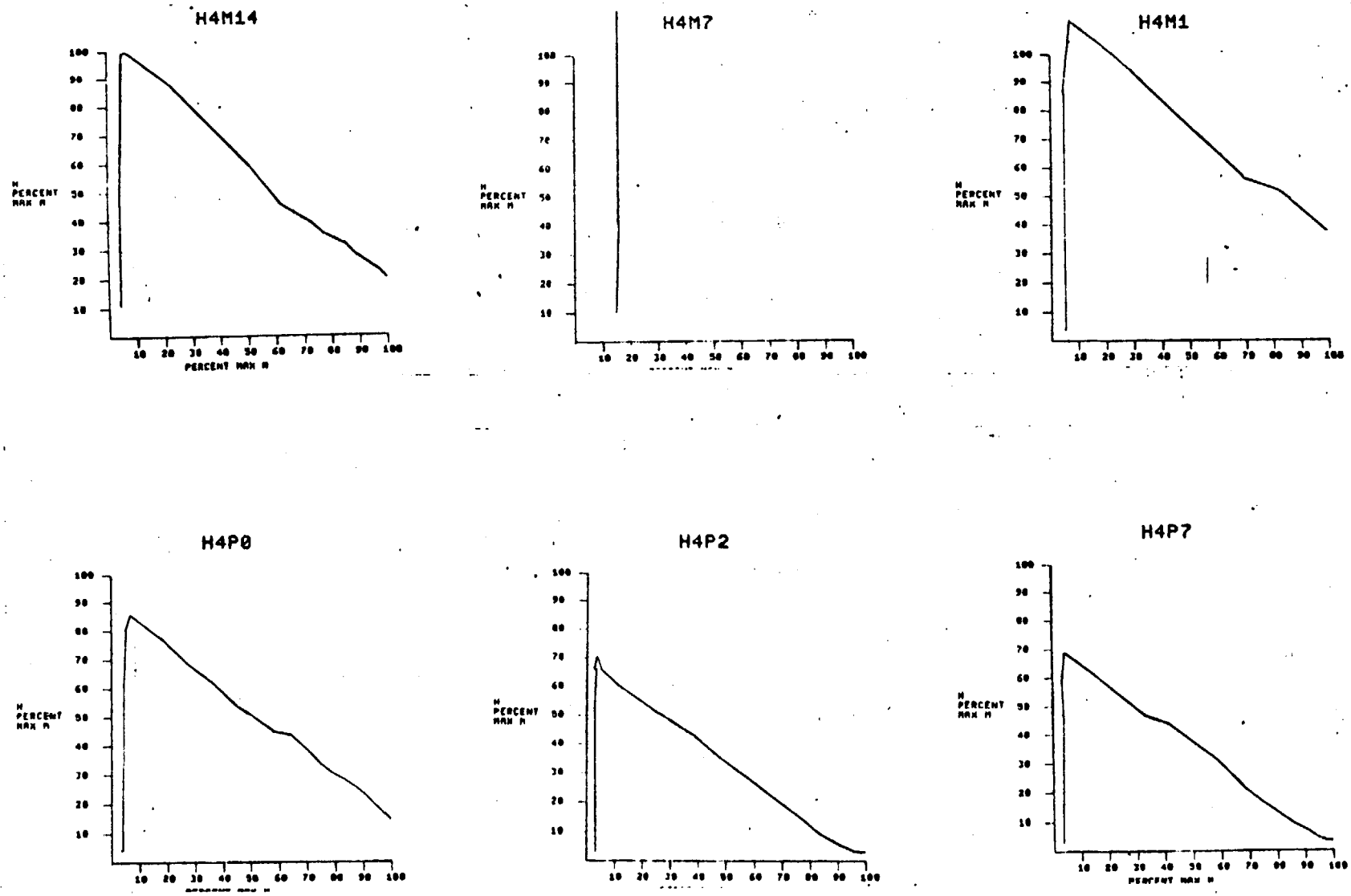


Fig. 24d

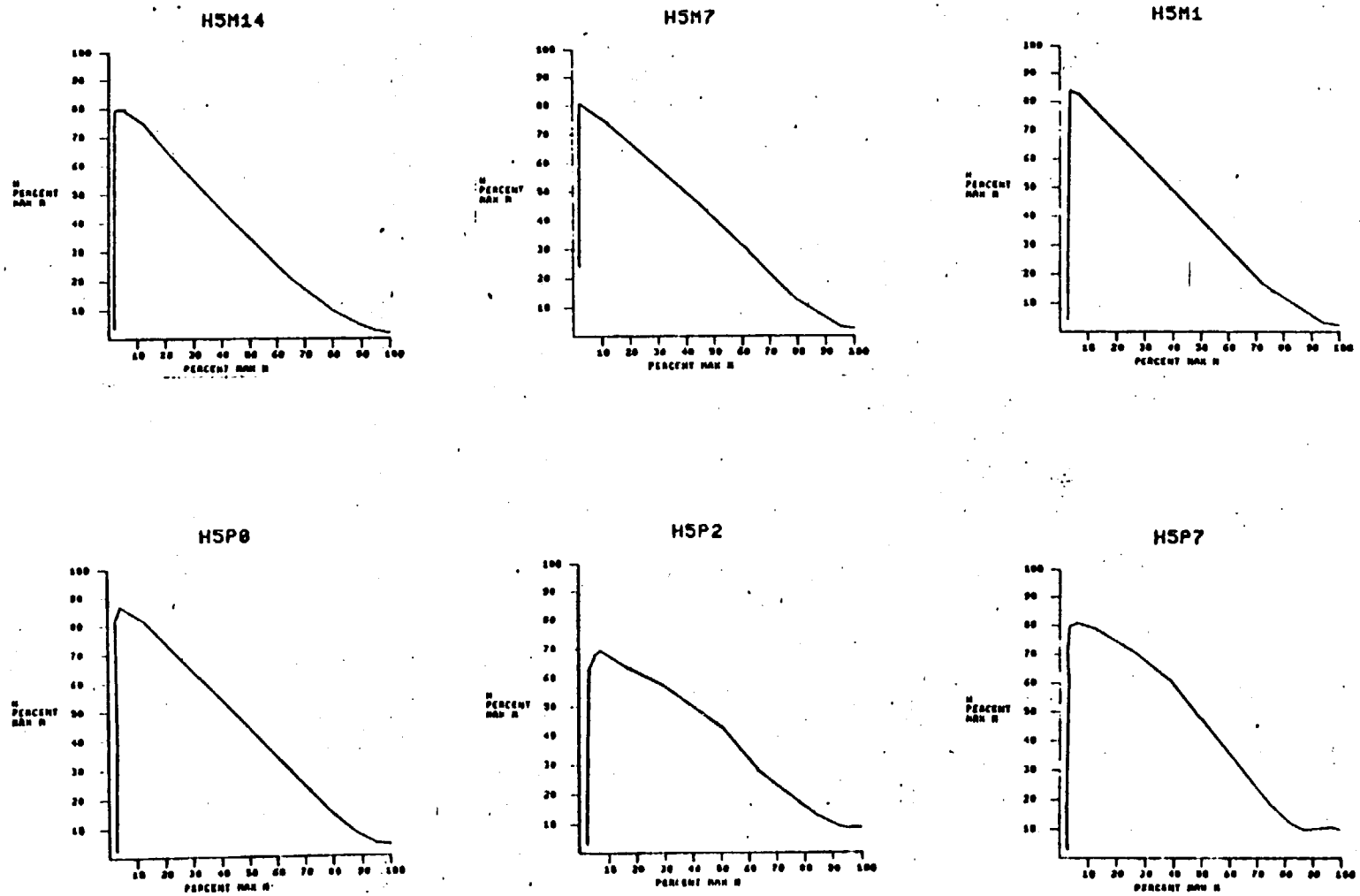
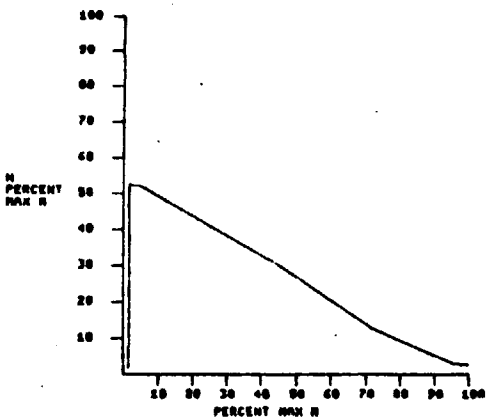
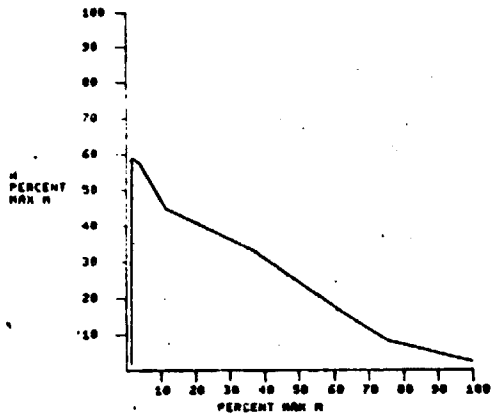


Fig. 2.4e

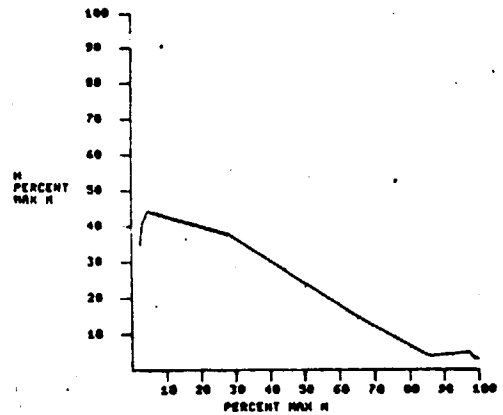
H6M14



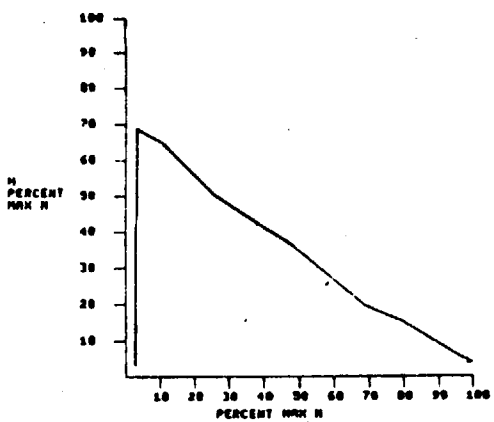
H6M7



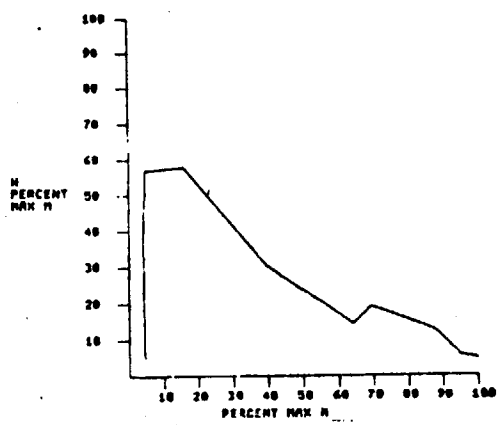
H6M1



H6P0



H6P2



H6P7

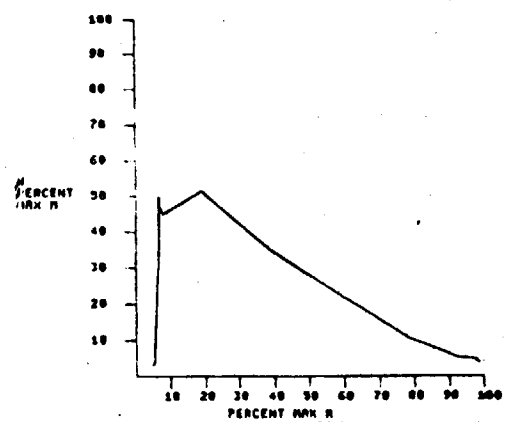


Fig. 2.4f

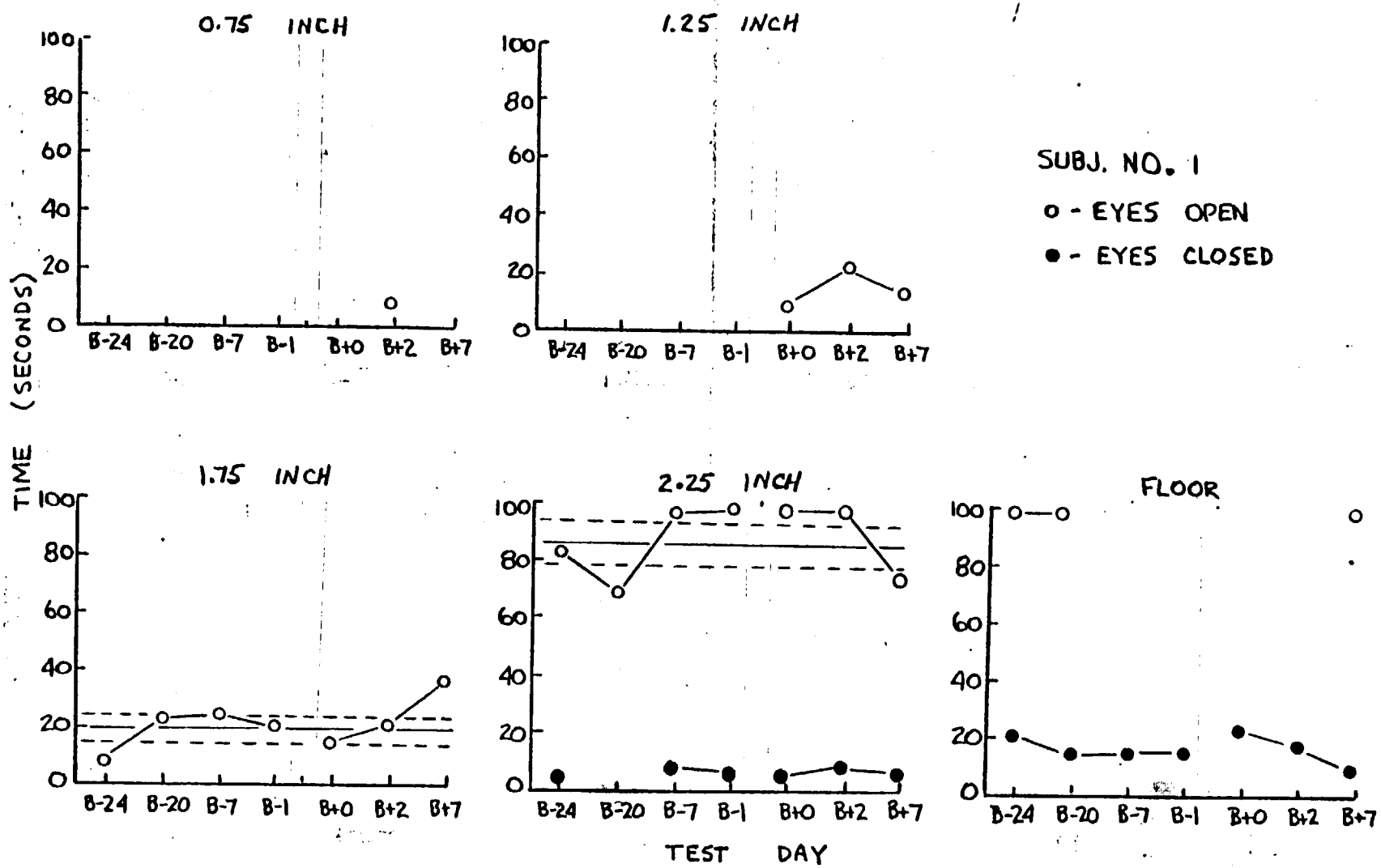

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
TIME (SECONDS)
100
80
60
40
20
0
B-24 B-20 B-7 B-1 B+0 B+2 B+7
TEST DAY
SUBJ. NO. 1
o - EYES OPEN
● - EYES CLOSED

FIG. 3.1

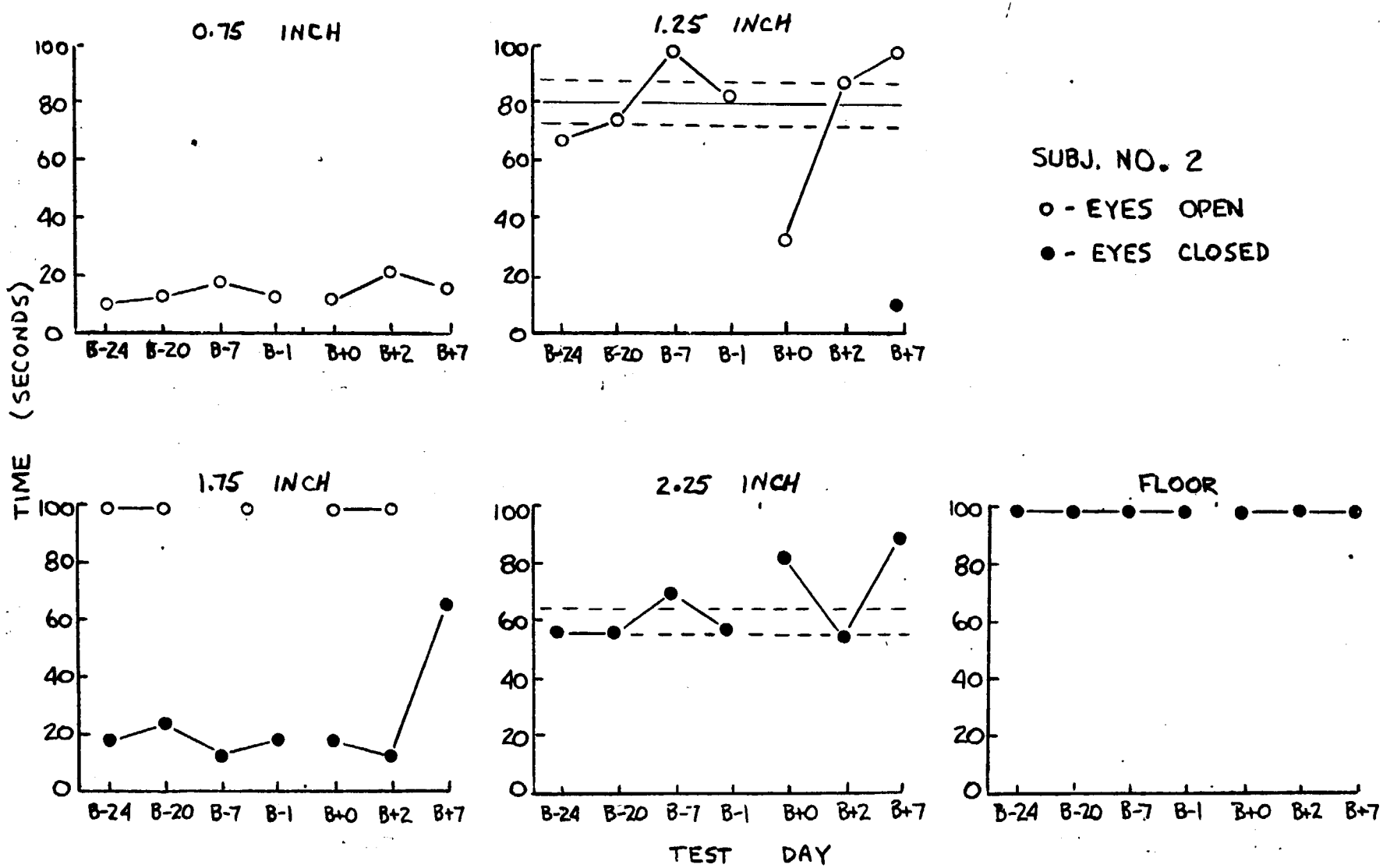

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
SUBJ. NO. 2
o - EYES OPEN
● - EYES CLOSED
TIME (SECONDS)
TEST DAY
B-24 B-20 B-7 B-1 B+0 B+2 B+7
0 20 40 60 80 100

FIG. 3.2

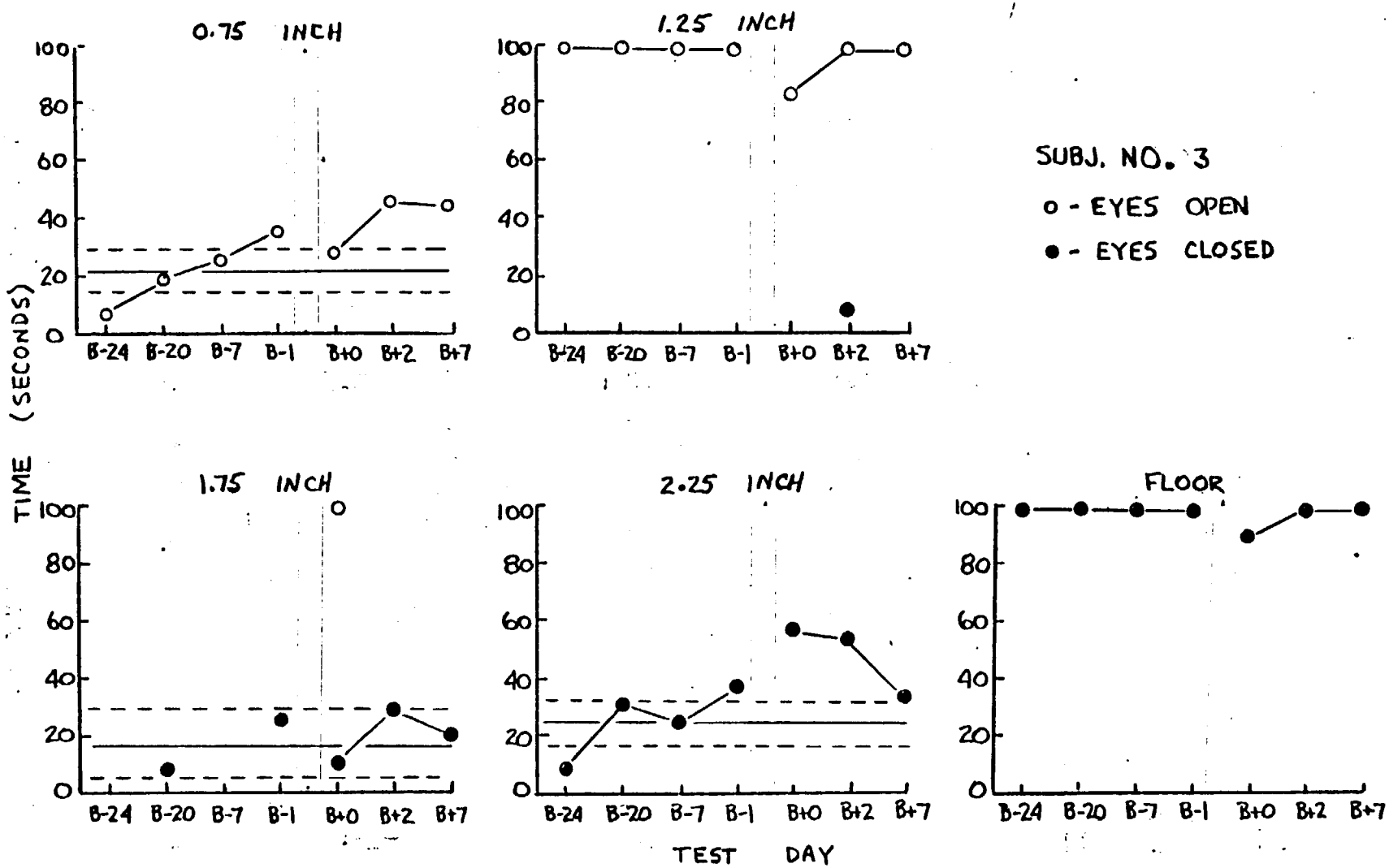

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
TIME (SECONDS)
100
80
60
40
20
0
B-24
B-20
B-7
B-1
B+0
B+2
B+7
TEST DAY
SUBJ. NO. 3
o - EYES OPEN
● - EYES CLOSED

FIG. 3.3

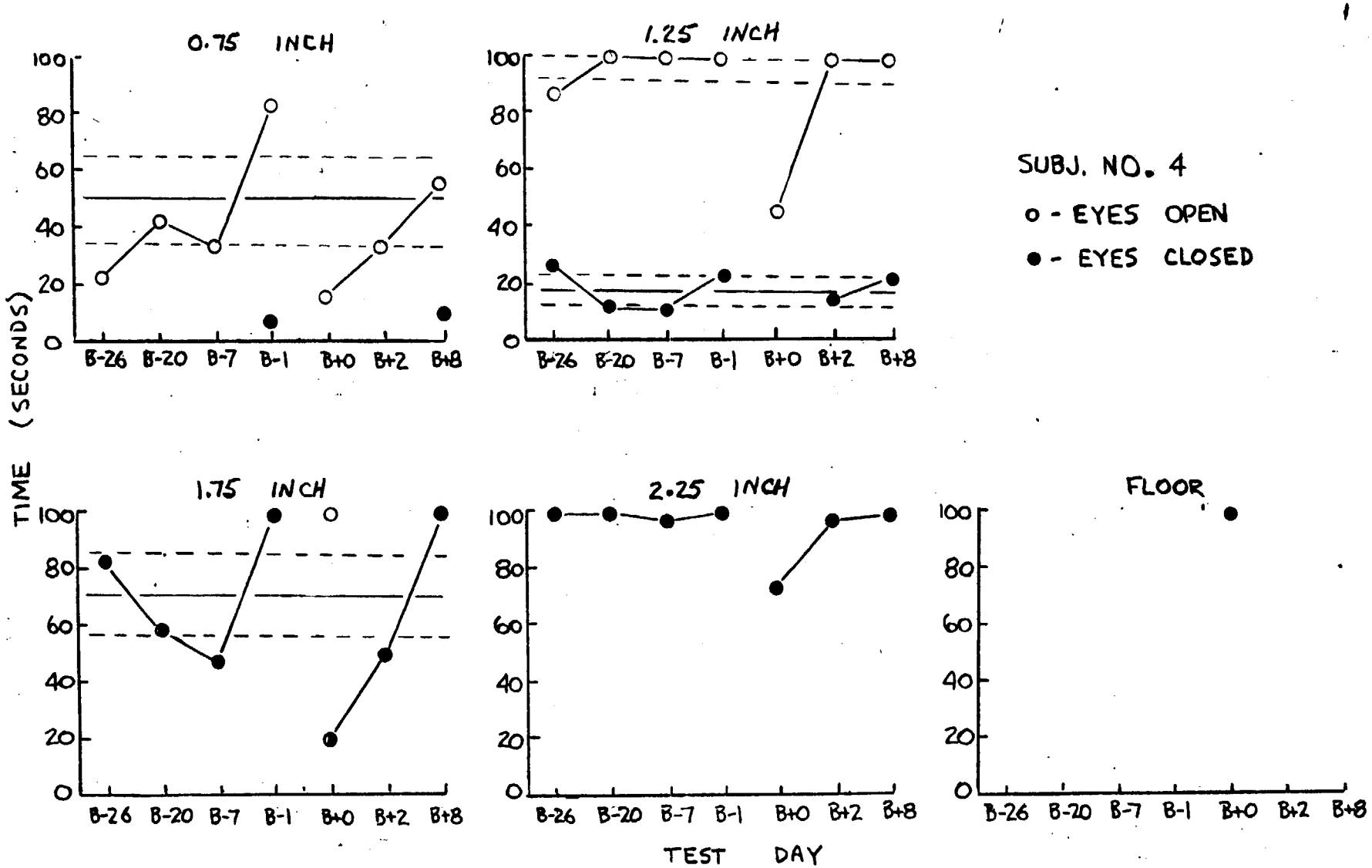

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
SUBJ. NO. 4
o - EYES OPEN
● - EYES CLOSED
TIME (SECONDS)
TEST DAY
0
20
40
60
80
100
B-26
B-20
B-7
B-1
B+0
B+2
B+8

FIG. 3.4

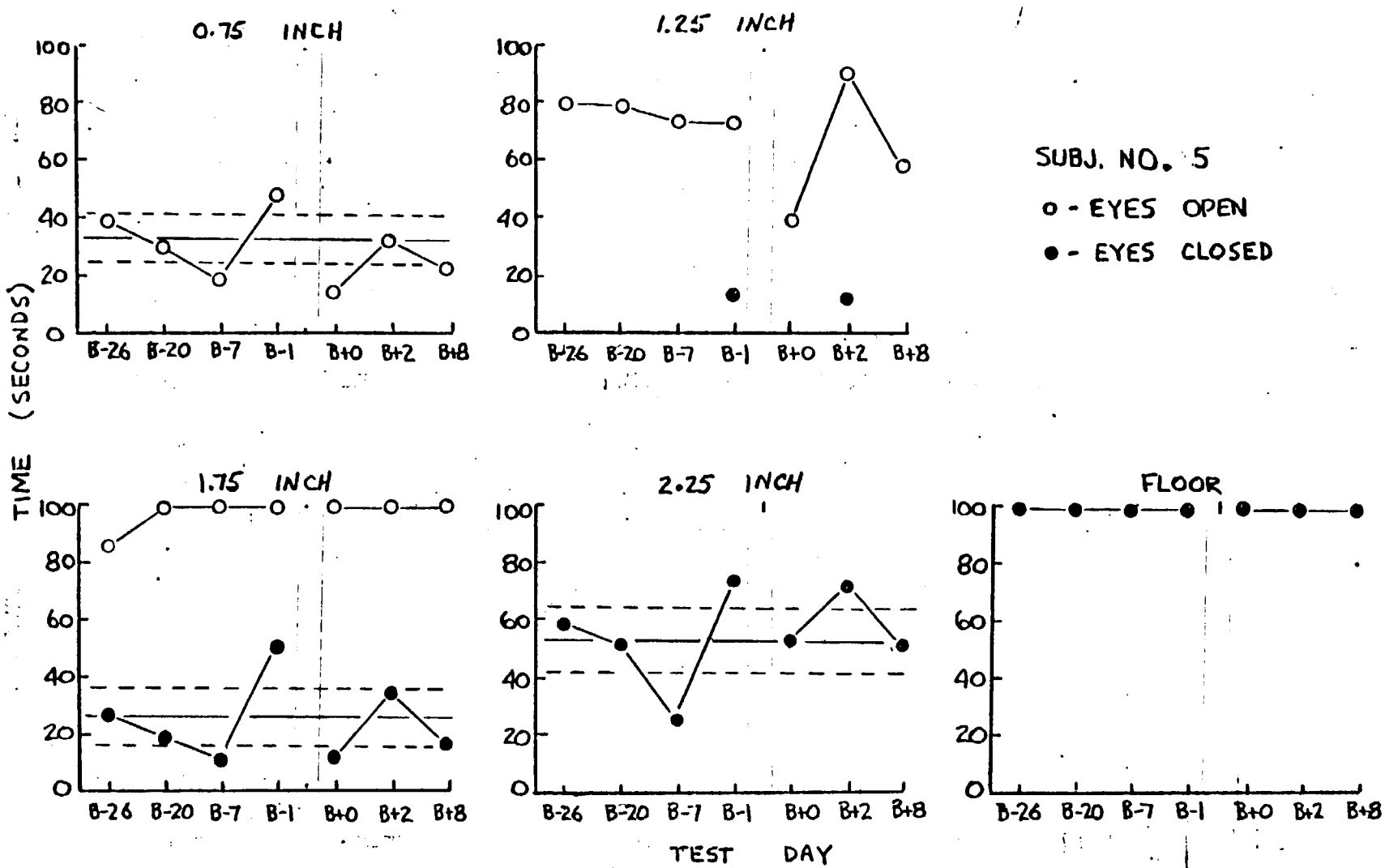

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
TIME (SECONDS)
TEST DAY
B-26 B-20 B-7 B-1 B+0 B+2 B+8
0 20 40 60 80 100
SUBJ. NO. 5
o - EYES OPEN
● - EYES CLOSED

FIG. 3.5

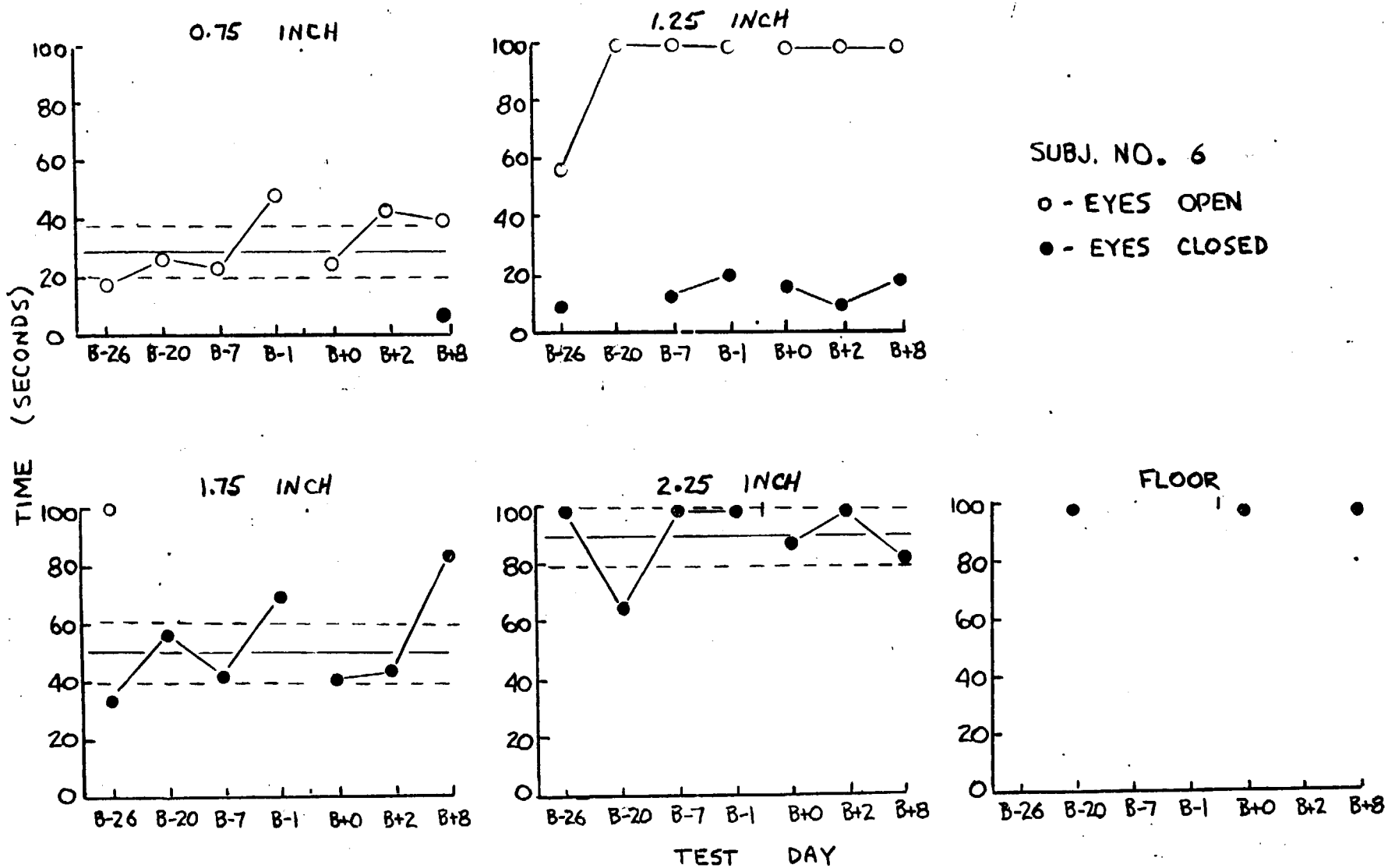
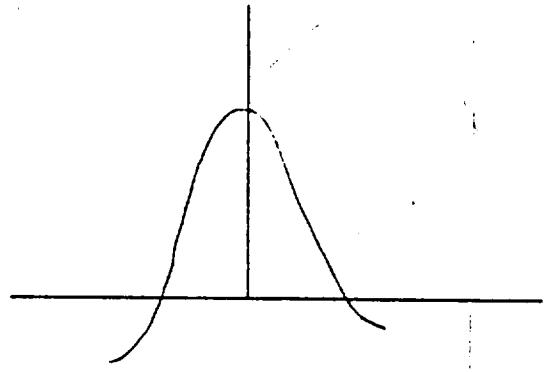
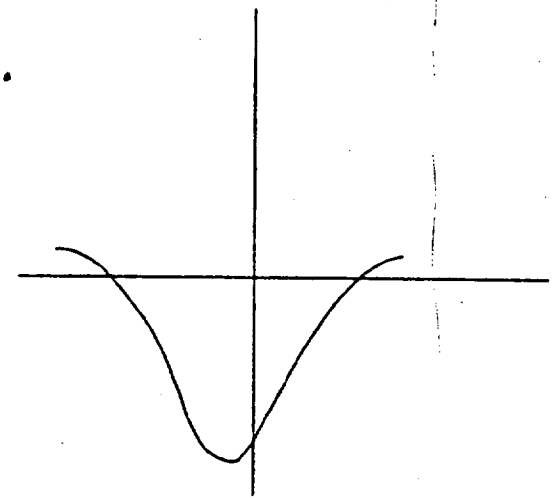

0.75 INCH
1.25 INCH
1.75 INCH
2.25 INCH
FLOOR
SUBJ. NO. 6
o - EYES OPEN
● - EYES CLOSED
TIME (SECONDS)
TEST DAY
B-26 B-20 B-7 B-1 B+0 B+2 B+8
0 20 40 60 80 100

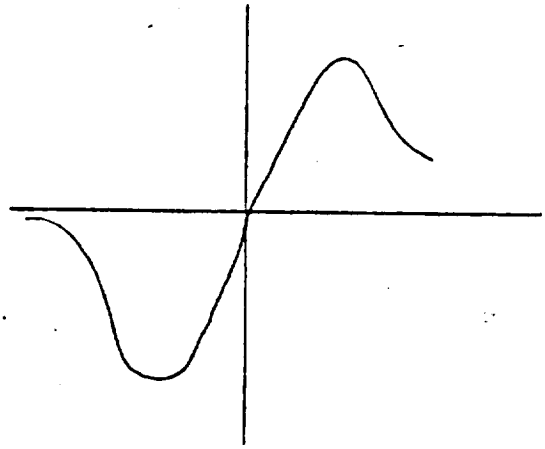
FIG. 5.6



POSITIVE



NEGATIVE



ALTERNATE

FIG. 3.7

EYES OPEN

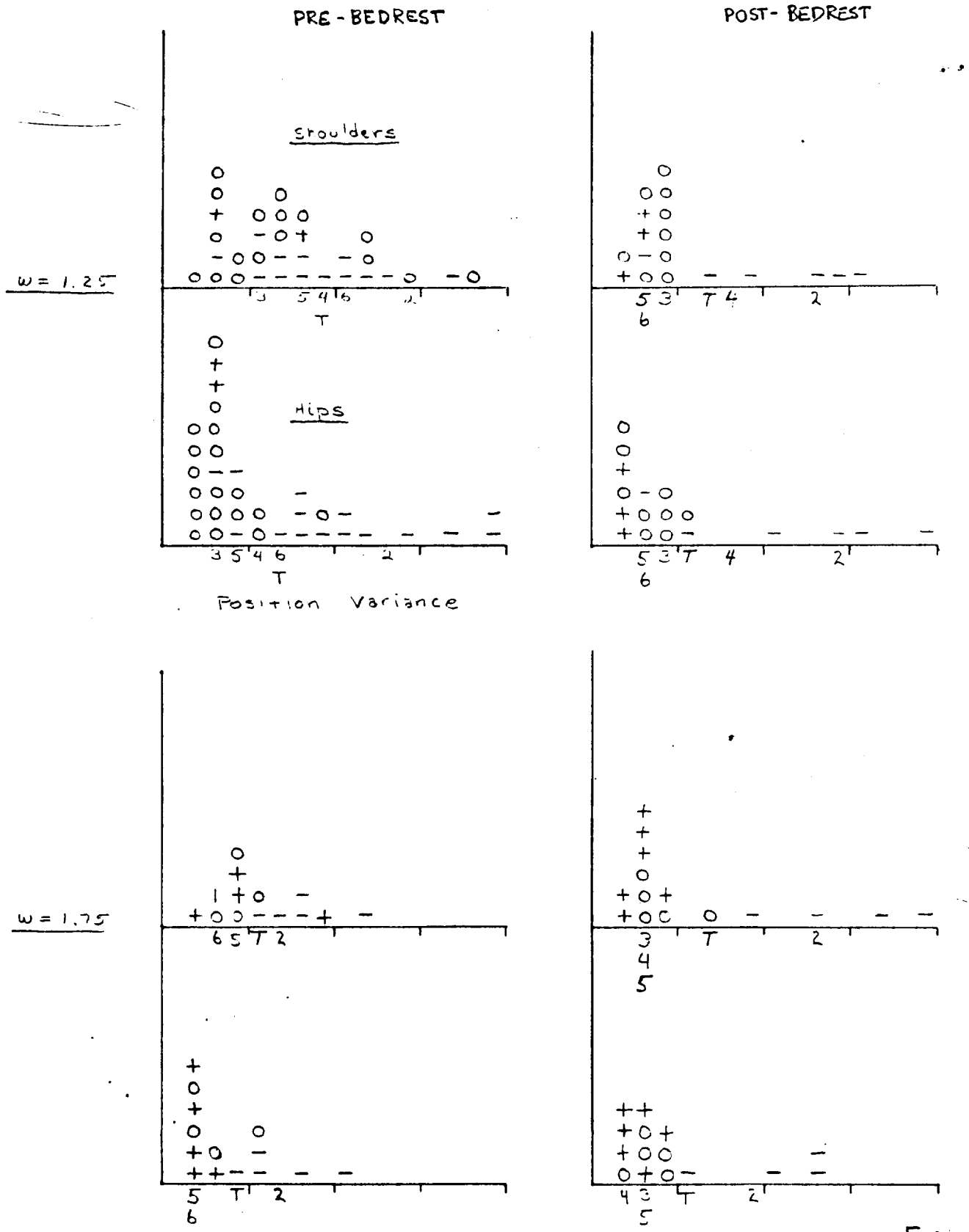


FIG. 3.8

EYES CLOSED

PRE- BEDREST | POST- BEDREST

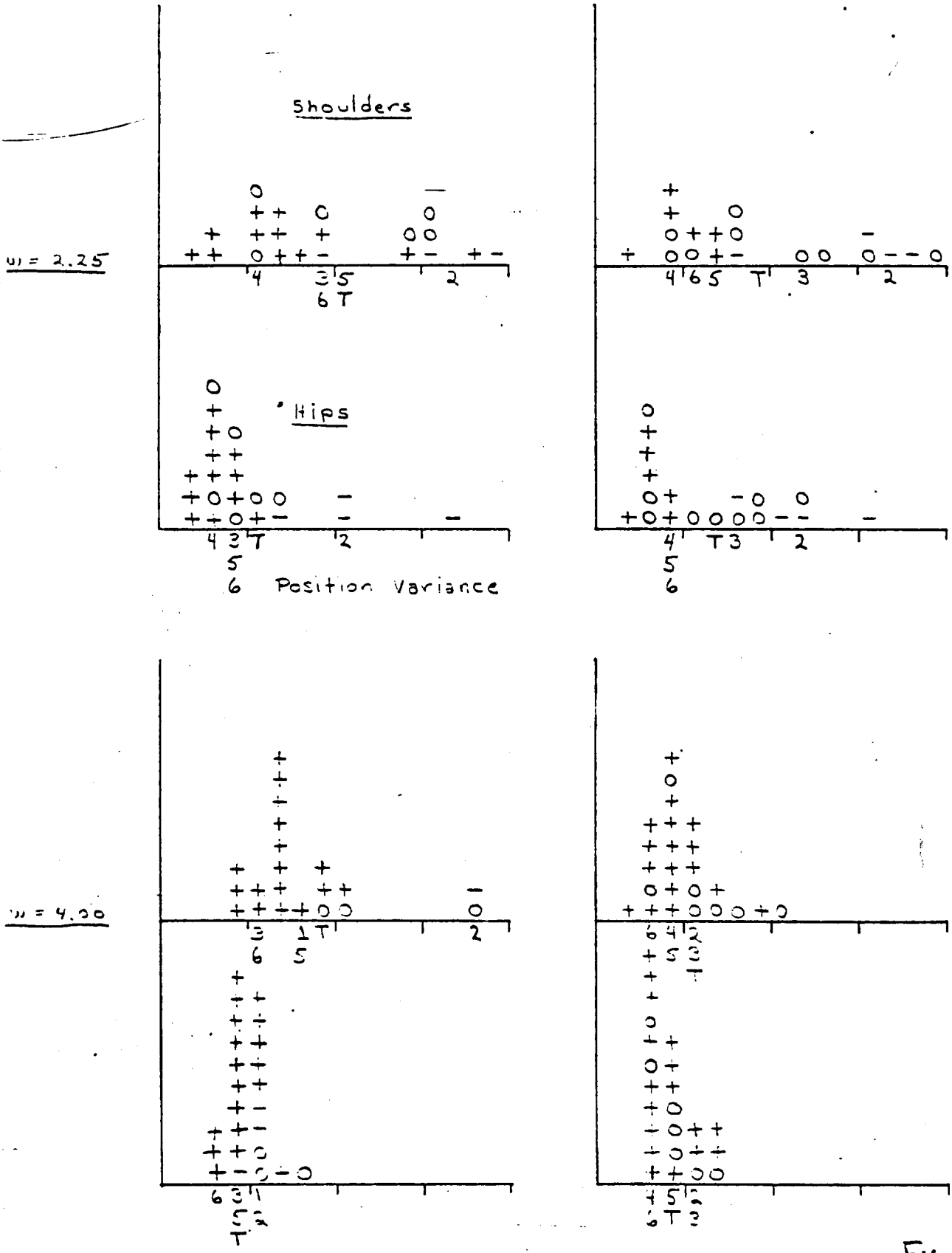


FIG. 3.9

Table 1.1

Diagnostic Categorization of Different Levels of Severity 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					Persistent Headache ≥ II
Central nervous system					Persistent Dizziness: 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.

Questionnaire data as well as his level of motion sickness manifested during the prerequisite indoctrination flight. This flight consisted of several parabolic maneuvers that generated typical transient periods of weightlessness preceded and followed by hypergravic (~ 2 g) periods of approximately 15 seconds' duration. During each maneuver the subject was restrained in an aircraft seat and his head was immobilized by an orthopedic collar device.

Testing under 1-g conditions involved repeating the sequence of five head movements (frontward, upright, pause, rightward, upright, pause, backward, upright, pause, leftward, upright, pause, frontward, and upright) executed over a 14-second period followed by 20 seconds in which the head was kept in the terminal upright position. This sequence of test events simulated those necessarily introduced by the subgravity and the normal/hypergravic phases of the parabolic maneuver, respectively, but there were certain procedural differences. In order to take full advantage of each maneuver, head movements were continued in the described clockwise sequence throughout the subgravity phase only, which allowed usually eight head movements in 0 g, 11 in 0.17 g, and 17 in 0.38 g per parabola. Allowing greater numbers of head movements in a series without pause would tend, in theory at least, to increase slightly the difficulty in preventing overshoot of the M IIA endpoint, but in practice, diagnosis and endpoint control were readily accomplished. The rest periods between head movement sequences, which occurred during the recovery phase of the parabola and the aircraft turnaround maneuvers, averaged approximately 40 seconds at all subgravity levels. This was about double the rest period of the ground-based test version, which was found to be long enough to allow symptoms to develop and be manifested but short enough to prevent any significant recovery from the symptoms. Inflight, symptom recovery during normal test conditions was undetectable and must have been small. When unusual flight requirements introduced long intratest delays, the data were rejected and the subject was retested on another day. The reliability of the method has been demonstrated by the similarity of results obtained in repeated tests of the same subject in this study and by a test-retest evaluation in a previous study (16).

The term "equivalent head movements" was introduced in this study to allow direct comparisons of the number of head movements executed at various g-levels and rotational velocities of the chair. The chair velocity often had to be changed from that used to calibrate a subject on the ground in order to fit the test situation as well as to elicit a proper growth rate of symptoms when an upward or downward shift in susceptibility occurred with a change in gravitational loading. The data were reduced to the common denominator of equivalent head movements that served as an inverse measure of susceptibility by utilizing vestibular stressor effect (E-factor) values associated with each of the test velocities (2.5 to 30.0 rpm) as determined in a previous study (17) and presented in Table II. The most frequently used rotational velocity for each individual served as the comparison base; equivalent numbers of head movements at other velocities were found by multiplying the number of head movements executed in reaching malaise IIA times the average stressor value of each head movement assigned to each of these velocities. Ten head movements at 5 rpm, for example, are calculated as approximately equivalent in terms of provocative effect to one head movement at 20 rpm.

TABLE 1.2

Pre- and Post-bedrest Motion Sickness Susceptibility Test Results for Subject 1.

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Signs/Symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec)
BR - 24	7.5 - CW	150	DIZ II, SAL I	3	N/A	--
BR - 20	10 - CCW	150	TMP II, DIZ II	2	N/A	30
BR - 14	12.5 - CW	150	TMP II, E.A. DIZ III	3	N/A	26
BR - 7	15 - CW	150	*DIZ III, TMP II	3	N/A	30
BR - 1	25 - CW	150	TMP II, *DIZ II	2	N/A	39
BR - +1	25 - CCW	150	HEAD FULLNESS	-	N/A	50
BR - +8	30 - CW	150	-	-	N/A	50

* Included feeling of head fullness

TABLE 1.3

Pre- and Post-bedrest Motion Sickness Susceptibility Test Results for Subject 2.

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Sign/symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec)
BR - 24	10 - CW	70	DIZ II, TMP II, SWT I, E.A.	5	7.4	-
BR - 20	10 - CCW	70	TMP II, DIZ II, SWT I, E.A.	5	7.4	15
BR - 14	10 - CW	35	DIZ II, E.A., SAL I, TMP II	5	3.7	20
BR - 7	10 - CCW	35	TMP II, DIZ III, SWT I, E.D.	6	3.7	19
BR + 1	10 - CCW	45	TMP II, DIZ III, E.D.	5	4.7	30
BR + 8	10 - CW	25	E.A., TMP II, SWT I, SAL I, DIZ III.	8	2.6	22

TABLE 1.4

Pre- and Post-bedrest Motion Sickness Susceptibility Test Results for Subject 3.

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Signs/Symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec)
BR - 24	10 - CW	150	DIZ II	1	N/A	-
BR - 20	12.5 - CCW	40	TMP II, SWT II	5	6.0	20
BR - 7	12.5 - CW	60	TMP II, SWT II	5	9.0	25
BR - 1	12.5 - CCW	140	E.A., DIZ II, SWT I, TMP II	5	21.0	25
BR + 1	12.5 - CW	50	HDAC, TMP II, *E.D., SWT I	6	7.5	27
BR + 8	12.5 - CCW	50	DIZ II, TMP II, NSA I	6	7.5	25

* Nausea I possibly present at end of test

TABLE 1.5

Pre- and Post-bedrest Motion Sickness Susceptibility Test Results for Subject 4.

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Signs/Symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec)
BR - 26	10 - CW	150	TMP II, E.D.	3	N/A	-
BR - 20	12.5 - CCW	75	TMP II, PAL I, E.D.	5	11.3	60
BR - 14	12.5 - CW	150	TMP II, E.D.	3	N/A	90
BR - 7	15 - CCW	45	SWT I, NSA I	6	9.2	60
BR + 1	15 - CW	35	TMP II, E.D., SWT I	5	7.2	55
BR + 7	15 - CCW	50	TMP II, E.D., SWT I	5	10.3	70

TABLE 1.6

Pre- and Post-bedrest Motion Sickness Susceptibility Test Results for Subject 5.

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Signs/Symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec).
BR - 26	10 - CW	85	TMP II, SWT I, SAL I	5	8.9	25
BR-- 20	10 - CCW	85	TMP III, SAL I, DIZ II, SWT I	6	8.9	20
BR - 14	10 - CW	95	DIZ III, TMP III, SAL I	5	10.0	35
BR - 7	10 - CCW	70	TMP II, DIZ III, SAL I	5	7.4	40
BR + 1	10 - CW	40	DIZ II, TMP II, SWT I, SAL I	6	4.2	37
BR + 7	10 - CCW	55	SAL I, DIZ II, TMP III, EA	5	5.8	28

TABLE 1.7

Pre - and Post-bedrest Motion Sickness susceptibility test Results for Subject 6

Test Day	Chair Velocity (RPM)/Direction	Head Movements	Signs/Symptomatology	Total Symptom Points	CSSI	After-Sensation Duration (Sec)
BR - 26	10 - CW	40	TMP II, SWT I, * E.D.	5	4.2	-
BR - 20	7.5 - CCW	115	TMP II, DIZ II, NSA I	6	7.4	45
BR - 14	10 - CW	55	TMP II, E.A., DIZ II, SWT I	5	5.8	30
BR - 7	10 - CCW	45	DIZ II, TMP II, E.A., SWT I	6	4.7	22
BR - + 1	10 - CW	40	DIZ II, TMP II, NSA I (PAL I)	6	4.2	28
BR - + 7	10 - CCW	25	DIZ II, TMP II, * E.D. (PAL I)	6	2.6	35

* Nausea I possibly present at end of test

	Test Day		H 1	H 2	H 3
Group A	Br	-8	0.746*	0,483	0.223
		-7	1.274	0.895	0.189
		-1	1.001	0.759	1.784
		$\bar{x}$	0.873	0.712	0.732
	BR	+0	0.306	0.712	1.156
		+2	0.411	0.737	0.467
		+8	0.402	0.816	1.111
		$\bar{x}$	0.373	0.755	0.911

	Test Day		H 4	H 5	H 6
Group B	BR	-14	0.998	0.797	0.526
		-7	3.624*	0.811	0.589
		-1	1.127	0.840	0.440
		$\bar{x}$	1.063	0.816	0.518
	BR	+0	0.858	0.869	0.693
		+2	0.709	0.696	0.579
		+7	0.692	0.809	0.514
		$\bar{x}$	0.753	0.791	0.595

TABLE 2-1 Peak values of H amplitude expressed as a percentage of Max M

* These values are excluded from the computations.

	TEST CONDITION	
SUBJECT	PRE-BEDREST	POST-BEDREST
H 1	1.138	0.373
H 2	0.712	0.755
H 3	0.732	0.911
H 4	1.063	0.753
H 5	0.816	0.518
H 6	0.791	0.575
MEAN	0.875	0.648
SD	0.180	0.195

TABLE 2-2 Summary of peak values of H amplitude for pre- and post- bedrest data.

	Test Day		H 1	H 2	H 3
Group A	BR	-8	+0.215*	-0.345	+0.158
		-7	-1.184	-0.789	+0.058
		-1	-0.339	-0.719	+1.725
		$\bar{x}$	-0.762	-0.618	+0.647
	BR	+0	-0.254	-0.583	+1.026
		+2	-0.418	-0.719	+0.405
		+8	-0.237	-0.780	+0.963
		$\bar{x}$	-0.303	-0.694	+0.798

	Test Day		H 4	H 5	H 6
Group B	BR	-14	-0.864	-0.824	-0.521
		-7	+1.941*	-0.835	-0.581
		-1	-0.807	-0.888	-0.449
		$\bar{x}$	-0.836	-0.849	-0.524
	BR	+0	-0.339	-0.913	-0.681
		+2	-0.686	-0.701	-0.557
		+7	-0.632	-0.838	-0.556
		$\bar{x}$	-0.552	-0.817	-0.598

TABLE 2-3 Slopes obtained from regression analysis of H on M for each subject and day.

* These values are excluded from the computations.

	Test Day		H 1	H 2	H 3
Group A	Br	-8	+.853*	-.979	+.949
		-7	-.152	-.992	+.546
		-1	-.986	-.997	+.984
		$\bar{x}$	-.569*	-.989	+.826
	Br	+0	-.808	-.708	+.961
		+2	-.997	-.996	+.993
		+8	-.529	-.997	+.980
		$\bar{x}$	-.778	-.900	+.978

	Test Day		H 4	H 5	H 6
Group B	Br	-14	+.997	-.994	-.997
		-7	+.412*	+.998	-.986
		-1	-.997	-.996	-.989
		$\bar{x}$	-.997	-.996	-.991
		+0	-.476	-.997	-.997
		+2	-.997	-.995	-.960
		+7	-.929	-.986	-.990
		$\bar{x}$	-.801	-.993	-.982

TABLE 2-4 Correlations obtained from regression analyses of H on M.

* These values are excluded from the computations.

TABLE 3.1
SUMMERY OF CAMERA DATA

SUBJECT 1

PRE-BEDREST DAY 24

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	255	88	ALT	1.0
OPEN	2.25	170	91	ALT	0.7
CLOSED	4.00	197	157	ALT	0.9
CLOSED	4.00	147	71	POS	0.0

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	182	65	NEG	-0.1
OPEN	4.00	101	49	ALT	1.0
OPEN	4.00	86	51	POS	0.1

PRE-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	137	50	ALT	1.1
OPEN	2.25	249	160	ALT	1.7

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	161	110	ALT	1.1
OPEN	2.25	91	53	ALT	0.8

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	199	146	NEG	-0.1
OPEN	2.25	236	187	NEG	-0.1

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	2.25	170	80	NEG	-0.1
OPEN	2.25	181	131	NEG	-0.1
OPEN	2.25	351	242	NEG	-0.2

POST-BEDREST DAY 8

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	4.00	79	47	ALT	0.9

SUBJECT 2

PRE-BEDREST DAY 24

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	659	377	NEG	-0.1
OPEN	1.75	163	120	NEG	-0.3
OPEN	1.75	137	117	NEG	-0.3
CLOSED	2.25	322	222	NEG	-0.3
CLOSED	4.00	415	108	ALT	1.4
CLOSED	4.00	517	94	NEG	-0.4

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	244	287	NEG	-0.2
OPEN	1.75	98	123	ALT	2.8
OPEN	1.75	111	85	NEG	-1.4
CLOSED	2.25	199	135	NEG	-1.5
CLOSED	2.25	309	92	ALT	2.1
CLOSED	4.00	363	122	ALT	1.8

PRE-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	221	188	NEG	-0.3
OPEN	1.25	363	178	ALT	1.8
CLOSED	2.25	376	224	NEG	-0.2
CLOSED	4.00	353	119	NEG	-0.7
CLOSED	4.00	222	119	ALT	1.0

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	129	374	NEG	-0.1
OPEN	1.25	132	128	NEG	-0.2
OPEN	1.75	151	158	NEG	-0.1
OPEN	1.75	226	202	NEG	-0.3
CLOSED	2.25	460	332	NEG	-0.2
CLOSED	4.00	444	122	POS	0.4
CLOSED	4.00	186	90	POS	0.5

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.75	252	223	NEG	-0.1
OPEN	1.75	342	259	NEG	-0.3
CLOSED	2.25	350	249	NEG	-0.2
CLOSED	2.25	307	236	ALT	1.7
CLOSED	4.00	206	138	ALT	1.4
CLOSED	4.00	33	88	POS	0.2

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	271	287	NEG	-0.1
OPEN	1.75	176	117	NEG	-0.2
OPEN	1.75	376	254	NEG	-0.3
OPEN	1.75	128	97	ALT	1.7
CLOSED	2.25	345	314	NEG	-0.2
CLOSED	4.00	118	117	ALT	1.0
CLOSED	4.00	125	96	ALT	1.7

POST-BEDREST DAY 8

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	317	392	NEG	-0.2
OPEN	1.25	194	206	NEG	-0.1
OPEN	2.25	255	208	NEG	-0.2
CLOSED	2.25	390	150	ALT	0.8
CLOSED	2.25	307	203	NEG	-0.2
CLOSED	4.00	121	96	ALT	1.4

SUBJECT 3

PRE-BEDREST DAY 24

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	141	73	ALT	1.9
OPEN	1.25	202	97	NEG	-1.3
CLOSED	4.00	127	76	POS	0.0
CLOSED	4.00	152	92	POS	0.0
CLOSED	1.25	73	46	ALT	1.7

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	95	37	ALT	2.0
CLOSED	4.00	132	91	POS	0.0
CLOSED	4.00	130	107	POS	0.0

PRE-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	128	63	ALT	2.5
OPEN	1.25	140	48	ALT	2.0
CLOSED	4.00	132	117	POS	0.1
CLOSED	4.00	107	84	POS	0.0

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	62	60	ALT	1.1
OPEN	1.25	58	63	NEG	-0.2
OPEN	1.25	84	73	ALT	1.9
CLOSED	2.25	197	96	POS	0.4
CLOSED	4.00	79	89	POS	0.0
CLOSED	4.00	84	104	POS	0.0

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	53	50	ALT	2.0
OPEN	1.25	79	72	ALT	1.5
OPEN	1.75	44	57	POS	0.0
OPEN	1.75	67	67	ALT	0.9
CLOSED	2.25	262	149	ALT	2.2
CLOSED	4.00	104	121	POS	-0.1
CLOSED	4.00	158	90	ALT	1.3

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	91	82	ALT	1.5
OPEN	1.25	82	85	ALT	1.0
CLOSED	2.25	227	178	ALT	0.9
CLOSED	4.00	80	67	POS	0.1
CLOSED	4.00	78	84	POS	0.0

POST-BEDREST DAY 8

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	62	70	NEG	-0.4
OPEN	1.25	130	112	NEG	-1.5
CLOSED	4.00	120	104	POS	0.1
CLOSED	4.00	188	139	POS	0.0

SUBJECT 4

PRE-BEDREST DAY 26

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	249	52	ALT	1.5
OPEN	1.25	494	82	ALT	1.3
OPEN	1.25	230	44	ALT	0.9
CLOSED	2.25	152	89	POS	0.2
CLOSED	2.25	137	72	POS	0.5
CLOSED	1.75	78	69	POS	0.1
CLOSED	1.75	389	135	NEG	-0.2

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	168	151	NEG	-0.4
OPEN	2.25	137	86	POS	0.0
CLOSED	2.25	116	64	ALT	1.9
CLOSED	2.25	113	76	POS	-1.5
CLOSED	1.75	128	61	POS	0.1

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	48	55	ALT	1.3
OPEN	1.25	56	79	ALT	1.4
OPEN	0.75	151	231	NEG	-0.1
OPEN	0.75	100	163	NEG	-0.1
CLOSED	2.25	62	49	POS	0.1
CLOSED	2.25	48	41	POS	0.0
CLOSED	1.75	49	37	POS	0.1
CLOSED	1.75	88	66	POS	0.4

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.75	71	51	ALT	1.5
OPEN	1.75	63	45	ALT	1.6
CLOSED	2.25	157	171	NEG	-0.3
CLOSED	4.00	98	62	POS	0.3
CLOSED	4.00	76	64	POS	0.1

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	41	29	POS	0.0
CLOSED	2.25	94	54	ALT	1.8
CLOSED	2.25	93	56	ALT	1.9
CLOSED	1.75	129	107	ALT	1.7

POST-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	0.75	283	320	NEG	-0.1
CLOSED	2.25	89	58	POS	0.5
CLOSED	2.25	47	49	POS	0.2
CLOSED	1.75	41	30	ALT	1.2
CLOSED	1.75	53	55	ALT	1.2

SUBJECT 5

PRE-BEDREST DAY 26

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	299	105	ALT	2.3
OPEN	1.25	118	48	ALT	1.1
OPEN	1.75	90	29	POS	0.0
OPEN	1.75	178	65	POS	0.1
OPEN	0.75	273	88	NEG	-0.3
CLOSED	2.25	356	109	POS	0.1
CLOSED	2.25	135	61	POS	0.0
CLOSED	4.00	97	55	POS	0.1
CLOSED	4.00	208	127	POS	0.1

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	150	54	POS	0.5
OPEN	1.25	70	55	POS	0.0
OPEN	1.75	76	43	POS	0.0
OPEN	1.75	112	37	ALT	1.3
CLOSED	2.25	287	72	POS	0.0
CLOSED	4.00	193	121	POS	0.0

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	0.75	123	202	NEG	-0.2
OPEN	1.75	80	65	ALT	1.0
OPEN	1.75	40	29	POS	0.2
CLOSED	2.25	108	78	POS	0.1
CLOSED	4.00	140	98	POS	0.1
CLOSED	4.00	136	87	POS	0.1

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	89	103	ALT	1.6
OPEN	1.75	83	76	ALT	1.5
OPEN	1.75	60	43	POS	0.2
CLOSED	2.25	128	95	POS	0.7
CLOSED	4.00	84	56	POS	0.2
CLOSED	4.00	89	60	POS	0.0
CLOSED	4.00	91	52	ALT	1.4

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	54	49	POS	0.2
OPEN	1.25	39	33	ALT	1.3
OPEN	1.75	45	44	POS	0.0
OPEN	1.75	64	54	POS	0.0
OPEN	1.75	80	77	POS	0.0
OPEN	2.25	148	119	POS	0.0
CLOSED	1.75	86	96	POS	0.2
CLOSED	4.00	149	143	POS	0.0
CLOSED	4.00	68	71	POS	0.0

POST-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	64	43	POS	0.2
OPEN	1.75	59	37	POS	0.2
CLOSED	4.00	91	77	POS	0.1
CLOSED	4.00	105	80	POS	0.1

SUBJECT 6

PRE-BEDREST DAY 26

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	153	124	ALT	1.2
OPEN	1.75	73	41	ALT	1.6
OPEN	1.75	72	35	POS	0.0
OPEN	2.25	116	57	POS	0.0
CLOSED	2.25	149	65	POS	0.1
CLOSED	1.75	354	208	NEG	-0.7

PRE-BEDREST DAY 20

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	106	45	ALT	2.1
OPEN	1.25	345	160	NEG	-0.4
OPEN	1.25	496	325	NEG	-0.2
CLOSED	2.25	280	67	ALT	1.4
CLOSED	2.25	302	118	ALT	1.3
CLOSED	1.75	461	291	NEG	-0.2
CLOSED	4.00	103	71	POS	0.0
CLOSED	4.00	127	76	POS	0.0

PRE-BEDREST DAY 1

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	51	37	ALT	2.0
OPEN	1.25	71	62	ALT	1.5
OPEN	0.75	192	212	NEG	-0.1
CLOSED	2.25	118	83	ALT	0.9
CLOSED	2.25	186	145	ALT	1.8
CLOSED	2.25	71	44	POS	0.1
CLOSED	1.75	218	161	NEG	-0.3
CLOSED	1.75	230	221	NEG	-0.3

POST-BEDREST DAY 0

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	76	86	ALT	1.1
CLOSED	2.25	167	110	ALT	1.3
CLOSED	2.25	104	176	ALT	1.3
CLOSED	4.00	74	59	ALT	1.2
CLOSED	4.00	67	69	POS	-0.1

POST-BEDREST DAY 2

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	60	48	ALT	1.9
CLOSED	2.25	94	54	POS	0.3
CLOSED	2.25	100	54	POS	0.3
CLOSED	1.75	138	104	ALT	1.4

POST-BEDREST DAY 7

CONDITIONS		S. D.		XCORR	
EYES	RAIL WIDTH	SHOULDERS	HIPS	TYPE	TIME
OPEN	1.25	80	45	ALT	2.9
CLOSED	2.25	129	83	POS	0.3
CLOSED	2.25	153	56	ALT	2.3
CLOSED	1.75	192	163	NEG	-0.2
CLOSED	1.75	162	130	ALT	1.6
CLOSED	4.00	64	74	POS	0.0
CLOSED	4.00	74	71	POS	0.0

TABLE 3.2

EXPERIMENTAL CONDITIONS BY SUBJECT

SUBJECT 1

	PRE EYES		POST EYES	
	OPEN	CLOSED	OPEN	CLOSED
W 1.25	0	0	0	0
I 1.75	0	0	0	0
D 2.25	7	0	5	0
T 4.00	2	2	1	0
H				

SUBJECT 2

	PRE EYES		POST EYES	
	OPEN	CLOSED	OPEN	CLOSED
W 1.25	6	0	3	0
I 1.75	6	0	5	0
D 2.25	0	5	1	5
T 4.00	0	7	0	5
H				

SUBJECT 3

	PRE EYES		POST EYES	
	OPEN	CLOSED	OPEN	CLOSED
W 1.25	8	1	6	0
I 1.75	0	0	2	0
D 2.25	0	1	0	2
T 4.00	0	8	0	6
H				

SUBJECT 4

	PRE EYES		POST EYES	
	OPEN	CLOSED	OPEN	CLOSED
W 1.25	8	0	2	0
I 1.75	0	5	2	3
D 2.25	1	6	0	5
T 4.00	0	0	0	2
H				

SUBJECT 5

	PRE EYES		POST EYES	
	OPEN	CLOSED	OPEN	CLOSED
W 1.25	6	0	4	0
I 1.75	6	0	6	1
D 2.25	0	4	1	1
T 4.00	0	5	0	7
H				

SUBJECT 6

	PRE EYES OPEN	PRE EYES CLOSED	POST EYES OPEN	POST EYES CLOSED
W 1.25	7	0	3	0
I 1.75	2	4	0	3
D 2.25	1	6	0	6
T 4.00	0	2	0	4
H				

SUMMERY OF STIMULUS CONDITIONS FOR ALL SUBJECTS

	PRE EYES OPEN	PRE EYES CLOSED	POST EYES OPEN	POST EYES CLOSED
W 1.25	35	1	18	0
I 1.75	14	9	15	7
D 2.25	9	22	7	19
T 4.00	2	24	1	24
H				

APPENDIX A

Special Labyrinthine Function Tests Performed On Subject Number 1 (H. Lee)

As previously indicated the vestibular function tests performed pre- and post-bedrest indicated that subject 1 in the 28-day bedrest study was almost completely insusceptible to experimentally induced motion sickness and he displayed abnormally poor balancing ability on the postural equilibrium test rails. These findings suggested some type of dysfunction of the vestibular labyrinth. In order to better define the nature of the presumed abnormality three special tests of labyrinthine function were performed on this individual 15 days following termination of bedrest. These included audiometry, cupulometry and caloric irrigation. The latter two are basically tests of semi-circular canal function. Each test was performed one time. A brief description of the procedures and findings from each test follows.

AUDIOGRAM

Procedure

A sweep-frequency audiogram, using a Grason-Stadler diagnostic audiometer (Model 1701), was performed according to standard audiometric test procedures. The test tone frequency ranged from 100 Hz to 10K Hz. The rate of frequency change of the test tone was 2 octaves per minute; the intensity rate of change was 5 db per second. During this test procedure the subject was isolated in an IAC (Model 1203) audiometric room.

Results

Figure 1 is a reproduction of the obtained audiogram. The left ear record is represented by the trace with open circles at the turning points. The audiogram indicates a slight left ear hearing loss in the mid and high frequency range and a slight right ear hearing loss in the high frequency range. These losses, however, are only marginally clinically significant.

CUPULOGRAM

Procedure

Silver/silver chloride recording electrodes were placed at the outer canthus of each eye and a ground electrode was located in a medial position (with respect to the eye electrodes) on the forehead. Because the recording of nystagmus is enhanced with the eyes dark adapted, the subject was required to wear goggles with red lenses for approximately 30 minutes before testing began.

Following dark adaptation the subject was restrained in a modified Skylab M-131 rotating chair. Restraint was accomplished with a custom fitted bite that was attached to the chair so as to maintain the head in the proper orientation of 30^0 downward tilt (bringing the horizontal semicircular canals perpendicular to the axis of rotation). Following eye movement calibration, light tight goggles which allowed the subject to open his eyes without irritation, were then exchanged for the red goggles. The desired velocity was selected and the chair placed into motion. The subject was required to keep his eyes open during this phase, fixate straight ahead and maintain alertness. Once the desired terminal velocity was reached the subject was maintained at this speed until all perrotary

nystagmus had ceased and no report of angular motion could be elicited (usually about 60 sec). When these conditions were achieved the chair was brought quickly to a stop (in 1-1/2 sec) and post-rotary nystagmus and the sensation of after-rotation were recorded.

Terminal velocities of 5, 10, 15, 20, 25, and 30 RPM were used. Testing began with the lowest velocity and progress to the highest. A rest period of 2-1/2 to 5 minutes was instituted between each run to ensure that all effects from the previous exposure had run their course. Testing was restricted to clockwise rotation. Total time required for this test procedure was approximately 1 hour.

Results

The findings from this test are summarized in figure 2 where cupulograms are plotted for each of four measurement parameters. These include a) duration of after sensation of rotation, b) duration of post-rotary nystagmus, c) maximum velocity of post-rotary nystagmus and d) maximum frequency of post-rotary nystagmus. In each case the obtained values are plotted as a function of the chair velocity before deceleration. The computed value of π/Δ, which indicates the slope of the cupulogram, is also given.

Several observations can be made with the aid of figure 2. First, the duration, maximum frequency and maximum velocity of post-rotary nystagmus increased with increasing chair terminal velocities. That is, the cupulograms are linear and the slopes are positive. Such positive slopes are to be expected. Also, the absolute values for post-rotary nystagmus duration, velocity and frequency are within normally expected limits although the

duration values may be considered low-normal. The most striking finding is the slightly negative slope for the after sensation duration cupulogram. Previous studies using cupulometric techniques suggest that differences in slopes for post-rotary nystagmus duration and after sensation duration cupulograms may be due to differential effects in the central nervous system. Furthermore, these studies indicate that the slopes for these two type of cupulograms tend to be more alike in individuals susceptible to motion sickness than in people who are not, suggesting that those who suffer from motion sickness are not able to modify the effects of canal stimulation by central control.

Conversely, dissimilar cupulogram slopes suggest lower susceptibility to motion sickness. Subject 1 may be a case in point.

CALORIC IRRIGATION

Procedure

The caloric irrigation test followed the standard Fitzgerald-Hallpike procedure with the exception that air rather than water was used to irrigate the subjects ears. Following an otoscopic examination and application of the nystagmus recording electrodes the subject was placed in a patient examination chair and his eye movements were calibrated. The subject was then blindfolded and the chair tilted to 30^0 from horizontal thus placing the lateral semi-circular canals parallel to earth gravity. With the subject lying still eye movements were recorded for approximately 2 minutes to monitor for spontaneous nystagmus. Irrigation then commenced with air at 24^0 C being presented first to the left ear and then to the right ear.

The same sequence was used to irrigate the left and right ears with air at a temperature of 50^0 C. In each case the duration of irrigation was 40 seconds. A minimum 4 minute rest period was imposed following each irrigation. During and immediately following each irrigation (i.e. while nystagmus was being recorded) the subject was required to keep his eyes open under the blindfold and maintain mental alertness. At prescribed times after each irrigation the subject was required to describe any sensations of movement induced by the irrigation. The total time required for this test procedure was approximately 35 minutes.

Results

Analysis and interpretation of these nystagmus data were difficult because of the unusually large amount of high frequency, low amplitude nystagmus present in the graphic recordings. Also, the onset and termination of nystagmus was not well defined. Never the less, nystagmus was clearly produced by all of the caloric irrigations.

A summary of the caloric irrigation data appears in Table I. Parameters for which values are given are nystagmus lag, maximum velocity, maximum frequency and duration. Also,computed values for relative excitability and directional preponderance are given.

Visual inspection of Table I indicates that on the average, nystagmus velocity, frequency and duration was greater with right ear irrigations. This observation corresponds with the computation of relative excitability which indicates that the right ear was 24.6% more excitable (i.e. more responsive) than the left ear. The subject reported that sensations of turning and mild dizziness (these are normal responses associated with caloric irrigation) were slightly greater following irrigations of the

right ear. However, in general this individual experienced fewer subjective sensations than are typically reported with irrigations of the type used. Also, a clinically insignificant (2.6%) left directional preponderance was found. That is, there was a slightly greater tendency toward left beating nystagmus. In no case did nystagmus occur in a direction opposite to that normally expected and no spontaneous nystagmus was observed.

Discussion

Although certain peculiarities were detected, the results of the three special tests described here indicate that subject 1 has reasonably normal function of the acoustic and canicular portions of the labyrinth. These findings suggest that his insusceptibility to motion sickness and poor balancing ability may be more directly related to at least partial loss of function of the otolithic portion of the vestibular apparatus. Unfortunately no tests of otolith function were performed, however, they would be highly desirable in this case.

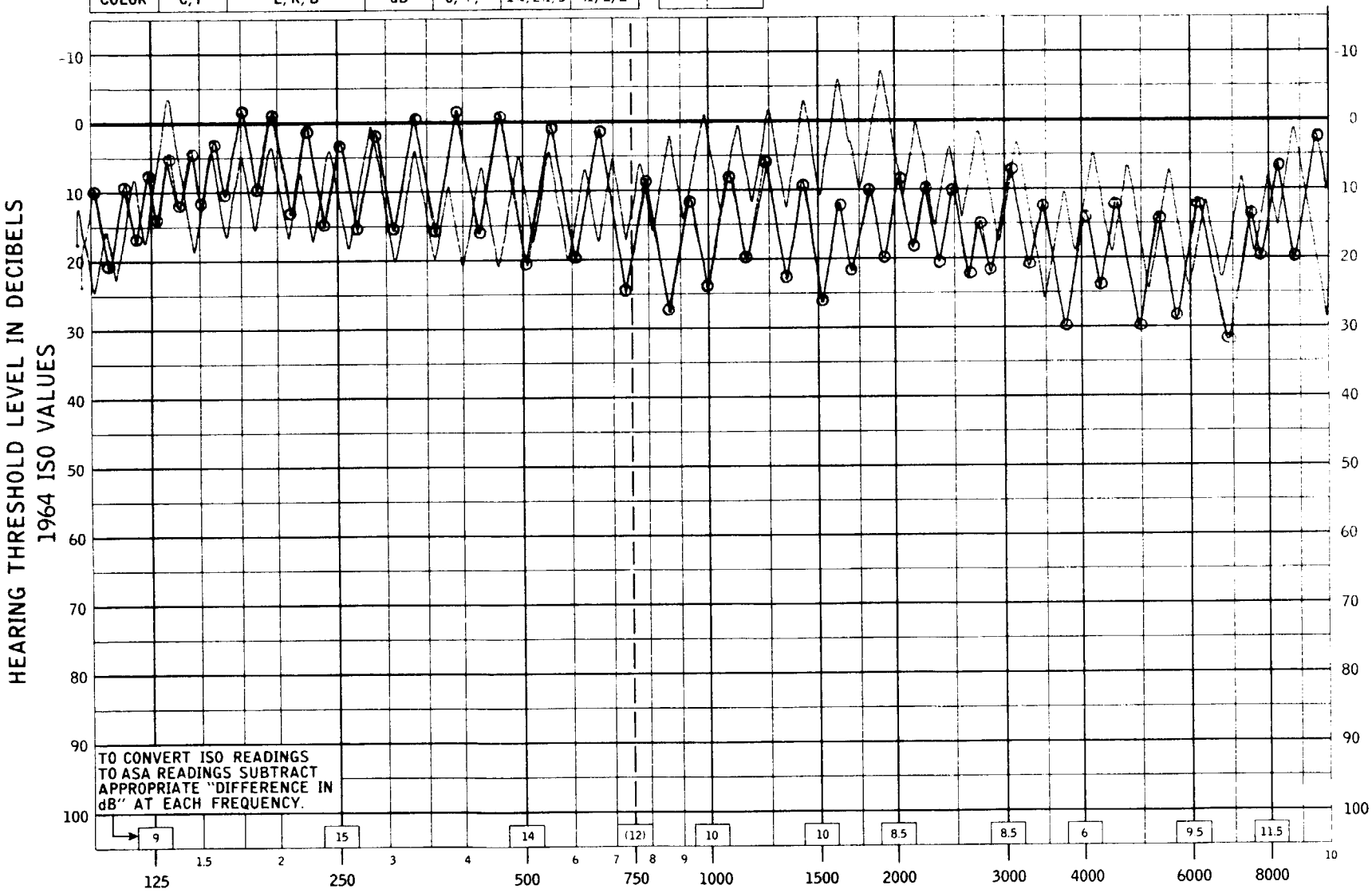
TRACE	TONE		MASKING		20 dB	dB/SEC	OCTAVE/ MIN.
B	C	L				5	2
R	C	R				5	2
COLOR	C, P	L, R, B		dB	0, +, −	1¼, 2½, 5	½, 1, 2

SISI	
FREQ.	%

NAME _____ NO. 1

SEX MALE AGE _____

DATE 19 JUL 76 TIME 1045 BY _____

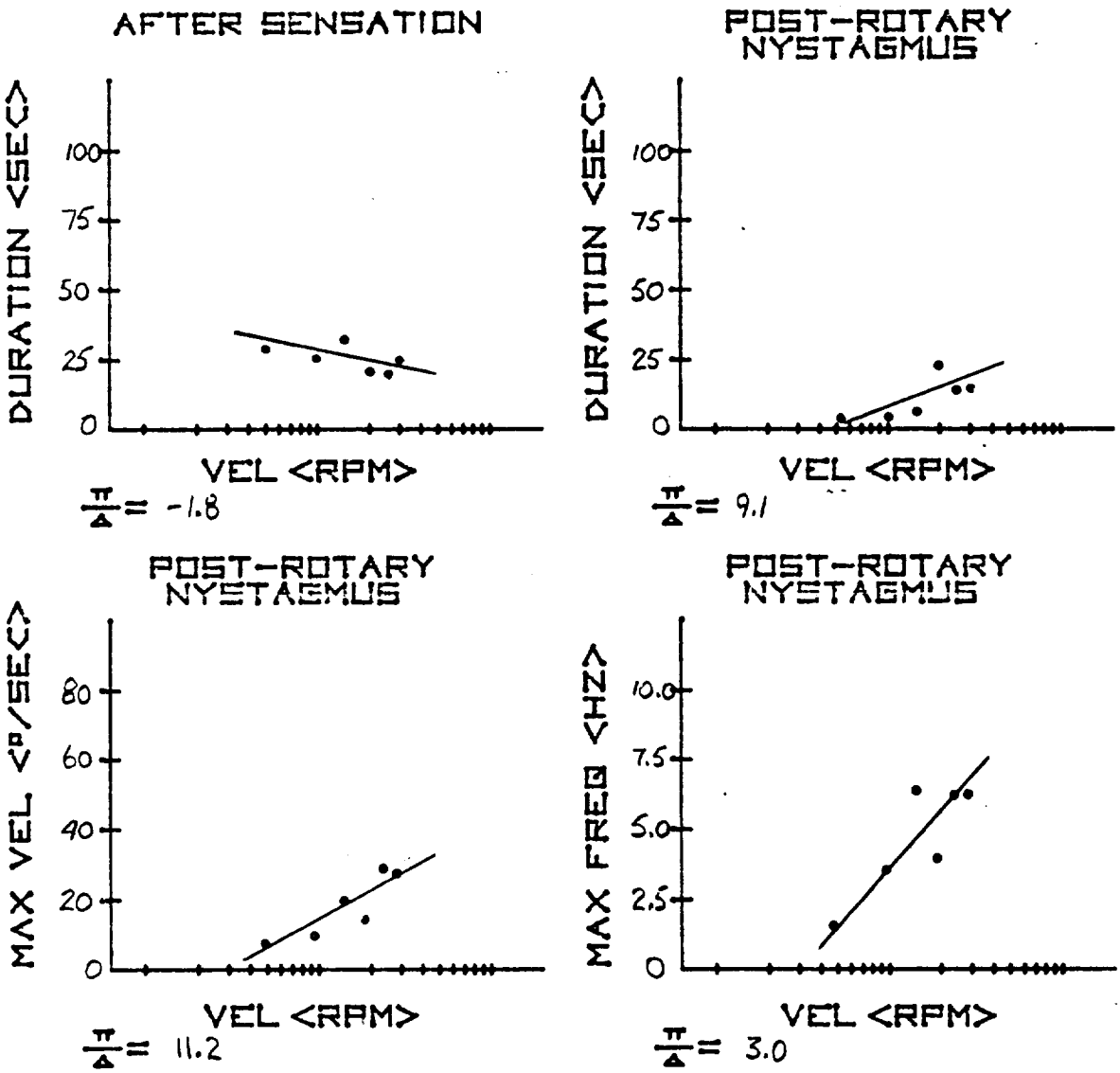


BÉKÉSY AUDIOMETER
GRASON-STADLER COMPANY, INC.
MODEL NO. _____ SERIAL NO. _____

FIGURE 1

CUPULOGRAM TEST DATA

SUBJ No. 1 SEX M AGE ___ DATE 7-23-76



COMMENTS: _____

FIGURE 2.

TABLE I.

CALORIC IRRIGATION

SUBJECT NAME _____ SUBJECT NO. 1

TEST DATE 7-23-76 TIME _____

SUBJECT CORE TEMP. (°C) _____

Irrigating Ear Temp. (°C) Water	Air		Lag (Sec)	*Max Velocity (°Sec)	**Max Freq. (Beats/Sec)	Duration (Sec)
32	24	L	26.0	3.7	2.1	65.6
32	24	R	13.5	8.9	4.7	173.5
42	50	L	31.3	10.7	4.5	108.0
42	50	R	35.2	14.9	5.7	100.2

*10 Beat Average
**From 10 Sec. Epoch with Greatest No. of Beats

RELATIVE EXCITABILITY = $\frac{(1 + 3) - (2 + 4)}{1 + 2 + 3 + 4} \times 100 =$ 24.6 % RIGHT

DIRECTION PREPONDERANCE = $\frac{(1 + 4) - (2 + 3)}{1 + 2 + 3 + 4} \times 100 =$ 2.6 % LEFT

Where max slow phase velocity is taken from:

1 = LEAR Cool
2 = REAR Cool
3 = LEAR Warm
4 = REAR Warm

SPONTANEOUS NYSTAGMUS: NONE

Direction: R L
Average Velocity (°/Sec) _____
Total Beats (3 min. period) _____

VIGILANCE TASK: N/A

CONDITION	Σ Tone Change	% Correct
PREIRRIGATION		
COOL L EAR		
COOL R EAR		
WARM L EAR		
WARM R EAR		

28-DAY BED-REST STUDY: SLEEP CHARACTERISTICS

James D. Frost, Jr., M.D.

Department of Neurophysiology
The Methodist Hospital
Houston, Texas

CONTENTS

	page
SECTION 2. 28-DAY BED-REST STUDY: SLEEP CHARACTERISTICS	1
2.1. SUMMARY	1
2.2. INTRODUCTION	1
2.3. METHODS	2
2.4. RESULTS	3
2.4.1. General	3
2.4.2. Sleep and Wakefulness	3
2.4.3. Sleep-Stage Characteristics	4
2.4.3.1. Stage 1	4
2.4.3.2. Stage 2	4
2.4.3.3. Stage 3	4
2.4.3.4. Stage 4	4
2.4.3.5. Stage REM	4
2.5. DISCUSSION	5
REFERENCES	9
FIGURES AND TABLES	10

SECTION 2

28-DAY BED-REST STUDY: SLEEP CHARACTERISTICS

2.1. SUMMARY

Prior to the 28-day bed-rest study, two subjects (J.H., aged 26 years, and R.T., aged 28 years) were chosen for electroencephalographic (EEG), electro-oculographic (EOG), and electromyographic (EMG) monitoring. The individuals were monitored for three consecutive nights in the pre-bed-rest period, during 12 nights of the bed-rest phase, and on the first six nights following termination of bed rest. The data was analyzed, using standardized criteria for the determination of sleep stages. There were several sleep-pattern alterations that were common to both subjects. During the second half of the bed-rest period, sleep latency and stage 3 increased, while total sleep time, stage 2, and REM latency decreased. In addition, during bed rest both subjects showed an increase in the number of REM periods and a slight increase in stage REM amount. No major alterations were seen in the recovery period. Of the alterations found to be associated with bed rest, only one, the increase in stage 3 sleep, was also seen consistently during Skylab. Conversely, none of the post-flight changes seen following Skylab were observed during the post-bed-rest recovery period. It was concluded that in spite of some similarities, the bed-rest study did not appear to provide a situation truly analogous to space flight in terms of sleep characteristics.

2.2. INTRODUCTION

The Skylab findings (Frost et al., 1974, 1975a, b, 1976) suggested that man is able to obtain adequate sleep during prolonged exposure to the weightless environment of space flight. Of the three subjects studied, only one experienced a significant degree of insomnia, and this was a transient phenomenon, confined to the first part of the mission.

However, while adequate sleep was obtained during these excursions, certain alterations in sleep-stage characteristics did occur in flight and in the immediate postflight period. In spite of a considerable amount of individual variation, three findings were common to all subjects: (1) the amount of stage 3 sleep was increased in flight and decreased postflight, compared to preflight baseline studies; (2) stage 4 sleep was consistently decreased in amount postflight; and (3) stage REM sleep was elevated in amount, and its latency decreased, in the late postflight period. In addition, preliminary analysis of the waking EEG characteristics has revealed an increase of the subjects' alpha-rhythm frequency during the in-flight portion of all three missions.

These findings suggest that while the neurophysiological mechanisms responsible for maintenance of the sleep/waking cycle were not severely disrupted by

Note:
J.H. is subject 2 and R.T. is subject 3

exposure to the unique environment, they were influenced by it. The nature of this influence cannot be determined from the Skylab data alone, but factors such as altered sensory input and fluid-shift mechanisms must be considered among the most likely possibilities. These factors seem to be worthy of further study, since they may reflect underlying neurophysiological processes which may possibly be involved in the production of the space motion sickness syndrome experienced by several astronauts.

The 28-day bed-rest study provided an opportunity to observe sleeping characteristics of subjects confined to a controlled environment that mimicked some aspects of space flight.

2.3. METHODS

Two subjects (J.H., aged 26 years, and R.T., aged 28 years) were chosen for EEG monitoring. These individuals were monitored concurrently for three consecutive nights in the pre-bed-rest period, during twelve nights of the bed-rest phase (nights 1, 2, 3, 5, 12, 16, 18, 21, 24, 26, 27, and 28), and on the first six nights following termination of bed rest. Each sleep-monitoring session lasted 8 hours.

The subjects slept in the Neurophysiology Sleep Laboratory of The Methodist Hospital during the 21 nights they were monitored. They were instructed to maintain approximately the same schedule, with respect to sleep, on those nights when monitoring was not conducted. In addition, they were asked to refrain from napping during the day.

During each monitoring session, the electroencephalogram (EEG), electro-oculogram (EOG), and electromyogram (EMG) were continuously recorded, graphically and on magnetic tape. EEG was derived from six scalp recording electrodes, which provided four channels of data (F_1-C_3, F_2-C_4, C_3-O_1, and C_4-O_2). EOG was recorded from two electrodes, one placed above and the other lateral to the left eye. EMG was detected from a pair of electrodes located in the submental area.

Identical procedures were followed for all recording sessions. The electrodes were attached in the various locations approximately 30 minutes before bedtime (normally, 11:00 p.m.). After calibration and check-out of the recording apparatus, approximately 3 minutes of data were obtained under each of the following conditions: (1) awake, eyes open, relaxed; and (2) awake, eyes closed, relaxed. The lights were then extinguished in the bedroom, the door was closed, and the subjects began the 8-hour sleep period. Upon awakening in the morning, 3-minute samples were again obtained in the eyes-open and eyes-closed conditions, after which the electrodes were removed, and the subjects were permitted to resume their usual activities.

The data was subsequently evaluated, using standardized criteria for the determination of sleep stages, by a combination of human visual and computer techniques. In the statistical evaluation of the results, each subject was considered individually, and the various parameters were grouped into pre-bed-rest, bed-rest, and post-bed-rest categories.

2.4. RESULTS

2.4.1. General

The results of analysis for each night of the study are presented for subject J.H. in Table I, and for subject R.T. in Table II. Average values for the same parameters in the pre-bed-rest (N = 3), bed-rest (N = 12), and post-bed-rest (N = 6) periods for subjects J.H. and R.T. are listed in Tables III and IV, respectively. These tables also indicate the results of between-group comparisons, using a nonparametric statistical test (Mann-Whitney U). Several of the parameters listed in Tables I and II have been plotted versus time to facilitate analysis; thus, Figs. 1-3 pertain to subject J.H., while Figs. 4-6 apply to subject R.T. In all figures, limits (dashed lines), representing plus or minus two standard deviations around the pretest mean, have been projected across the graph. In Tables V and VI, for J.H. and R.T., respectively, the bed-rest period has been divided into first (days 1-12) and second (days 16-28) halves, and average values and between-group comparisons are given for selected parameters.

2.4.2. Sleep and Wakefulness

Neither subject experienced difficulty falling asleep during the pre-bed-rest baseline recordings, and the averages were well below 10 minutes. Sleep latency rose during the bed-rest study (Tables III and IV), with J.H. averaging 26.4 minutes, and R.T. 37.2 minutes. Because of the variability, however, neither was statistically significant. It is clear, though, that this measure exhibited a tendency to increase as the bed-rest phase progressed (Figs. 1 and 4), with highest values seen on days 21 and 24 in both subjects. Thus, J.H. averaged 12.6 minutes during the first half of the bed-rest phase and 35.4 minutes in the second half, while the average values for R.T. were 15.0 minutes and 53.4 minutes, respectively (Tables V and VI). The second-half elevation was statistically significant in the case of R.T. ($p<0.01$). Post bed rest, the values for both subjects returned promptly to the pre-bed-rest range, with each averaging 10.2 minutes.

Both subjects slept well during the baseline series, with J.H. averaging 7 hours, 46 minutes total sleep time, and R.T., 7 hours, 40 minutes. Values dropped somewhat during bed rest, with J.H. averaging 7 hours, 26 minutes (20-minute decrease), and R.T. averaging 7 hours, 20 minutes (20-minute decrease). As with sleep latency, the alterations seen occurred primarily in the second half of the bed-rest phase (Tables V and VI), with first-half values almost identical to the baseline average. The second-half values were significantly decreased in both subjects. Post-bed-rest values did not differ significantly from the pre-bed-rest series, although the average value for J.H. was 13.2 minutes below baseline.

By considering the distribution of time spent awake in the various thirds of the night (Tables III and IV), it is clear that the decrease of total sleep time seen in the second half of the study is, in both subjects, due primarily to decreases during the first third. This, in turn, may be accounted for by the sleep-latency alterations described above. This is also evident in Figs. 1 and 4, where the sleep-latency pattern for each subject is mirrored by the total-sleep-time characteristic.

Neither subject exhibited a significant change in the overall number of nocturnal awakenings while at bed rest, although R.T. showed a small decrease in the last third of the night. Post bed rest, subject J.H. showed a slight increase, which was statistically significant. As indicated in Table III, this resulted from an increased number of arousals during the last third of the night.

2.4.3. Sleep-Stage Characteristics

During the pre-bed-rest baseline recording period, the sleep-stage characteristics of both participants were found to be typical of subjects in this age group (20-30 years).

2.4.3.1. Stage 1. There were no stage 1 changes during the study that were common to both subjects. Subject J.H. showed a slight but significant increase in the average percent stage 1 in the post-bed-rest phase (from 14.3% during the baseling studies to 19.6% following bed rest). Subject R.T. had slightly less stage 1 ($p<0.05$) in the first half of the bed-rest study (5.2%), compared to baseline (6.2%).

2.4.3.2. Stage 2. Both subjects had a small but significant ($p<0.05$) drop in percent stage 2 sleep during the second half of the bed-rest phase (J.H., baseline = 51.2%, bed rest, second half = 43.9%; R.T., baseline = 59.4%, bed rest, second half = 51.2%). Average values during the first half were also below baseline but did not achieve statistical significance. Post bed rest, the values for J.H. remained low ($p<0.05$), while those for R.T. returned to the baseline level.

2.4.3.3. Stage 3. The percentage of sleep time occupied by stage 3 tended to increase during the bed-rest period in both subjects, although there was considerable variability from night to night. The highest values were seen in the second half of the study (Tables V and VI). The average value for J.H. rose from 9.7% during the baseline period to 12.6% in the second half ($p<0.05$). A similar but not statistically significant trend was observed in the case of R.T. (baseline = 11.8%; bed rest, second half = 15%). The post-bed-rest values continued to be somewhat elevated but did not differ significantly from the pre-bed-rest values.

2.4.3.4. Stage 4. No significant alterations in stage 4 were seen in either subject, although in the case of R.T. there was a tendency toward somewhat increased values during the second half of the bed-rest study.

2.4.3.5. Stage REM. REM latency is the elapsed time from sleep onset (excluding stage 1) until the first appearance of stage REM. In typical subjects, this measure is usually between 1 and 3 hours. During the baseline period, average values for both subjects fell within this range. A decreased REM latency characterized the second half of the bed-rest period in both subjects (J.H., baseline = 1.0 hours, bed rest, second half = 0.62 hours; R.T., baseline = 1.86 hours, bed rest, second half = 0.85 hours; $p<0.05$). Clearly abnormal values were seen for J.H. on days 16, 21, and 24, when the measure was less than 8 minutes. True sleep-onset stage REM occurred on day 16 (latency = 0), when the subject entered a short stage REM period directly from the drowsy stage, without an intermediate period of stage 2 sleep.

The number of discrete REM periods tended to increase slightly during bed rest for both subjects, but this finding was not statistically significant. A significant increase was, however, observed post bed rest in one subject (J.H., baseline average = 16.7 periods, post-bed-rest average = 24.2 periods).

The percentage of total sleep time spent in stage REM tended to increase slightly during bed rest, but the change was significant only in the case of subject J.H. during the first half of the bed-rest period (baseline = 21.6%; bed rest, first half = 25.7%). Post bed rest, the percent REM values were not significantly different from those seen pre bed rest, although relatively high values were seen on days 4 and 5 for subject J.H. In addition, both subjects exhibited a significant increase in the amount of stage REM that occurred during the final third of the night in the post-bed-rest period, although total REM time remained relatively unchanged.

2.5. DISCUSSION

Most of the sleep-pattern alterations that were common to both subjects were associated with the second half of the 28-day bed-rest period: (1) sleep latency increased, (2) total sleep time decreased, (3) stage 2 decreased, (4) stage 3 increased, and (5) REM latency decreased. Throughout the bed-rest period, both subjects showed some increase in the number of discrete REM periods per night and a slight increase in stage REM amount. In the post-bed-rest phase, there was a relative increase in stage REM during the last third of the night but no overall change in other REM characteristics.

In spite of a reduction in total sleep time in the latter portion of the bed-rest study, neither subject showed objective evidence of sleep deprivation. On no occasion were less than 6½ hours of sleep per night obtained. As pointed out above, the total-sleep-time reduction resulted largely from an increase in sleep latency on certain nights. It is noteworthy that on nights 21 and 24, those associated with the longest sleep-latency measurements, the two subjects were noted to engage in conversation with each other during most of the latency period and thus, to some extent, were voluntarily remaining awake.

These findings differ in several respects from those obtained during Skylab. Sleep latency was significantly altered only during the 84-day Skylab mission, and, in this case, the increase seen was confined to the first half of the flight, rather than to the last half, as observed during the bed-rest study. While a significant reduction in sleep time occurred during the 28-day Skylab flight, it was attributable to a voluntary reduction in total time spent in bed and was not accompanied by an increased sleep latency. The findings are similar in that in neither case did the imposed environment appear to prevent the subjects from obtaining sleep of adequate duration.

The decrease in stage 2 and increase in stage 3 sleep during bed rest are findings that were also seen in two earlier bed-rest studies reported by Ryback

and his co-workers (Ryback and Lewis, 1971; Ryback et al., 1971a, b). In these studies, the increase was seen in both stages 3 and 4, especially in subjects who were not permitted to exercise. Somewhat analogous findings were seen during Skylab, where an in-flight increase in stage 3 was observed during each flight; however, stage 2 was not consistently reduced. While a consistent postflight decrease in stage 4 was seen during Skylab, no such drop was evident in the post-bed-rest period.

The shortening of REM latency, observed during the second half of the bed-rest study, was an unexpected finding, and, in the case of subject J.H., several of the individual values were well below the range typical of normal subjects. In the absence of drug administration or prior REM deprivation, sleep-onset stage REM, such as occurred on night 16 for J.H., or very brief latencies (less than 8 minutes), as on nights 21 and 24, are considered to be abnormal findings. Patients afflicted with narcolepsy often exhibit this pattern in association with the onset of nocturnal sleep or during daytime sleep attacks. Other findings, such as an increased number of REM periods and a slight increase of REM time, seen in both subjects, did not deviate from the normal range.

The REM alterations seen during bed rest were not found during the Skylab studies. In fact, there was a slight tendency for REM to decrease near the end of each Skylab mission, rather than to increase as it did during the final portions of the bed-rest period. Consistent alterations in REM latency and number of REM periods were similarly absent during Skylab. On the other hand, while the most remarkable Skylab findings were the increase in REM time and decrease in REM latency seen in the late postflight period (beyond day R + 3), following bed rest the REM characteristics were essentially the same as those seen pre bed rest. The single exception, common to both subjects, was a redistribution of REM time, with a relative increase in the last third of the night. One bed-rest subject showed a small increase of REM time after day 3, similar to that seen in all three Skylab astronauts. It should be noted that the late postflight Skylab changes in REM characteristics are very similar to the changes seen in the second half of the bed-rest period. While the reasons for the Skylab alterations were not clear, it was postulated that the marked alteration in sensory input, particularly with respect to the visual, vestibular, and proprioceptive systems, might underlie the changes. This hypothesis was based upon evidence which links sleep, and in particular the REM stage, to the neurophysiological mechanisms of memory transformation. Such an explanation does not appear to apply to the bed-rest situation, since the changes were not apparent immediately after the transition to the new environment but appeared only after approximately 2 weeks - a length of time expected to permit relatively complete adaptation. It is, of course, possible that the effects of bed rest may not follow a time course analogous to Skylab and that a similar mechanism could conceivably be in effect.

A summary, comparing the Skylab results with those obtained during the 28-day bed-rest study as well as with those recorded during the Skylab Medical Experiments Altitude Test (SMEAT) (Frost and Salamy, 1973), is provided in Table VII. In preparing this table, sleep characteristics were considered to have been altered whenever a clear-cut difference, compared to baseline, occurred under the imposed test condition. Thus, in some instances, values which did not achieve statistical significance were included.

The incidence of altered sleep characteristics is expressed as a percentage of each group's total membership; for example, in the Skylab column, a value of 33% indicates that one crewman showed this change, while a value of 100% indicates that all three did. In the bed-rest and SMEAT columns, 50% indicates one subject, and 100%, two. In order to quantify the similarity or dissimilarity among the three test conditions, correlations are expressed as percentage values; thus, a correlation of 100% indicates that all members of the specified groups being compared showed the particular alteration.

Consideration of Table VII indicates that during exposure to the three test environments, the most consistently altered characteristic among the three groups was stage 3 sleep, which tended to increase. This was true in all three Skylab astronauts, in both bed-rest subjects, and in one of the two SMEAT crewmen, providing an overall correlation factor (cf) of 50%. Relatively high values (cf = 34%) were seen for total-sleep-time and stage 1 values, both of which tended to decrease in some members of all three groups. An increase of sleep latency and increased amounts of stage 4 were also observed in at least one member of each group. In the post-exposure period, only one alteration (an increase of stage REM after day R + 3) was common to all three environments, with a correlation value of 50%.

Table VII also permits a differential analysis to be made of the efficacy of the SMEAT and bed-rest projects as simulations, with respect to sleep alterations, of actual space flight. As noted previously, only one in-flight alteration (increased stage 3) was common to all three Skylab astronauts. This finding correlated best with the bed-rest project (cf = 100%) but was seen in one SMEAT participant (cf = 50%). Two out of three Skylab subjects had a decreased overall amount of sleep in flight. Again, the bed-rest results (cf = 67%) agreed with the Skylab findings more closely than did those of SMEAT (cf = 34%). With respect to the stage 1 decrease noted in two Skylab crew members, the best correlation was with the SMEAT test (cf = 67%). Thus, the bed-rest study appears to have been somewhat more similar to Skylab in terms of in-flight characteristics. Postflight, four alterations were common to all three astronauts: the increase in stage REM after day R + 3 was also seen in both SMEAT subjects (cf = 100%) and in one bed-rest subject (cf = 50%); the increase in stage 3 and the increase in stage 4 were also observed in one SMEAT participant (cf = 50% for both measures) but in none of the bed-rest subjects (cf = 0 on both comparisons); the decrease in REM latency seen after day R + 3 during Skylab was not seen during bed rest or SMEAT (cf = 0 in both cases). Thus, with respect to postflight findings, SMEAT clearly provided the closest approximation to Skylab.

In spite of some similarities, the bed-rest study did not appear to provide a situation truly analogous to space flight, in terms of sleep characteristics. Alterations in stages 3 and 4 have been reported previously (Ryback and Lewis, 1971; Ryback et al., 1971a, b) in association with bed rest and have been tentatively ascribed to changes in muscular-system status. In particular, subjects undergoing bed rest with no exercise showed the greatest changes. To some extent, we might postulate that this is borne out by the Skylab findings, which also reflected an increase of slow-wave sleep (primarily stage 3). Although the Skylab crew exercised regularly, perhaps some muscle groups were under-utilized. Yet,

we saw a similar change in one of the SMEAT crew members, who almost certainly was not significantly under-exercised and furthermore was living under 1 g environmental conditions. Thus, the increase in stage 3 may well result from some other factor common to all three test situations - perhaps confinement or stress.

The findings with respect to stage REM argue most strongly against the bed-rest situation as an analogue of in-flight sleeping conditions. REM latency decreased to abnormal levels in one subject, and a similar tendency was noted in the other. In addition, REM amount tended to increase near the end of the bed-rest period, while in Skylab it tended to decrease. Changes in REM were not significant in the earlier bed-rest studies, but this may have been due to the long sampling intervals used in the previous studies.

During Skylab, we also observed certain alterations in the basic EEG characteristics - most notably an in-flight increase in the alpha-rhythm frequency. We are now making a similar analysis of the bed-rest data, but the results are not yet available for comparison. Pending these results, which may alter our opinion, the conclusion appears to be that bed rest, while associated with alterations in sleep characteristics, for the most part does not influence this physiological process in a manner comparable to the weightless environment of space flight. Out of eight alterations associated with bed rest, only one, an increase in stage 3 sleep, was also seen consistently during Skylab. Conversely, none of the four Skylab changes seen postflight were observed consistently in the post-bed-rest phase.

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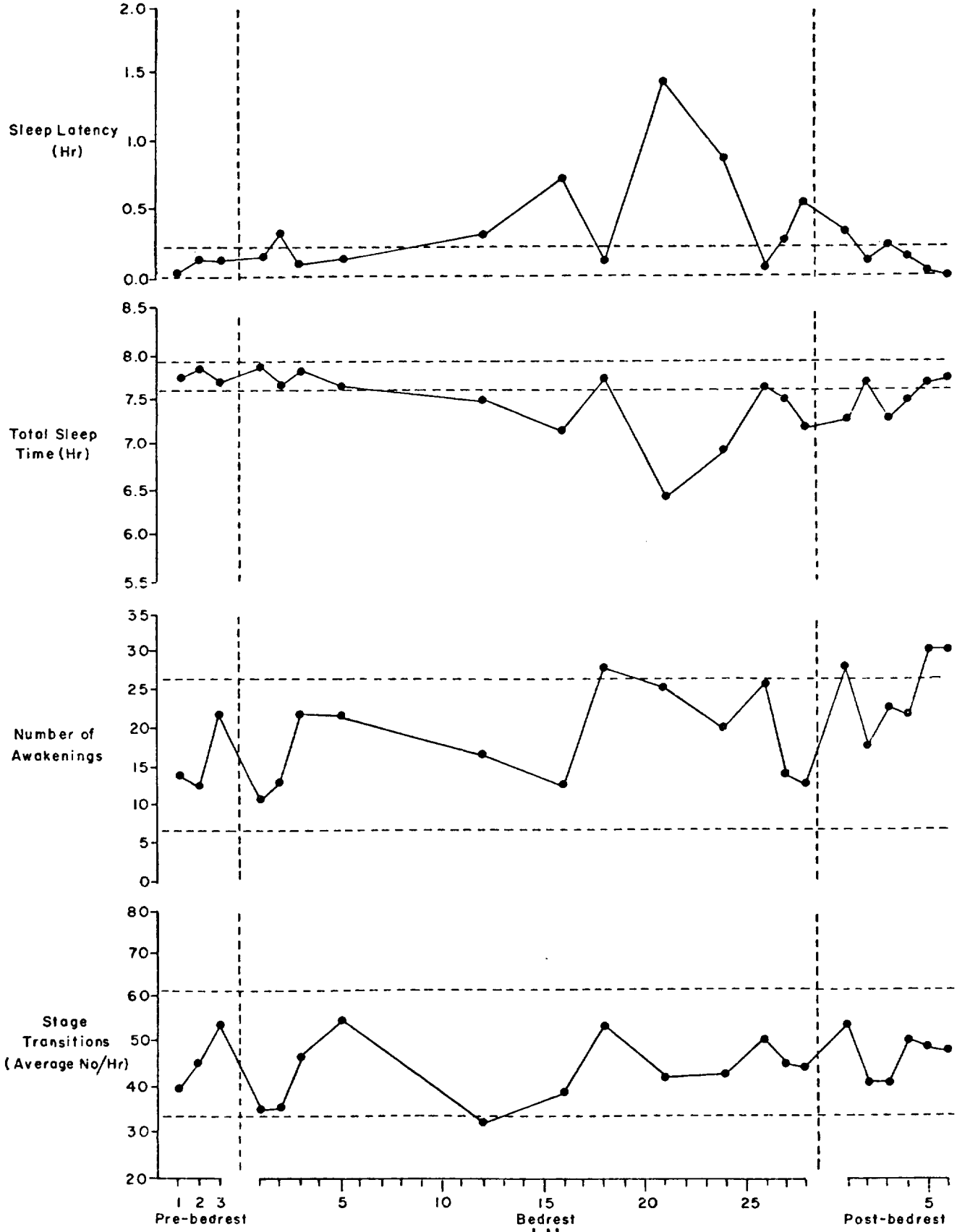
FIGURES AND TABLES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1.5
1.0
0.5
0.0
Total Sleep Time (Hr)
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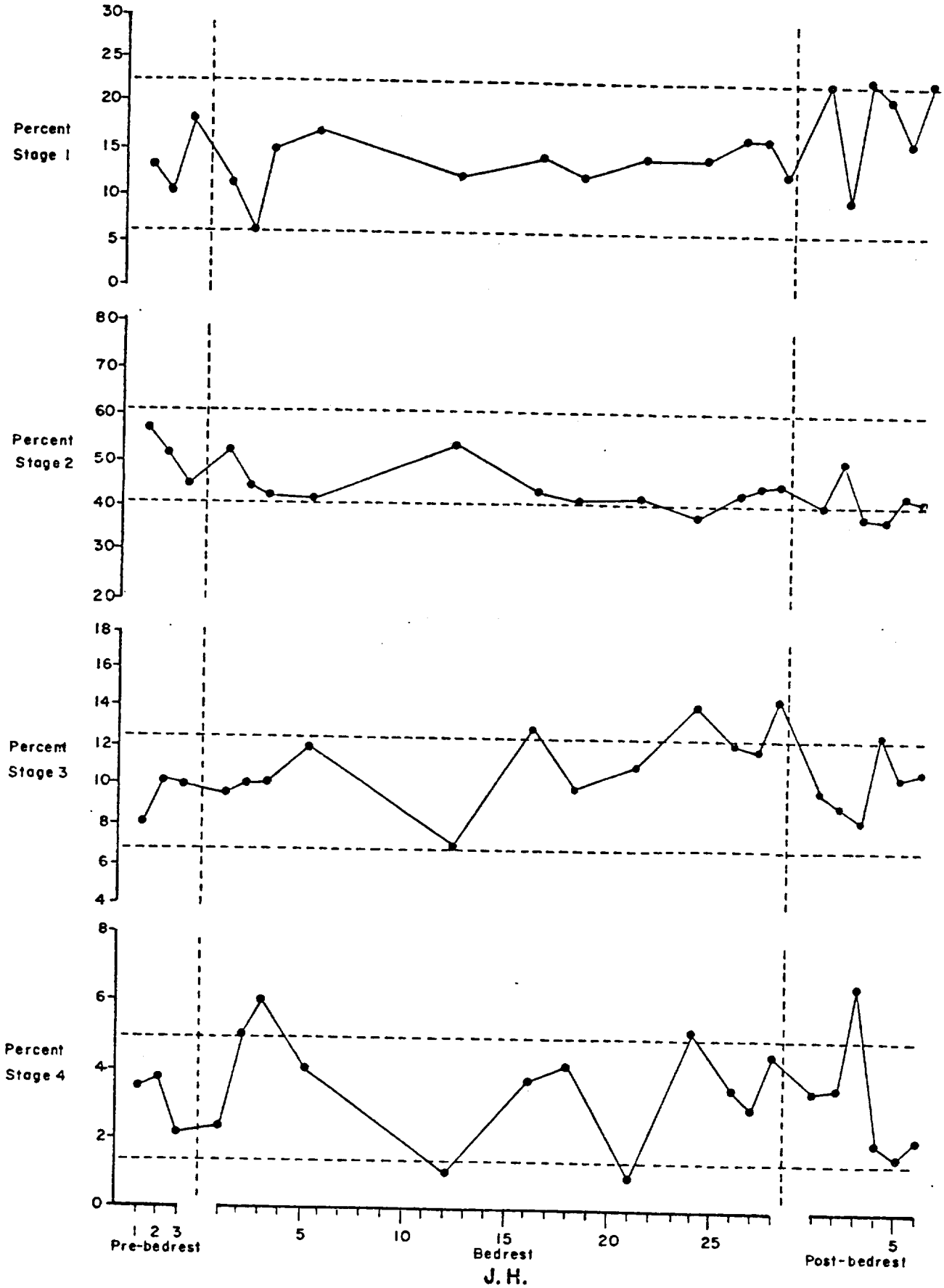
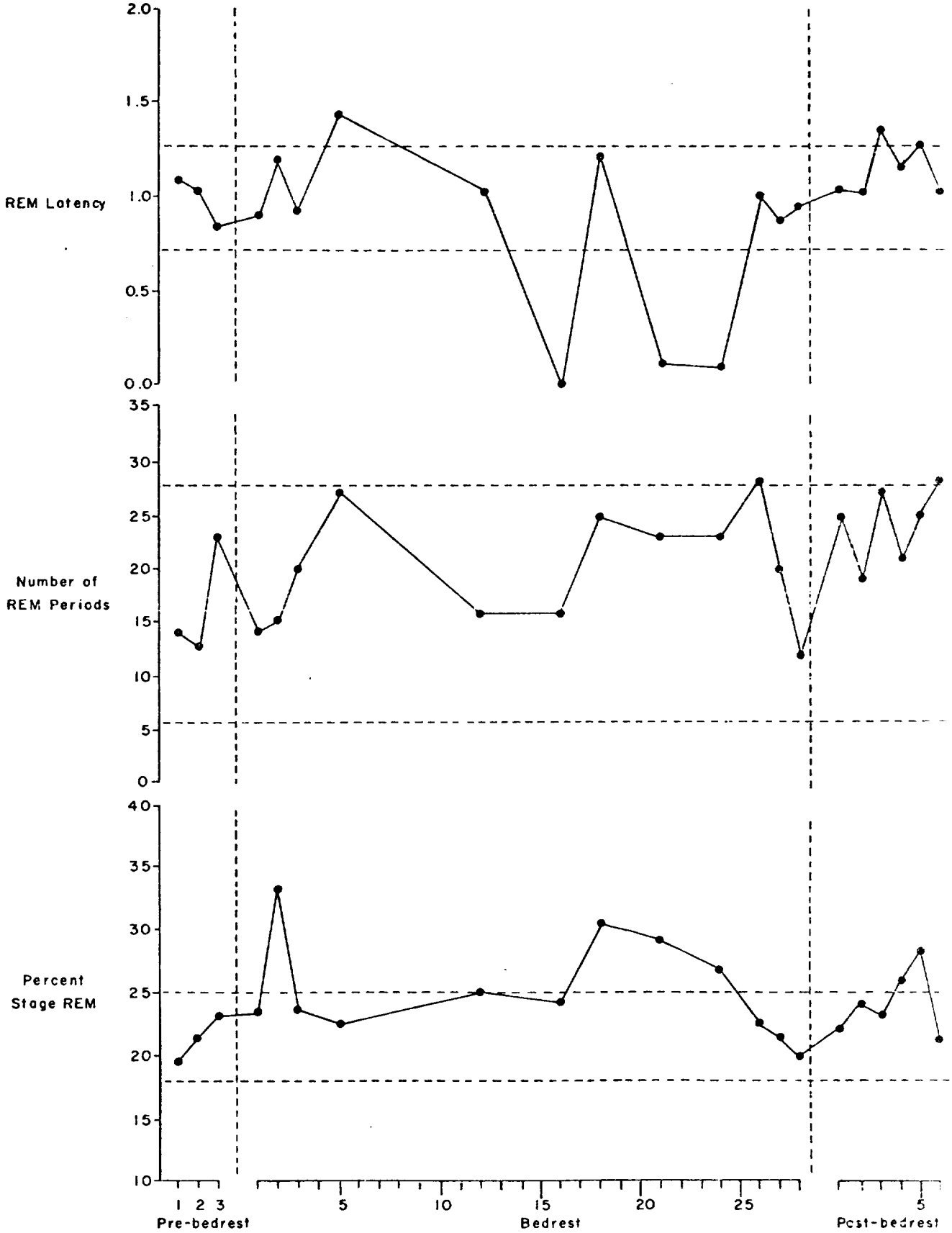
8.0
7.5
7.0
6.5
6.0
5.5
Number of Awakenings
35
30
25
20
15
10
5
0
Stage Transitions (Average No/Hr)
80
70
60
50
40
30
20
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

J.H.
Fig. 1


Percent Stage 1
Percent Stage 2
Percent Stage 3
Percent Stage 4
Pre-bedrest
Bedrest
Post-bedrest

J. H.
Fig. 2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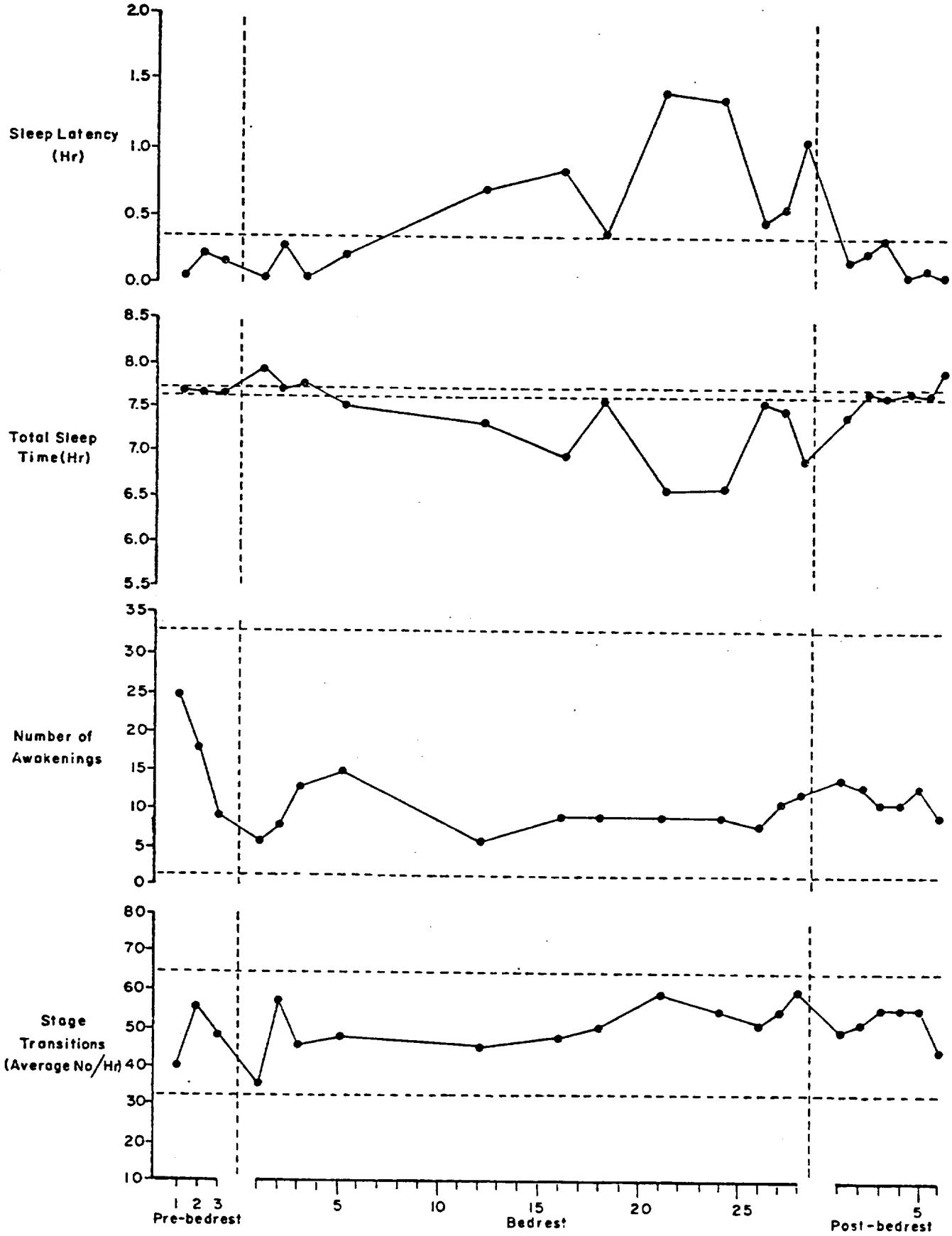
1.5
1.0
0.5
0.0
Number of REM Periods
35
30
25
20
15
10
5
0
Percent Stage REM
40
35
30
25
20
15
10
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

J.H.
Fig. 3


Sleep Latency (Hr)
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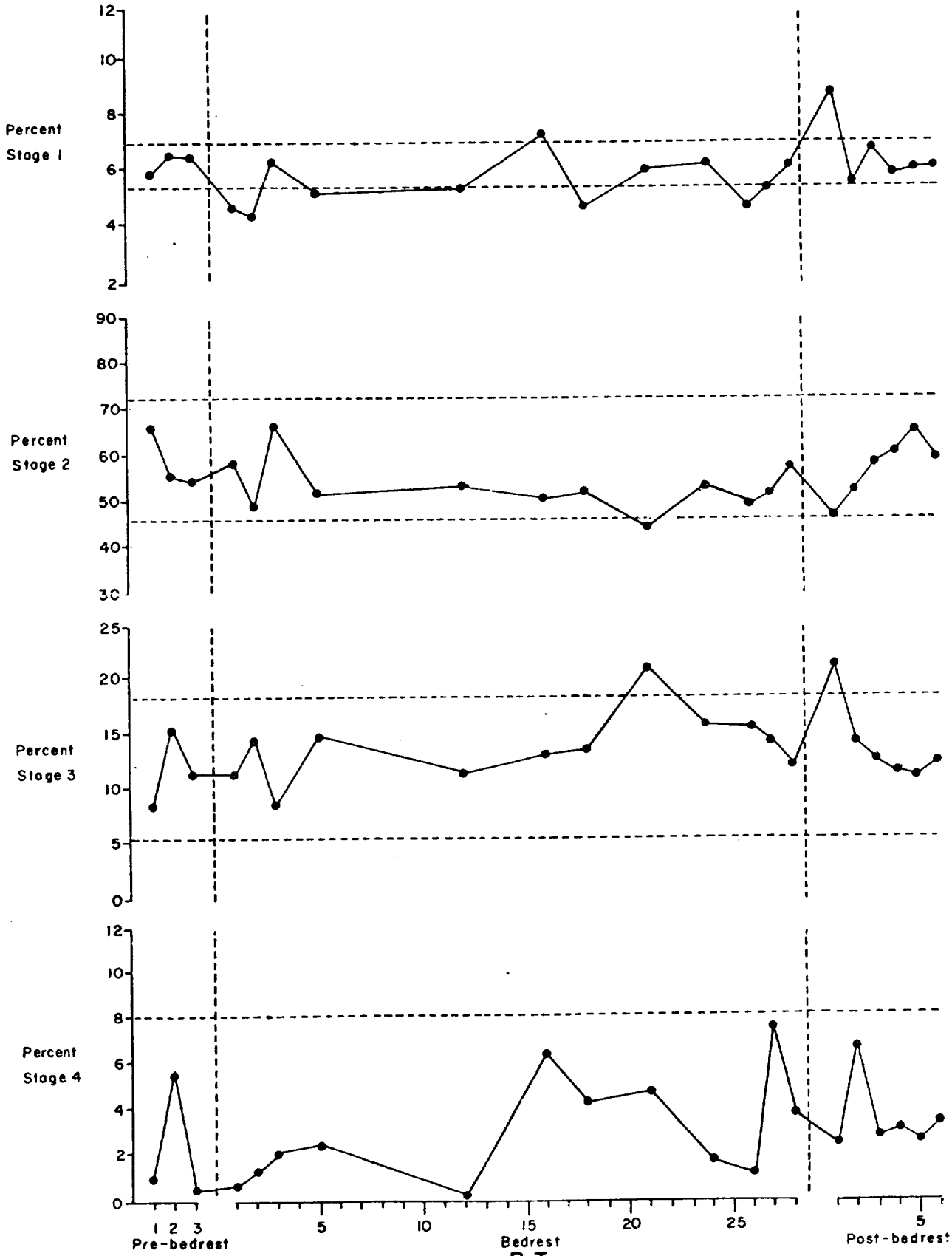
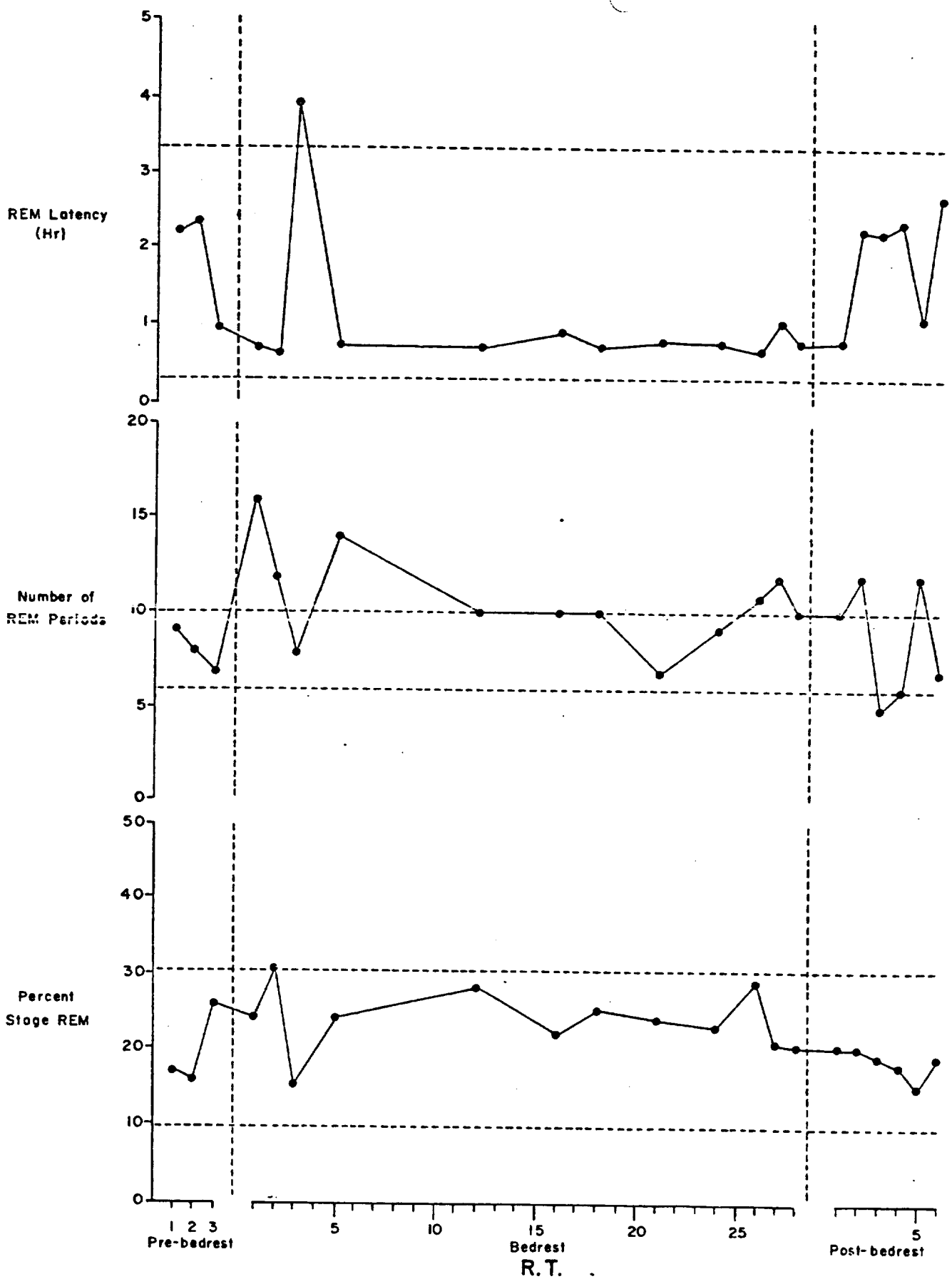
1.5
1.0
0.5
0.0
Total Sleep Time(Hr)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
Number of Awakenings
35
30
25
20
15
10
5
0
Stage Transitions (Average No/Hr)
80
70
60
50
40
30
20
10
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

R.T.
Fig. 4


Percent Stage 1
Percent Stage 2
Percent Stage 3
Percent Stage 4
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

R.T.
Fig. 5


REM Latency (Hr)
Number of REM Periods
Percent Stage REM
Pre-bedrest
Bedrest
Post-bedrest

R.T.
Fig. 6

Table I.

NASA BEDREST STUDY

	PRE-TEST			TEST												POST-TEST					
TEST DAYS	1	2	3	1	2	3	5	12	16	18	21	24	26	27	28	1	2	3	4	5	6
Total Time in Bed	8.04	8.05	8.03	8.04	8.04	8.06	8.02	8.04	8.04	8.06	8.02	8.02	8.07	8.07	8.04	8.04	8.03	8.03	8.04	8.03	8.03
Total Sleep Time	7.75	7.85	7.70	7.88	7.68	7.84	7.67	7.51	7.19	7.74	6.41	6.95	7.65	7.51	7.16	7.28	7.71	7.33	7.53	7.72	7.74
Total Sleep Percent	96.4	97.5	95.9	97.9	95.6	97.3	95.6	93.4	89.5	96.0	79.9	86.6	94.8	93.1	89.1	90.5	96.0	91.3	93.7	96.1	96.4
Total Awake Time	0.29	0.20	0.33	0.17	0.35	0.22	0.35	0.53	0.85	0.33	1.62	1.07	0.42	0.56	0.88	0.76	0.32	0.70	0.51	0.31	0.29
1 st 3rd	0.04	0.11	0.05	0.08	0.24	0.06	0.09	0.15	0.61	0.08	1.32	0.81	0.05	0.21	0.53	0.23	0.07	0.18	0.09	0.04	0.03
2 nd 3rd	0.09	0.03	0.09	0.01	0.04	0.08	0.08	0.18	0.05	0.05	0.09	0.04	0.15	0.04	0.05	0.18	0.16	0.19	0.15	0.10	0.03
3 rd 3rd	0.16	0.07	0.19	0.08	0.07	0.09	0.18	0.20	0.18	0.20	0.21	0.22	0.23	0.31	0.29	0.36	0.09	0.33	0.27	0.17	0.23
Sleep Latency	0.06	0.16	0.16	0.17	0.31	0.11	0.16	0.31	0.73	0.13	1.44	0.89	0.10	0.29	0.58	0.35	0.15	0.26	0.19	0.07	0.02
REM Latency	1.12	1.04	0.84	0.91	1.22	0.94	1.44	1.03	0.00	1.24	0.13	0.10	1.00	0.89	0.95	1.05	1.04	1.36	1.19	1.29	1.04
Number of Awakenings	14	13	22	11	13	22	22	17	13	28	25	20	26	14	13	28	18	23	22	30	30
1 st 3rd	2	0	3	2	1	1	2	2	1	3	2	0	1	2	3	1	1	1	2	1	1
2 nd 3rd	7	5	7	2	4	10	8	7	7	6	8	5	8	4	3	8	8	4	8	9	6
3 rd 3rd	5	8	12	7	8	11	12	8	5	19	15	15	17	8	7	19	9	18	12	20	23
Number of REM Periods	14	13	23	14	15	20	27	16	16	25	23	23	28	20	12	25	19	27	21	25	28
1 st 3rd	1	3	3	3	3	2	4	1	4	5	1	4	3	4	2	4	5	1	5	2	3
2 nd 3rd	6	4	7	4	6	7	9	7	5	7	12	5	11	7	2	10	7	6	6	8	5
3 rd 3rd	7	6	13	7	6	11	14	8	7	13	10	14	14	9	8	11	7	20	10	15	20
Stage 1 Time	1.02	0.86	1.46	0.91	0.47	1.20	1.36	0.94	1.07	0.97	0.94	1.02	1.30	1.26	0.95	1.67	0.79	1.70	1.60	1.27	1.79
% Stage 1	13.2	10.9	18.9	11.5	6.2	15.3	17.7	12.5	14.9	12.5	14.7	14.7	17.0	16.7	13.2	22.9	10.2	23.2	21.3	16.5	23.2
Stage REM Time	1.53	1.71	1.78	1.85	2.56	1.88	1.74	1.88	1.74	2.36	1.87	1.88	1.73	1.62	1.43	1.61	1.87	1.69	1.96	2.19	1.66
1 st 3rd	0.25	0.44	0.34	0.38	0.35	0.37	0.33	0.29	0.32	0.35	0.04	0.38	0.36	0.28	0.29	0.14	0.33	0.28	0.36	0.11	0.44
2 nd 3rd	0.38	0.66	0.67	0.80	0.95	0.59	0.42	0.71	0.77	0.79	1.05	0.47	0.48	0.54	0.51	0.65	0.58	0.58	0.35	0.86	0.14
3 rd 3rd	0.91	0.61	0.78	0.67	1.26	0.92	0.99	0.88	0.65	1.22	0.78	1.03	0.89	0.80	0.63	0.82	0.96	0.83	1.25	1.23	1.09
% Stage REM	19.8	21.8	23.2	23.5	33.3	23.9	22.8	25.1	24.3	30.6	29.2	27.0	22.7	21.5	20.0	22.2	24.2	23.1	26.0	28.4	21.5
Stage 2 Time	4.29	4.14	3.50	4.17	3.46	3.44	3.31	4.05	3.17	3.30	2.78	2.70	3.39	3.50	3.41	3.01	4.04	2.84	2.86	3.3	3.28
% Stage 2	55.4	52.8	45.5	53.0	45.1	43.8	43.1	53.9	44.0	42.6	43.3	38.8	44.4	46.6	47.6	41.4	52.4	38.8	38.0	42.8	42.3
Stage 3 Time	0.63	0.84	0.79	0.76	0.79	0.85	0.94	0.55	0.95	0.78	0.76	0.99	0.94	0.90	1.04	0.72	0.72	0.61	0.95	0.82	0.85
% Stage 3	8.1	10.8	10.3	9.7	10.3	10.8	12.3	7.3	13.2	10.1	11.8	14.3	12.4	12.0	14.5	9.9	9.3	8.4	12.7	10.6	11.0
Stage 4 Time	0.28	0.30	0.17	0.19	0.40	0.48	0.32	0.09	0.26	0.33	0.06	0.37	0.28	0.24	0.33	0.26	0.29	0.48	0.15	0.13	0.16
% Stage 4	3.6	3.8	2.2	2.4	5.2	6.2	4.2	1.3	3.7	4.2	0.9	5.3	3.7	3.2	4.7	3.6	3.8	6.6	2.0	1.7	2.1
Transitions/Hr.	40	47	54	35	36	48	55	32	39	54	43	44	51	46	45	54	42	42	51	48	47

J. H.

Table II.

NASA BEDREST STUDY

	PRE-TEST			TEST												POST-TEST					
TEST DAYS	1	2	3	1	2	3	5	12	16	18	21	24	26	27	28	1	2	3	4	5	6
Total Time in Bed	8.04	8.06	8.05	8.05	8.05	8.09	8.04	8.06	8.04	8.05	8.04	8.04	8.08	8.11	8.06	8.03	8.04	8.05	8.05	8.05	8.04
Total Sleep Time	7.69	7.67	7.66	7.97	7.71	7.78	7.51	7.33	6.96	7.61	6.59	6.60	7.56	7.46	6.94	7.39	7.68	7.63	7.73	7.73	7.93
Total Sleep Percent	95.7	95.2	95.2	99.0	95.8	96.2	93.3	90.9	86.5	94.6	82.0	82.0	93.6	92.0	86.1	92.1	95.5	94.8	95.9	96.0	98.6
Total Awake Time	0.34	0.39	0.39	0.08	0.34	0.31	0.54	0.73	1.08	0.44	1.45	1.45	0.52	0.65	1.12	0.64	0.36	0.42	0.33	0.32	0.12
1 st 3rd	0.09	0.18	0.13	0.03	0.22	0.06	0.18	0.65	0.83	0.34	1.39	1.36	0.44	0.51	1.01	0.14	0.19	0.30	0.04	0.17	0.04
2 nd 3rd	0.14	0.02	0.02	0.01	0.08	0.19	0.28	0.05	0.14	0.03	0.01	0.03	0.01	0.06	0.03	0.39	0.06	0.05	0.04	0.02	0.02
3 rd 3rd	0.11	0.19	0.24	0.04	0.04	0.06	0.09	0.03	0.11	0.07	0.06	0.06	0.07	0.08	0.09	0.11	0.11	0.08	0.24	0.13	0.06
Sleep Latency	0.06	0.23	0.18	0.04	0.27	0.04	0.20	0.71	0.85	0.38	1.43	1.39	0.49	0.57	1.09	0.17	0.23	0.34	0.08	0.12	0.06
REM Latency	2.25	2.35	0.97	0.75	0.63	3.96	0.79	0.78	0.90	0.77	0.86	0.83	0.72	1.04	0.81	0.82	2.26	2.23	2.36	1.12	2.71
Number of Awakenings	25	18	9	6	8	13	15	6	9	9	9	9	8	11	12	14	13	11	11	13	9
1 st 3rd	4	1	0	1	1	4	3	0	0	2	1	0	0	0	1	1	0	0	0	3	2
2 nd 3rd	11	3	2	2	2	6	6	2	2	3	1	3	2	5	3	3	5	4	3	3	2
3 rd 3rd	10	14	7	3	5	3	6	4	7	4	7	6	6	6	8	10	8	7	8	7	5
Number of REM Periods	9	8	7	16	12	8	14	10	10	10	7	9	11	12	10	10	12	5	6	12	7
1 st 3rd	2	1	2	5	7	0	6	2	2	2	1	2	3	3	1	2	1	1	1	4	0
2 nd 3rd	2	4	3	6	2	3	4	4	5	5	1	3	2	3	4	1	4	3	2	3	2
3 rd 3rd	5	3	2	5	3	5	4	4	3	3	5	4	6	6	5	7	7	1	3	5	5
Stage 1 Time	0.44	0.50	0.49	0.36	0.33	0.49	0.39	0.39	0.51	0.36	0.39	0.41	0.36	0.41	0.42	0.65	0.42	0.52	0.45	0.46	0.48
% Stage 1	5.8	6.5	6.4	4.6	4.3	6.3	5.2	5.4	7.4	4.7	6.0	6.2	4.7	5.4	6.1	8.8	5.5	6.8	5.8	6.0	6.1
Stage REM Time	1.37	1.27	2.01	1.93	2.39	1.22	1.85	2.09	1.57	1.95	1.58	1.55	2.21	1.57	1.42	1.53	1.56	1.46	1.46	1.17	1.53
1 st 3rd	0.10	0.10	0.08	0.35	0.42	0.00	0.35	0.19	0.01	0.12	0.13	0.10	0.19	0.09	0.10	0.35	0.19	0.11	0.15	0.11	0.00
2 nd 3rd	0.52	0.48	1.23	0.92	0.30	0.44	0.27	0.65	0.92	0.67	0.51	0.67	0.80	0.48	0.73	0.27	0.39	0.63	0.49	0.31	0.52
3 rd 3rd	0.76	0.70	0.70	0.67	1.66	0.79	1.23	1.26	0.63	1.16	0.95	0.78	1.22	1.00	0.60	0.91	0.98	0.72	0.81	0.75	1.01
% Stage REM	17.8	16.6	26.2	24.3	30.9	15.7	24.6	28.6	22.5	25.7	24.0	23.5	29.2	21.0	20.5	20.7	20.4	19.2	18.8	15.1	19.3
Stage 2 Time	5.14	4.30	4.24	4.68	3.75	5.23	3.98	3.97	3.53	3.94	2.93	3.49	3.72	3.88	3.99	3.47	4.10	4.46	4.67	5.01	4.64
% Stage 2	66.8	56.1	55.3	58.7	48.6	67.2	52.9	54.2	50.7	51.7	44.5	52.9	49.2	52.0	57.5	47.0	53.3	58.5	60.5	64.8	58.5
Stage 3 Time	0.66	1.17	0.89	0.93	1.14	0.69	1.12	0.86	0.91	1.04	1.36	1.03	1.18	1.05	0.84	1.56	1.08	0.97	0.90	0.88	1.00
% Stage 3	8.6	15.2	11.7	11.7	14.8	8.8	14.9	11.7	13.1	13.6	20.7	15.7	15.6	14.1	12.2	21.2	14.1	12.7	11.7	11.4	12.6
Stage 4 Time	0.08	0.43	0.04	0.06	0.11	0.16	0.18	0.01	0.44	0.33	0.32	0.12	0.09	0.56	0.26	0.18	0.52	0.22	0.25	0.21	0.28
% Stage 4	1.1	5.6	0.5	0.8	1.4	2.0	2.3	0.2	6.4	4.3	4.8	1.8	1.3	7.5	3.8	2.4	6.8	2.9	3.2	2.7	3.5
Transitions/Hr.	40	56	48	36	58	46	48	46	48	51	59	55	52	55	60	50	52	56	56	56	45

R. T.

Table III.

	AVERAGE VALUES			BETWEEN GROUP COMPARISONS * (P = 0.05)		
	Pre-bedrest	Bedrest	Post-bedrest	Pre-bedrest vs. Bedrest	Pre-bedrest vs. Post-bedrest	Bedrest, vs. Post-bedrest
Total Time in Bed	8.04(0.01)	8.04	8.03	N.S.	N.S.	N.S.
Total Sleep Time	7.77(0.08)	7.43	7.55	N.S.	N.S.	N.S.
Total Sleep Percent	96.60(0.80)	92.40	94.00	N.S.	N.S.	N.S.
Total Awake Time	0.27(0.07)	0.61	0.48	N.S.	N.S.	N.S.
1 st 3rd	0.07(0.04)	0.35	0.11	N.S.	N.S.	N.S.
2 nd 3rd	0.07(0.03)	0.07	0.14	N.S.	N.S.	N.S.
3 rd 3rd	0.14(0.06)	0.18	0.24	N.S.	N.S.	N.S.
Sleep Latency	0.13(0.06)	0.44	0.17	N.S.	N.S.	N.S.
REM Latency	1.00(0.14)	0.82	1.16	N.S.	N.S.	0.05
Number of Awakenings	16.30(4.90)	18.70	25.20	N.S.	0.05	0.05
1 st 3rd	1.70(1.50)	1.70	1.20	N.S.	N.S.	N.S.
2 nd 3rd	6.30(1.10)	6.00	7.20	N.S.	N.S.	N.S.
3 rd 3rd	8.30(3.50)	11.00	16.80	N.S.	0.05	0.05
Number of REM Periods	16.70(5.50)	19.90	24.20	N.S.	0.05	N.S.
1 st 3rd	2.30(1.10)	3.00	3.30	N.S.	N.S.	N.S.
2 nd 3 rd	5.70(1.50)	6.80	7.00	N.S.	N.S.	N.S.
3 rd 3rd	8.70(3.80)	10.10	13.80	N.S.	N.S.	N.S.
Stage 1 Time	1.11(0.31)	1.03	1.47	N.S.	N.S.	0.05
% Stage 1	14.30(4.10)	13.90	19.60	N.S.	N.S.	0.05
Stage REM Time	1.67(0.13)	1.88	1.83	N.S.	N.S.	N.S.
1 st 3rd	0.34(0.10)	0.31	0.28	N.S.	N.S.	N.S.
2 nd 3rd	0.57(0.16)	0.67	0.53	N.S.	N.S.	N.S.
3 rd 3 rd	0.77(0.15)	0.89	1.03	N.S.	0.05	N.S.
% Stage REM	21.60(1.70)	25.30	24.20	N.S.	N.S.	N.S.
Stage 2 Time	3.98(0.42)	3.39	3.22	0.05	0.05	N.S.
% Stage 2	51.20(5.10)	45.50	42.60	N.S.	0.05	N.S.
Stage 3 Time	0.75(0.11)	0.85	0.78	N.S.	N.S.	N.S.
% Stage 3	9.70(1.40)	11.60	10.30	N.S.	N.S.	N.S.
Stage 4 Time	0.25(0.07)	0.28	0.25	N.S.	N.S.	N.S.
% Stage 4	3.20(0.90)	3.80	3.30	N.S.	N.S.	N.S.
Transitions / Hr.	47.00(7.00)	44.00	47.30	N.S.	N.S.	N.S.

Subject: J.H.

* Mann-Whitney U Test

Table IV.

	AVERAGE VALUES			BETWEEN GROUP COMPARISONS * (P=0.05)		
	Pre-bedrest	Bedrest	Post-bedrest	Pre-bedrest vs. Bedrest	Pre-bedrest vs. Post-bedrest	Bedrest, vs. Post-bedrest
Total Time in Bed	8.05(0.01)	8.06	8.04	N.S.	N.S.	N.S.
Total Sleep Time	7.67(0.02)	7.34	7.68	N.S.	N.S.	N.S.
Total Sleep Percent	95.40(0.30)	91.00	95.50	N.S.	N.S.	N.S.
Total Awake Time	0.37(0.03)	0.73	0.37	N.S.	N.S.	N.S.
1 st 3rd	0.13(0.05)	0.59	0.15	N.S.	N.S.	0.05
2 nd 3rd	0.06(0.07)	0.08	0.10	N.S.	N.S.	N.S.
3 rd 3rd	0.18(0.07)	0.07	0.12	0.02	N.S.	0.05
Sleep Latency	0.16(0.09)	0.62	0.17	N.S.	N.S.	N.S.
REM Latency	1.86(0.77)	1.07	1.92	0.05	N.S.	0.02
Number of Awakenings	17.30(8.00)	9.60	11.80	N.S.	N.S.	N.S.
1 st 3rd	1.70(2.10)	1.08	1.00	N.S.	N.S.	N.S.
2 nd 3rd	5.30(4.90)	3.10	3.30	N.S.	N.S.	N.S.
3 rd 3rd	10.30(3.50)	5.40	7.50	0.02	N.S.	0.05
Number of REM Periods	8.00(1.00)	10.80	8.70	N.S.	N.S.	N.S.
1 st 3rd	1.70(0.60)	2.80	1.50	N.S.	N.S.	N.S.
2 nd 3 rd	3.00(1.00)	3.50	2.50	N.S.	N.S.	N.S.
3 rd 3rd	3.30(1.50)	4.40	4.70	N.S.	N.S.	N.S.
Stage 1 Time	0.48(0.03)	0.40	0.50	N.S.	N.S.	0.02
% Stage 1	6.20(0.40)	5.50	6.50	N.S.	N.S.	N.S.
Stage REM Time	1.55(0.40)	1.78	1.45	N.S.	N.S.	0.02
1 st 3rd	0.09(0.01)	0.17	0.15	N.S.	N.S.	N.S.
2 nd 3rd	0.74(0.42)	0.61	0.44	N.S.	N.S.	N.S.
3 rd 3rd	0.72(0.03)	1.00	0.86	N.S.	0.05	N.S.
% Stage REM	20.20(5.20)	24.00	18.90	N.S.	N.S.	0.02
Stage 2 Time	4.56(0.50)	3.92	4.39	N.S.	N.S.	N.S.
% Stage 2	59.40(6.40)	53.30	57.10	N.S.	N.S.	N.S.
Stage 3 Time	0.91(0.26)	1.01	1.07	N.S.	N.S.	N.S.
% Stage 3	11.80(3.30)	13.90	14.00	N.S.	N.S.	N.S.
Stage 4 Time	0.18(0.21)	0.22	0.28	N.S.	N.S.	N.S.
% Stage 4	2.40(2.80)	3.10	3.60	N.S.	N.S.	N.S.
Transitions / Hr.	48.00(8.00)	51.20	52.50	N.S.	N.S.	N.S.

Subject: R.T.

* Mann-Whitney U Test

Table V.

Subject: J.H.

	AVERAGE VALUES				BETWEEN GROUP COMPARISONS * ($P \leq 0.05$)		
	Pre-bedrest	Bedrest, First Half	Bedrest, Second Half	Post-bedrest	Pre-bedrest vs. Bedrest, First Half	Pre-bedrest vs. Bedrest, Second Half	Pre-bedrest vs. Post-bedrest
Total Sleep Time	7.77	7.72	7.23	7.55	N.S.	0.02	N.S.
Sleep Latency	0.13	0.21	0.59	0.17	N.S.	N.S.	N.S.
REM Latency	1.00	1.11	0.62	1.16	N.S.	N.S.	N.S.
No. of Awakenings	16.30	17.00	19.90	25.20	N.S.	N.S.	0.05
No. of REM Periods	16.70	18.40	21.00	24.20	N.S.	N.S.	0.05
% Stage 1	14.30	12.60	14.80	19.60	N.S.	N.S.	N.S.
% REM	21.60	25.70	25.00	24.20	0.05	N.S.	N.S.
% Stage 2	51.20	47.80	43.90	42.60	N.S.	0.05	0.05
% Stage 3	9.70	10.10	12.60	10.30	N.S.	0.05	N.S.
% Stage 4	3.20	3.90	3.70	3.30	N.S.	N.S.	N.S.

* Mann-Whitney U Test

Table VI.

Subject: R.T.

	AVERAGE VALUES				BETWEEN GROUP COMPARISONS * ($P \leq 0.05$)		
	Pre-bedrest.	Bedrest, First Half	Bedrest, Second Half	Post-bedrest	Pre-bedrest vs. Bedrest, First Half	Pre-bedrest vs. Bedrest, Second Half	Pre-bedrest vs. Post-bedrest
Total Sleep Time	7.67	7.66	7.10	7.68	N.S.	0.01	N.S.
Sleep Latency	0.16	0.25	0.89	0.17	N.S.	0.01	N.S.
REM Latency	1.86	1.38	0.85	1.92	N.S.	0.05	N.S.
No. of Awakenings	17.30	9.60	9.60	11.80	N.S.	N.S.	N.S.
No. of REM Periods	8.00	12.00	9.90	8.70	N.S.	N.S.	N.S.
% Stage 1	6.20	5.20	5.80	6.50	0.05	N.S.	N.S.
% REM	20.20	24.80	23.80	18.90	N.S.	N.S.	N.S.
% Stage 2	59.40	56.30	51.20	57.10	N.S.	0.05	N.S.
% Stage 3	11.80	12.40	15.00	14.00	N.S.	N.S.	N.S.
% Stage 4	2.40	1.30	4.30	3.60	N.S.	N.S.	N.S.

* Mann-Whitney U Test

Table VII.

COMPARISON OF SKYLAB, BEDREST, AND S.M.E.A.T. RESULTS

SLEEP CHARACTERISTICS	INCIDENCE OF ALTERED SLEEP CHARACTERISTICS (Percentage of Group Membership)			% CORRELATION $\frac{n_1 \times n_2 \cdots n_x}{10^{2X-2}}$		
	SKYLAB n=3	BEDREST n=2	S.M.E.A.T. n=2	OVERALL	SKYLAB & BEDREST	SKYLAB & S.M.E.A.T.
Increased During Exposure						
Sleep Latency	33	100	50	17	33	17
Stage 2	0	0	50	0	0	0
Stage 3	100	100	50	50	100	50
Stage 4	33	50	50	8	17	17
Stage REM	0	100	0	0	0	0
Decreased During Exposure						
Sleep Latency	33	0	0	0	0	0
Sleep Time	67	100	50	34	67	34
Stage 1	67	50	100	34	34	67
Stage 2	33	100	0	0	33	0
Stage 3	0	0	50	0	0	0
Stage 4	33	0	50	0	0	17
Stage REM	67	0	50	0	0	34
REM Latency	0	100	0	0	0	0
Increased Post-Exposure						
Sleep Time	33	0	0	0	0	0
Stage 1	33	50	0	0	17	0
Stage 2	33	0	50	0	0	17
Stage REM (>R+3)	100	50	100	50	50	100
Decreased Post-Exposure						
Sleep Latency	33	0	0	0	0	0
Stage 1	0	0	100	0	0	0
Stage 2	0	50	0	0	0	0
Stage 3	100	0	50	0	0	50
Stage 4	100	0	50	0	0	50
Stage REM (<R+3)	33	0	0	0	0	0
REM Latency (>R+3)	100	0	0	0	0	0

MONITORING INBED SPONTANEOUS ACTIVITY

Data Base Modifications, Analysis, and Discussion of Results

by

Dan Rinks

During the last bedrest study, the inbed activity monitoring allowed us to assess the importance of spontaneous low grade activity in the horizontal plane during bedrest. Investigators have taken different approaches to this problem: Dietrick placed his subjects in plaster casts; Hyatt allowed his subjects low grade activity in the horizontal plane, similar to what was allowed in this study; and Saltin allowed the subjects not only low grade activity in the horizontal plane, but also allowed the subjects to sit for meals and reading. In addition they were allowed bathroom privileges, but they were never allowed to stand. Qualitatively similar postbedrest changes were found in each of these studies. In our 2 week study the subjects demonstrated different degrees of spontaneous activity during bedrest, but we found no correlation between the extent of any measured change and the amount of inbed activity recorded by the inbed monitor. In fact, the most restless and active subject showed the greatest change postbedrest in not only exercise and orthostatic tolerance, but also red cell mass, and electrolyte balance. Thus our 2 week bedrest study has confirmed what could be inferred from the literature: that non-strenuous inbed spontaneous activity, designed to ease the rigors of the inbed environment, has no measureable effect on the results obtained. To confirm these findings, a more sophisticated system for monitoring inbed spontaneous activity was utilized during the second 28 day bedrest study.

METHODS: The methods employed for the primary collection of data are described elsewhere (See "Monitoring Inbed Spontaneous Activity" by Johnson, Mitchell, Grieder, and Dean in JSC/Methodist Hospital 28-Day Bedrest Study, Vol. I, Protocols). Prior to the actual analysis of data, several corrections to the data were performed. In particular, (1) the data were scaled to account for differences in potentiometer sensitivity and subject weights; (2) out-of-bed time periods were identified and the corresponding data points were eliminated; and (3) and $\log_{10}$ transformation was employed to minimize heterogeneity of variances. A relative rating of the subjects inbed activity was obtained.

SCALING CORRECTION FACTORS: The amplitudes of the signals from the potentiometers were arbitrarily set at levels that would result in acceptable traces for the strip charts. In addition, the primary data collection did not take into account the differences in amplitudes that would result because of the differences in subject weights. In order to correct for this arbitrary scaling, an experiment was conducted at the end of the study to determine appropriate scaling correction factors. The experiment consisted of recording the amplitudes for a monitor performing similar movements on all of the subjects' beds. The following formula was used to compute the scaling correction factors:

$$\left(\frac{\text{Monitor amplitude on subject bed}}{\text{Monitor weight}} \times \text{Subject weight}\right) \Big/ \text{Base}$$

where the Base was the score computed from the numerator for subject 3.

The multiplicative scaling factors obtained were:

Subject	1	1.1216
	2	0.8322
	3	1.0000
	4	1.3058
	5	1.1409
	6	0.7757

The primary collected data (M) were multiplied by the correction factors (CF) to obtain the corrected motion readings (CM) for each subject.

$$CM = M * CF$$

CORRECTION FOR OUT-OF-BED PERIODS: At various times, the subjects were removed from their beds for the purpose of conducting experiments. In addition, several in-bed experiments were conducted. Data collected in these time periods were considered to be contaminated and were eliminated from the study. The activity log was used as an approximate basis for the determination of contaminated data points. Whenever there were questions regarding the exact timing of experiments, a conservative approach was taken to insure that the contaminated data points were eliminated. This resulted in the loss of an insignificant amount of reliable data.

TRANSFORMATION OF DATA: The corrected data exhibited an extremely wide range, on the order of from 10^2 to 10^7. A preliminary analysis revealed that the variances of the subjects data were approximately proportional to the means of the subject data indicating that a logarithmic transformation was appropriate. A $\log_{10}$ transformation resulted in the variances of the subject data being much more homogeneous. All subsequent analyses used the $\log_{10}$ transformed data.

$$LOG\ M = \log_{10}(CM)$$

RESULTS: Mean levels of activity (means of LOG M) were computed for the subjects on two bases: 7 AM- 7 AM and 9 AM - 9 AM. Multiple Range Tests for the means of the two bases were computed. The results of the Multiple Range Tests are summarized in the Tables below.

Table 1

Count	Mean of $\log_{10}$ Transformed Data LOG M 7 AM - 7 AM	Multiple Range Test Duncan Procedure (.05 level) Homogeneous Subsets Subjects		
502	4.3183	5	Subset 1	(Least Active)
495	4.4913	4	Subset 2	↓
488	4.5289	6		
490	4.8929	1	Subset 3	
385	5.3121	2	Subset 4	
386	5.3207	3		(Most Active)

Table 2

Count	Mean of Log_{10} Transformed Data LOG M 9 AM - 9 AM	Multiple Range Test Duncan Procedure (.05 level) Homogeneous Subsets Subjects		
252	4.5479	5	Subset 1	(Least Active)
272	4.8677	4	Subset 2	↓
258	4.8756	6		
259	5.2744	1	Subset 3	
250	5.6192	2	Subset 4	
250	5.6554	3		(Most Active)

It should be noted that the ranking of the subjects into subsets indicating least active to most active are intended to be used as relative rankings only. The information contained in the collected data is not sufficient to make statements such as how active the most active participant was or to quantify the differences in activity levels between subsets.

When these ranks were compared with ranked changed obtained by other investigators (e.g. LBNP, stressed heart rate, calcium balance, blood volume, exercised heart rate) no correlation was obtained, thus confirming our findings of last year. In future bedrest studies it would seem overly rigid to demand complete immobilization; moderate low grade activity which aids in maintaining subject cooperation and disposition has not been proven to affect any of the deconditioning processes in either this 28 day study or the 14 day study.

Biostereometric Measurement of Subjects Undergoing 28-Days of Bedrest

by:

R. E. Herron, Ph.D.
Texas Institute for
Rehabilitation and Research
Houston, Texas

Chris W. Keys
Technology Incorporated
Houston, Texas

ABSTRACT

Biostereometrics, the science of measuring, and describing in mathematical terms, the three-dimensional form of biological objects, was used to analyze shape and volume changes occurring in six subjects during a 28-day bedrest study. The study was conducted to better understand the physiological changes observed in the Skylab crewmembers as a result of extended weightlessness. Biostereometric measurements made before and after these missions indicate a similarity to the volume changes which occurred as a result of the 28-day bedrest. The similarity was most noticeable in the abdomen, buttocks, thighs and calves, particularly when the values for the first few days post-flight and post-bedrest were compared. Changes in limb and partial body volumes measured using biostereometrics reflect fluid shifts as well as changes in fat deposits and muscle mass. Such information can contribute to a better understanding of the comparative physiology of extended space flight and long periods of bedrest.

INTRODUCTION

Weight change is often one of the more important biological parameters considered by investigators who are studying the effect of various factors upon an organism. Certainly, it is one of the easiest to obtain. Of even more value is the knowledge of weight (or mass) change in a particular body region. Biostereometrics, the science of measuring, and describing in mathematical terms, the three-dimensional form of biological objects, can provide specific volume change information about any body region. Armed with precise volume change data, investigators can make more informed estimates of changes in fat deposits, muscle mass, and fluid shifts which result from exposure to sustained weightlessness and other environmental changes.

Biostereometric measurements were made before and after all three Skylab missions to help in assessing the physiological changes resulting from long spaceflights. The findings of this investigation yielded quantitative data on the redistribution of body fluid away from the lower limbs, provided an additional method for estimating the caloric intake per day per kilogram of lean body mass, and permitted estimates of muscle atrophy in the legs (Whittle, 1976).

The 28-day bedrest study was undertaken to better understand the physiological changes which occur during extended bedrest and to compare how the two conditions (spaceflight and bedrest) affect the human body. The biostereometric measurements made as part of this bedrest study exposed similarities as well as obvious differences between the two conditions.

METHOD

Biostereometrics System

In the NASA biostereometrics system, two Hasselblad stereometric cameras are used to photograph the front and back of the subject simultaneously. A strobe projector, mounted at the center of each camera illuminates the subject with a random pattern of lines, enhancing the plottability of the skin surface. Two calibration units are used to determine the scale factors in the three orthogonal axes. The subject wears an elastic skull cap and an abbreviated athletic supporter; he stands in a standard pose so that differences due to changes in posture are minimized. The subject places his feet on "footprint" patterns attached to the top of an electronic weighing scale with digital readout, with the arms held straight, alongside the body and palms toward the rear, approximately 10 cm from the thighs (Figure 1). Simultaneous front and rear stereophotos are taken on 6.5 x 6.5 cm glass plates, made at the moment the subject is judged to be at the minimum lung volume in a normal breathing cycle. Weight, date, time of day, and subject ID number from digital displays are recorded in the exposed image.

Plotting and Digitization

The glass plates are enlarged to 10 x 10 inches and placed in a Kern PG-2 stereoplotter which, through a metrigraphic terminal, punches the coordinates on IBM computer cards. The scales in the three orthogonal planes are derived from steel tapes and rods of known length attached to the calibration units in the stereo image. The front and back stereopairs are scaled independently. Plotting of the subject begins with the highest point of the head for the

front stereopair and moves from side to side working downwards. Successive plotting levels are determined from the markings on the steel tape. The levels are separated by 5 cm over most of the body with special cross-sections taken at the arm pits and crotch line. The same tape is used to fix plotting levels for the back stereopair, thereby assuring a match between the levels for the front and back of the body.

Initial Data Processing

The card deck is processed by a computer program which calculates the scale factors, shifting front and back coordinates to a common coordinate system, converting the raw coordinates into centimeters, matching the fronts and backs, and output to magnetic storage a level-by-level coordinate description. Cross-sections of each level is plotted on microfilm and examined. Any stereoplotting errors which may be found are corrected, and frontal and profile views are plotted on graph paper by a program using the processed level-by-level data.

Analysis of Data

In the present study, the cross-sectional area of the body at each plotted level was computed automatically, using a specially designed computer program. Areas invisible to the cameras were interpolated. Curve-fitting techniques were used to derive the cross-sectional area at 1 mm intervals over the head and trunk, and both arms and legs. The volume of a body segment under examination was calculated by integrating the cross-sectional areas between the previously determined landmarks. Volume comparisons

shown as percent changes were made between the pre-bedrest value and each of the post-bedrest values for the arms, chest, abdomen, buttocks, thighs, and calves for all six subjects.

RESULTS

The regional body volumes are given in Table 2 through Table 8 along with the changes from the values obtained one day before bedrest. The weights (accurate to 100 g) at the exact moment of biostereometric measurement are given in Table 1. The total body volumes are calculated separately from the regional body volume determinations in Table 8. Dividing the weight by the corresponding total volume yields the subject's density as shown in Table 9. Table 10 details the calculated total body surface area.

Percent changes in regional body volume for each subject along with the corresponding weight changes are shown in Figures 2 through 7. The comparative weight changes for all subjects are given in Figure 8. Figures 9 through 15 show the individual volume changes for each major body region.

The percent changes in mean regional body volumes from those recorded one day before bedrest for each measurement day are given in Figure 16 along with the corresponding changes in mean weight.

The six subjects can be divided in two groups; those who gained weight, and those who lost weight (Figure 8). The mean regional body volumes are shown for each of these subgroups in Figures 19 and 20.

DISCUSSION

While the chest is the largest single body region, it is also the most difficult region to measure accurately. The measurements were made at the moment of minimum lung volume in a normal breathing cycle as determined by the photographer. In a situation where a discrepancy of 140 ml can mean a 1.0 percent change in chest volume, it is obviously important to account for lung volume variations.

Inspection of Figure 14A shows an inconsistency in mean density values which should not have varied more than 0.1 percent. A negligible change in body density is ascribable to changes in muscle mass and fluid volume since each has a density of 1.0. Bone mass, with a density of 1.85, probably doesn't change appreciably during a 4-week period, leaving only a change in fat volume (density 0.91) to account for body density changes. Although several subjects underwent as much as a four percent weight change during the bedrest, the mean weight for all six subjects remained almost unchanged (Figure 17) which seems to rule out the effects of fat volume changes on the mean body densities recorded in this study.

On the assumption that irregularities in lung volume recordings were the major cause of body density inconsistencies (Figure 14A), new chest and abdomen volumes were calculated (Table 12). The measured total volumes were corrected according to a formula derived to resolve differences between volumes obtained using biostereometric techniques and volumes of the same subjects obtained from hydrostatic weighing, where $V_w = -1.7946\ l + 0.9859\ V_{st}$. Using the BR-1 mean density as a standard, total volumes were

recalculated using the respective mean weight of each subject and the difference between the two new total volumes computed. One-half of each difference was added to the respective chest volume while one-fourth of each difference was added to the respective abdomen volume. Figure 14B shows the adjusted changes in these volumes. While this approach is somewhat subjective, it may provide a more accurate estimate of the changes that actually took place.

Using these new values, it seems (Figure 14B) that mean chest volume increased as a result of bedrest. The mean abdomen volume increased approximately 2.5 percent in response to bedrest, rose a bit more as a result of the ingested saline solution and then fell back to near pre-bedrest levels. This suggests that much of the fluid that disappeared from the legs may have shifted to the abdomen.

Volume changes in the buttocks reflect changes in weight, but in a more exaggerated manner. A caloric intake requirement per day per kilogram of lean body mass could be determined from these buttock volumes for comparism with the figure arrived at by Whittle et al. (1976) of 49 Kcal/day/Kg LBM for weightless conditions. Unlike the legs which gained volume in the post-bedrest period and the abdomen which lost volume, the buttocks showed no net change in volume as a result of bedrest, suggesting that this region neither lost nor gained an appreciable amount of fluid. It appears that the buttocks did, however, respond to net changes in body fluid volume on day R+1 (Figure 17) in response to the one liter of ingested saline solution and day R+0 following the biostereometric measurement. The mean volume change

in the buttocks of the weight gainers dropped during the first post-bedrest day as opposed to the respective volume change in the weight losers which increased (Figures 19 and 20).

Thigh volume changes, somewhat like the changes seen in the buttocks, are related to weight changes. Figures 19 and 20 reveal the different responses seen in thigh volume as related to weight gain or loss. The mean thigh volume of the weight gainers, for the most part, showed a gain over pre-bedrest values with the low point actually coming two days following bed-rest, which points to an increase in fat in this region. The increase in thigh volume following day R+2 suggests that, indeed, lost fluid was being replaced in the thighs of the weight gainers.

In contrast, post-bedrest volume changes in the thighs of the weight losers were markedly different. The thighs in these individuals showed the greatest loss in volume for any body region in this group, which suggests that an appreciable amount of both fat and fluid were lost along with some muscle mass.

The calves, with the greatest hydrostatic pressure gradient, showed the largest overall loss in volume due to bedrest of any of the body regions (Figure 17). Calf volume showed the most significant change ($P < 0.01$) over pre-bedrest levels with a decrease of 3.7 percent. By day R+2, the mean volume was within 0.4 percent of the value attained by the end of the 8-day recovery period. Again, the contrast between the weight gainers and the weight losers is quite evident. In the weight gainers, the mean calf

volume dropped slightly below the R+0 value on day R+2 and then rose to within 0.3 percent of the pre-bedrest value. Calf volume in the weight losers, on the other hand, showed a sharp increase during the first recovery day and an additional but much smaller increase the next day, but dropped slightly by day R+8.

The accurate determination of arm volumes is greatly affected by the reproducibility of the vertical cut-off planes at the shoulders. However, the trend in changes in arm volume from BR-1 can be gauged from Figure 17 which follows closely changes seen in the abdomen and chest. Problems encountered in determining cutoff values can be overcome by adding a few strategically placed landmarks in the shoulder region prior to photography which had not been included in the present protocol.

CONCLUSIONS

In this bedrest study there was a shift in body fluid away from the lower regions of the body and some muscle atrophy was clearly apparent. The major fluid accumulation was in the abdomen and chest region, although the relative proportions are partially obscured by small variations in lung volume. Changes in weight were mainly reflected by an increase in buttocks volume (by a factor of from 1.6 to 2.0) which is consistent with previous observations that this region is a sensitive indicator of net changes in body fat. The variations in chest and abdomen volume seem to be inversely related to body density (Figure 14A) which implies not only that breathing influenced these volumes but that the expiratory reserve volume of the lungs was affected in a non-random manner by bedrest.

Interesting parallels were apparent between the response of the human body to prolonged space flight and to bedrest over a 28-day extended period. On the final Skylab mission biostereometric measurements were made on recovery day, the next day, and four days following recovery in addition to three pre-flight measurements. Figures 21 through 24 show the changes in post flight regional body volumes from the mean pre-flight values compared to the mean changes in post-bedrest volumes from values obtained the day before the bedrest began. Comparative volume changes in the thighs and calves between Skylab and Bedrest are similar although less pronounced in the bedrest subjects. Changes in buttock volumes more closely follow each other during the first two post recovery days than later in the recovery period.

A comparison of abdomen volume changes suggests a fundamental difference between the physiological effects of space flight, which causes a volume deficit, and bedrest, which causes a volume increase. There is strong evidence that much of the fluid which shifted from the lower portion of the body during weightlessness was removed from the body, while most of the fluid shifting from the lower portion of the body during bedrest moved to the abdomen and chest. This hypothesis is strengthened by comparing weight changes before, during and after the two experiences. The onset of weightlessness brings about a fairly rapid 3 to 4 percent decrease in weight with the reverse effect being observed after returning to a normal gravity situation. The onset of bedrest, on the other hand, brought about a very slight increase in weight followed by no significant overall change after the resumption of normal activities.

Biostereometrics is a relatively new science, but it is emerging as a powerful tool in the medical and biological sciences. The stereoscopic photographs of the bedrest subjects took no more than five minutes of the subjects' time for each measurement, but constitute a permanent and detailed record of each individuals body form, which may be re-examined at any future date, either to answer new questions, or to take advantage of the increased accuracy resulting from improvements in the analytical technique.

Table 1: Weight in Kilograms

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	76.60	74.50	-2.7	74.75	-2.4	74.88	-2.2	73.85	-3.6
2	70.10	67.75	-3.4	69.13	-1.4	68.55	-2.2	68.65	-2.1
3	73.50	74.20	1.0	74.55	1.4	73.85	0.5	75.10	2.2
4	62.65	61.85	-1.3	61.55	-1.8	61.55	-1.8	61.65	-1.6
5	74.80	78.05	4.3	78.00	4.3	77.05	3.0	77.10	3.1
6	64.85	65.10	0.4	66.75	2.9	65.30	0.7	65.40	0.8
Mean	70.42	70.24	-0.3	70.79	0.5	70.20	-0.3	70.29	-0.2
SD			2.8		2.7		2.1		2.6

Table 2: Chest Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	15.11	13.98	-7.5	14.64	-3.1	15.01	-0.6	14.77	-2.2
2	12.17	12.51	2.8	12.94	6.3	12.25	0.7	12.35	1.5
3	13.68	14.22	3.9	14.56	6.4	13.44	-1.8	14.08	2.9
4	12.76	12.65	-0.9	12.93	1.3	12.68	-0.6	12.66	-0.8
5	17.85	18.25	2.2	18.43	3.2	17.86	0.1	17.94	0.5
6	13.12	13.61	3.7	14.01	6.8	13.33	1.6	13.56	3.4
Mean	14.12	14.20	0.7	14.58	3.5	14.10	-0.1	14.23	0.9
SD			4.4		3.9		1.2		2.2

Table 3: Abdomen Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	14.30	14.32	0.2	13.98	-2.2	13.72	-4.1	13.86	-3.1
2	11.38	11.15	-2.0	11.59	1.8	11.22	-1.4	11.02	-3.2
3	11.91	12.25	2.9	12.49	4.9	11.88	-0.3	12.19	2.4
4	10.15	10.02	-1.3	10.10	-0.5	10.03	-1.2	9.99	-1.6
5	13.14	14.43	9.8	14.25	8.4	13.50	2.7	13.63	3.7
6	11.48	11.67	1.7	12.19	6.2	11.57	0.8	11.74	2.3
Mean	12.06	12.31	2.3	12.43	3.3	11.99	-0.3	12.07	0.3
SD			4.3		4.1		2.3		3.1

Table 4: Buttock Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	15.72	14.68	-6.6	14.86	-5.5	14.65	-6.8	14.70	-6.4
2	13.89	13.34	-4.0	13.60	-2.1	13.59	-2.2	13.67	-1.6
3	13.48	13.85	2.7	13.77	2.2	13.82	2.5	13.72	1.8
4	11.64	11.12	-4.5	11.42	-1.9	11.24	-3.4	11.39	-2.1
5	14.37	15.40	7.2	15.05	4.7	15.04	4.7	15.02	4.5
6	12.56	12.82	2.1	12.93	2.9	12.72	1.3	12.88	2.5
Mean	13.61	13.54	-0.5	13.60	-0.1	13.51	-0.7	13.56	-0.4
SD			5.3		3.8		4.2		3.9

Table 5: Thigh Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	12.75	12.31	-3.5	12.10	-5.1	12.32	-3.4	12.21	-4.2
2	10.83	10.16	-6.2	10.43	-3.7	10.54	-2.7	10.45	-3.5
3	12.22	12.23	0.1	12.18	-0.3	12.15	-0.6	12.34	1.0
4	9.20	8.57	-6.8	9.01	-2.1	8.89	-3.4	9.14	-0.7
5	10.36	10.63	2.6	10.66	2.8	10.55	1.8	10.63	2.6
6	9.95	9.70	-2.5	9.82	-1.3	9.82	-1.3	10.20	2.5
Mean	10.88	10.60	-2.6	10.70	-1.7	10.71	-1.6	10.83	-0.5
SD			3.6		2.8		2.0		2.9

Table 6: Calf Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	7.41	6.96	-6.1	7.26	-2.0	7.28	-1.8	7.14	-3.6
2	6.67	6.41	-3.9	6.56	-1.6	6.55	-1.8	6.55	-1.8
3	7.04	6.92	-1.7	6.98	-0.9	6.99	-0.7	7.03	-0.1
4	5.71	5.38	-5.8	5.45	-4.6	5.49	-3.9	5.50	-3.7
5	7.43	7.36	-0.9	7.48	0.7	7.37	-0.8	7.45	0.3
6	6.11	5.87	-3.9	5.90	-3.4	5.78	-5.4	6.00	-1.8
Mean	6.73	6.48	-3.7	6.60	-2.0	6.58	-2.2	6.61	-1.8
SD			2.1		1.9		1.9		1.6

Table 7: Arm Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	6.47	6.47	0.0	6.33	-2.2	6.42	-0.8	6.10	-5.7
2	5.88	5.78	-1.7	5.76	-2.0	6.03	2.6	5.71	-2.9
3	6.14	6.36	3.6	6.51	6.0	6.43	4.7	6.67	8.6
4	5.54	5.46	-1.4	5.64	1.8	5.47	-1.3	5.42	-2.3
5	6.91	6.91	0.0	7.48	8.2	6.67	-3.4	7.27	5.2
6	5.92	5.63	-4.9	6.01	1.5	5.73	-3.2	5.80	-2.0
Mean	6.14	6.10	-0.7	6.29	2.4	6.12	-0.3	6.16	0.3
SD			2.8		4.2		3.2		5.5

Table 8: Total Body Volume in Liters

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	79.67	76.84	-3.6	77.04	-3.3	77.19	-3.1	76.65	-3.8
2	69.98	67.96	-2.9	69.90	-0.1	69.20	-1.1	68.92	-1.5
3	73.21	74.92	2.3	75.71	3.4	73.36	0.2	74.20	1.3
4	63.85	62.04	-2.8	63.42	-0.6	62.61	-1.9	62.96	-1.4
5	80.75	83.50	3.4	83.20	3.0	81.43	0.8	81.90	1.4
6	67.48	67.35	-0.2	68.98	2.2	67.25	-0.3	68.07	0.9
Mean	72.49	72.10	-0.5	73.04	0.8	71.84	-0.9	72.12	-0.5
SD			3.0		2.6		1.4		1.8

Table 9: Body Density

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	0.962	0.970	0.8	0.970	0.9	0.970	0.9	0.964	0.2
2	1.002	0.997	-0.5	0.988	-1.4	0.991	-1.1	0.996	-0.6
3	1.004	0.990	-1.4	0.985	-1.9	1.007	0.3	1.012	0.8
4	0.981	0.997	1.6	0.970	-1.1	0.982	0.1	0.979	-0.2
5	0.926	0.935	0.9	0.938	1.2	0.946	2.1	0.941	1.6
6	0.961	0.967	0.6	0.968	0.7	0.971	1.0	0.961	-0.2
Mean	0.973	0.976	0.3	0.970	-0.3	0.978	0.5	0.976	0.3
SD			1.1		1.3		1.1		0.8

Table 10: Body Surface Area in Meter^2

Subject	BR-1	R+0	%Chg	R+1	%Chg	R+2	%Chg	R+7/8	%Chg
1	1.933	1.908	-1.3	1.920	-0.6	1.915	-0.9	1.914	-0.9
2	1.855	1.833	-1.2	1.862	0.4	1.833	-1.2	1.854	-0.5
3	1.878	1.911	1.8	1.914	1.9	1.912	1.8	1.906	1.5
4	1.764	1.716	-2.7	1.744	-1.1	1.729	-2.0	1.737	-1.5
5	2.025	2.065	2.0	2.059	1.7	2.037	0.6	2.049	1.2
6	1.794	1.785	-0.5	1.784	-0.6	1.794	0.0	1.810	0.9
Mean	1.895	1.870	-0.3	1.881	0.3	1.870	-0.3	1.878	0.1
SD			1.9		1.3		1.4		1.2

Table 11

Mean Regional Body Volume in Liters
For Skylab 4 Crew

	Mean Pre Flight	R+0	%Chg	R+1	%Chg	R+4	%Chg
Abdomen	11.16	10.59	-5.1	11.35	1.7	11.04	-1.1
Bottocks	12.93	12.89	-0.3	12.96	0.2	13.09	1.2
Thighs	9.02	8.59	-4.8	8.70	-3.5	9.03	0.1
Calves	5.98	5.53	-7.5	5.71	-4.5	5.86	-2.0

Table 12: Corrected Total Volume, Chest Volume and Abdomen Volume

	BR-1	R&0	R+1	R+2	R+7/8
$\bar{X}$ Total Volume	72.49	72.10	73.04	71.84	72.12
$\bar{X}$ Adj. Total Volume	69.68	69.27	70.22	69.04	69.31
$\bar{X}$ Weight	70.42	70.24	70.79	70.20	70.29
$\bar{X}$ Density	1.0106	1.0137	1.0081	1.0168	1.0141
Total Volume for D=1.0106	69.68	69.50	70.05	69.46	69.55
Δ Volume	0.0	0.21	-.17	0.42	.24
Volume added to Chest Volume	0.0	0.11	-.09	0.21	.12
Adj. Chest Volume	14.12	14.31	14.49	14.31	14.35
Volume Added to Abdomen Vol.	0.0	0.05	-.05	0.10	0.06
Adj. Abdomen Vol.	12.06	12.36	12.38	12.10	12.13

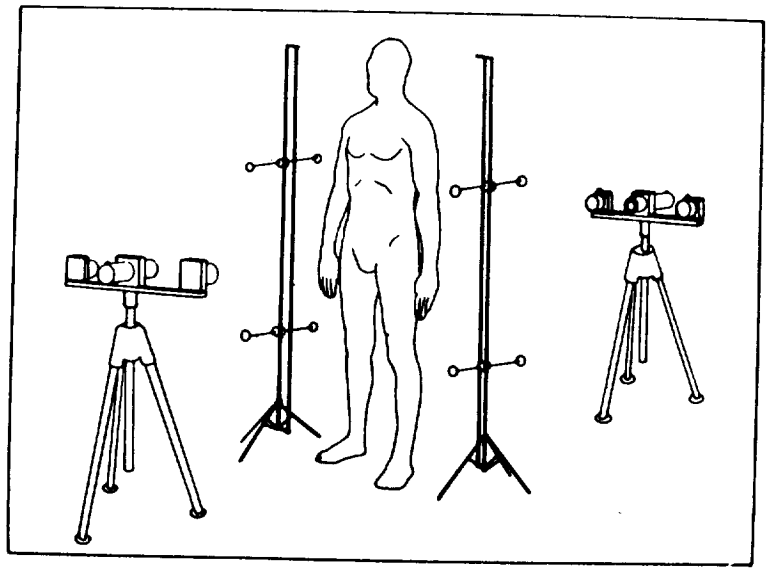


Fig. 1 Stereometric Equipment Used for Photographic Measurement

Percent Change in Regional
Body Volume from BR-1

Fig. 2

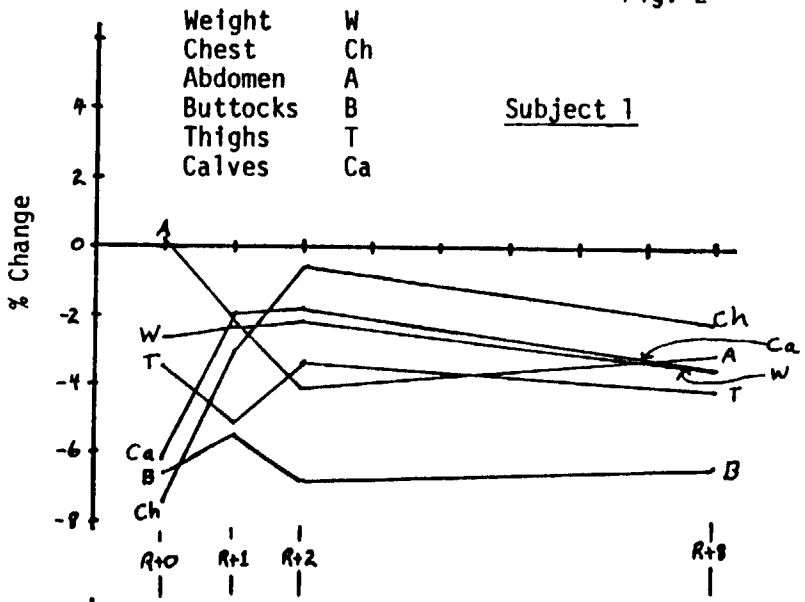


Fig. 3

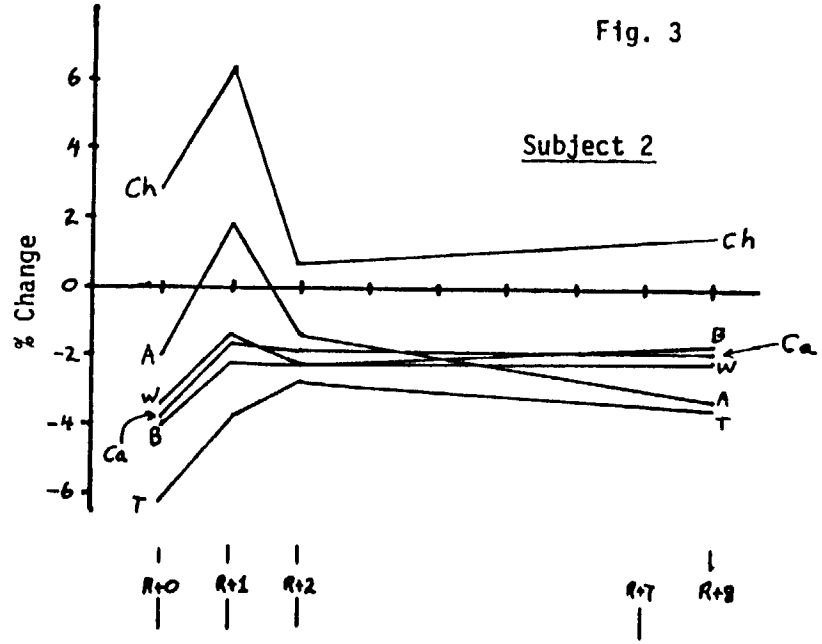


Fig. 4

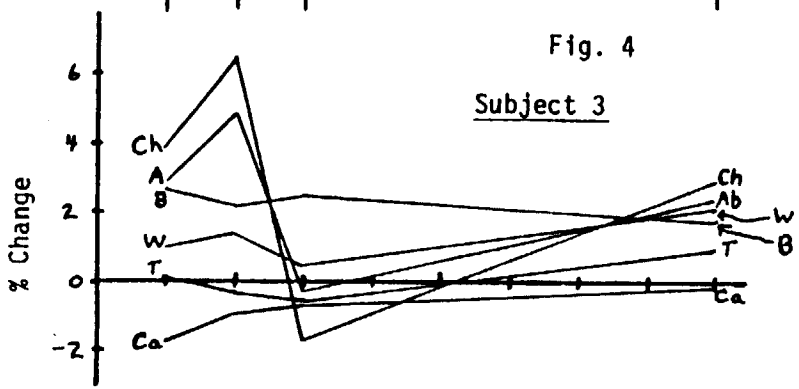
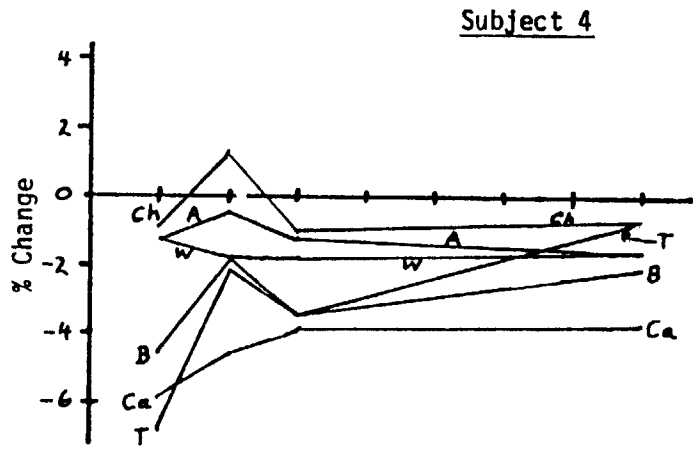


Fig. 5



Percentage Change in Regional Body Volume from BR-1 (Continued)

Fig. 6

Subject 5

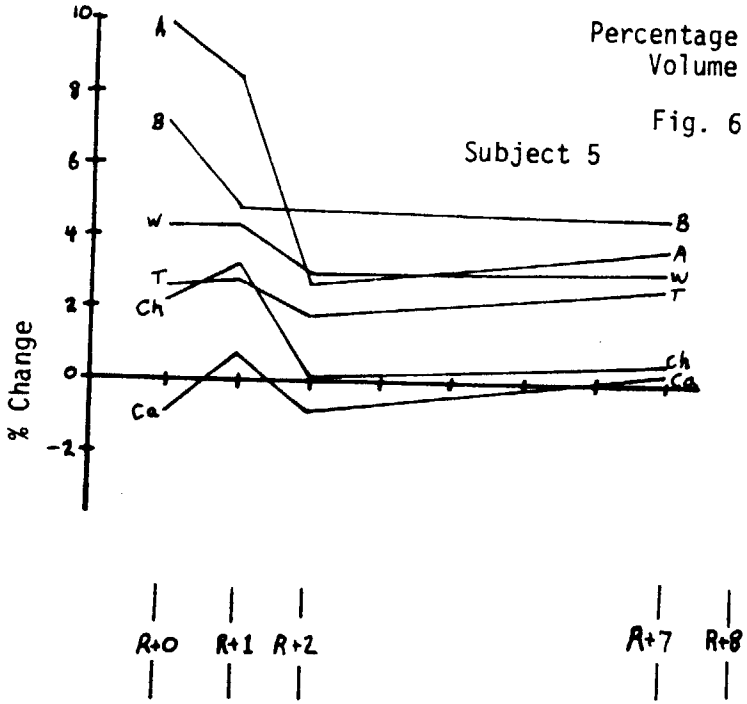


Fig. 7

Subject 6

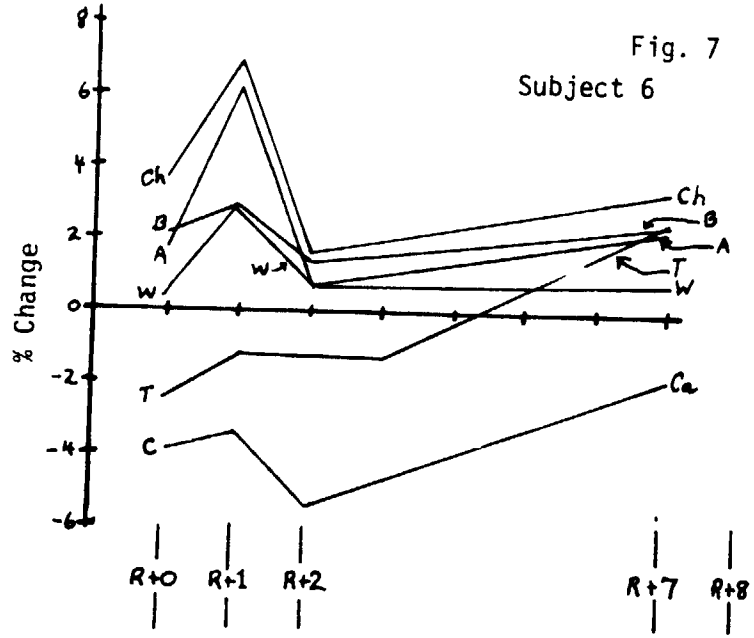


Fig. 8

Weight

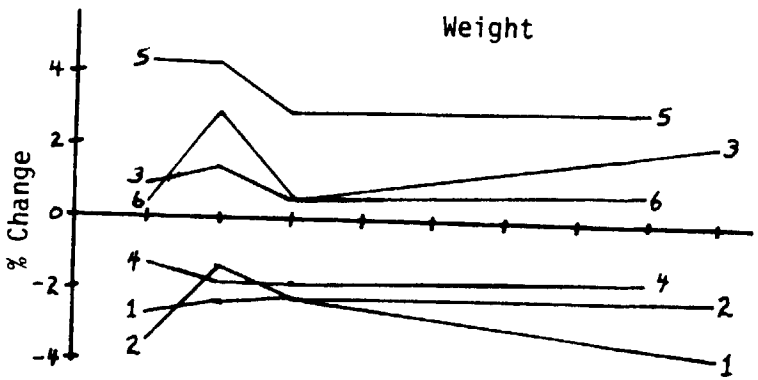
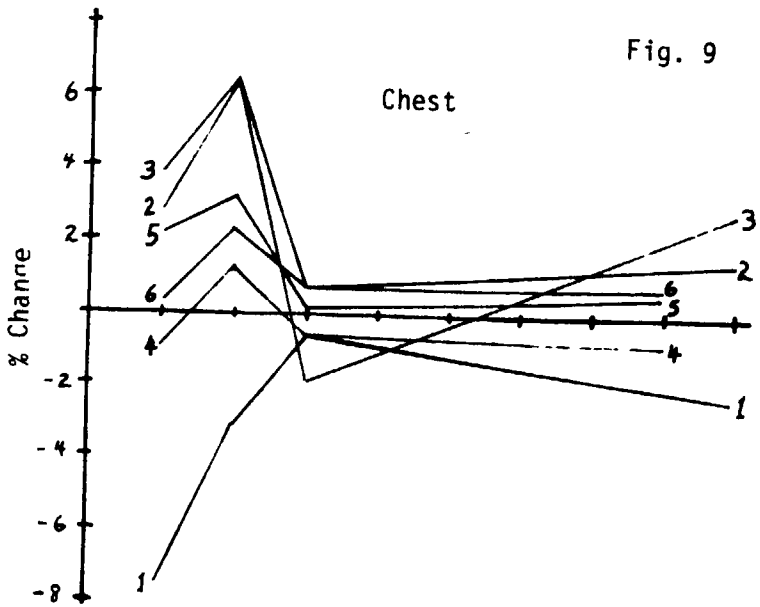


Fig. 9

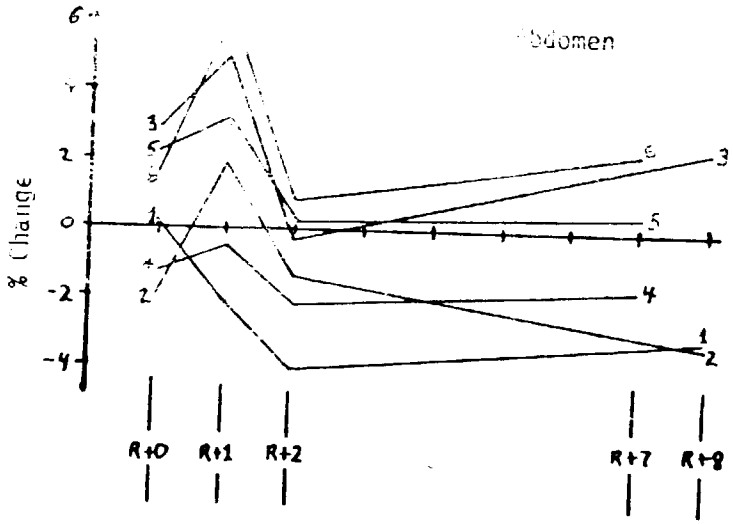
Chest



Percent Change in Regional
Body Volume from BR-1

Fig. 10

Abdomen



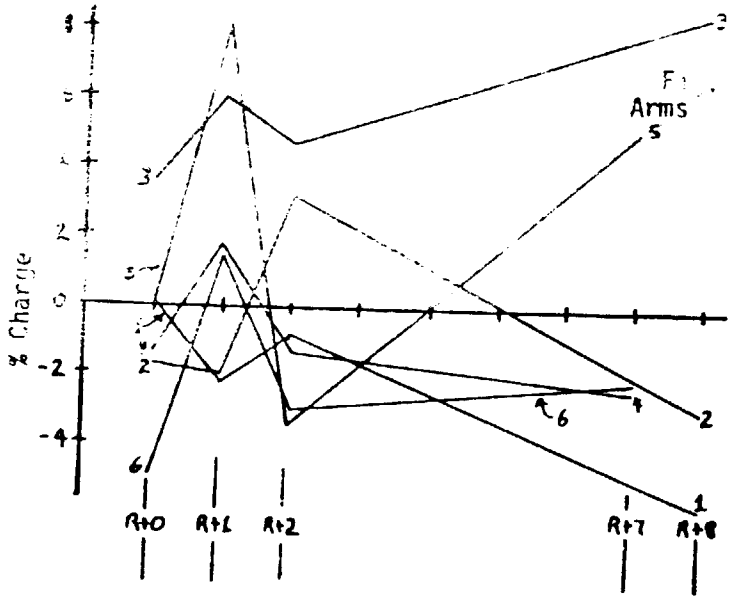


Fig. 12

Buttocks

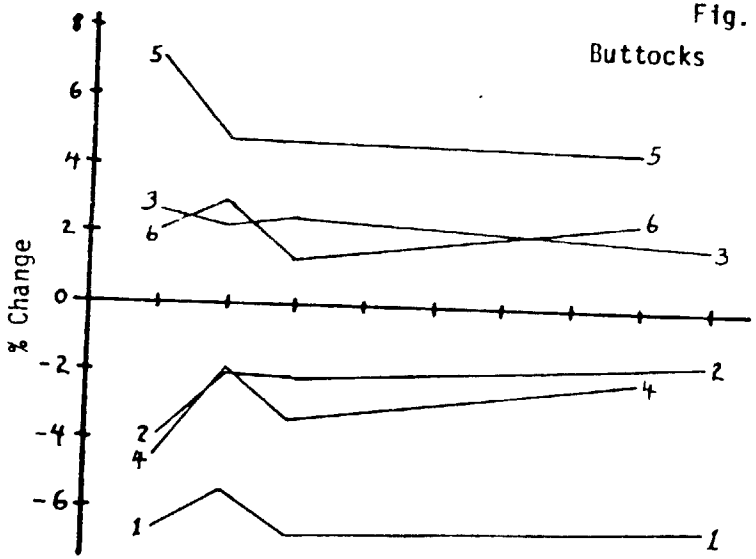


Fig. 13

Thighs

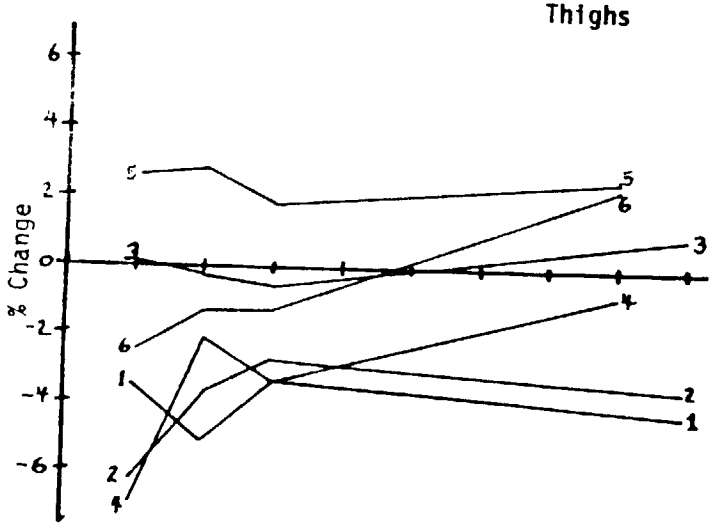


Fig. 14 Percent Change in Volume of Calves from BR-1

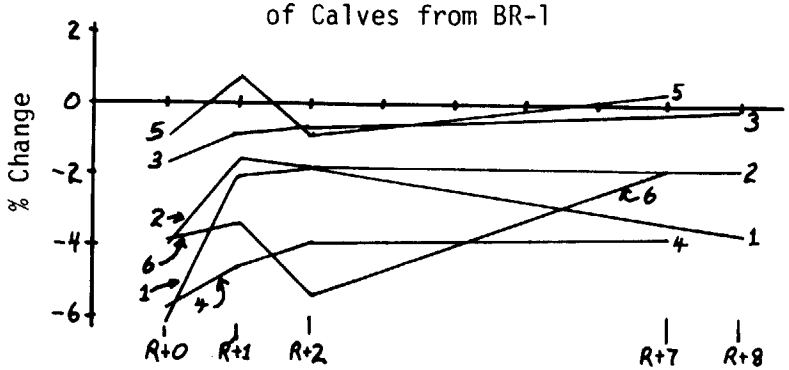


Fig. 14A Mean Percent Change in Abdomen and Chest Volumes from BR-1 Compared to Changes in Density Before Corrections due to Variations in Lung Volume.

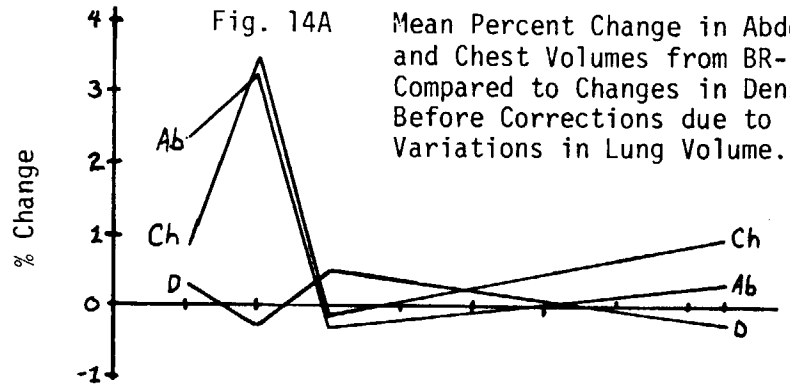


Figure 14B After Correction for Estimated Variations in Lung Volume

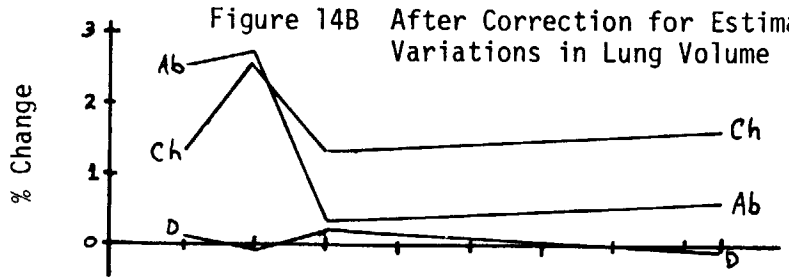


Fig. 15 Percent Change in Density from BR-1

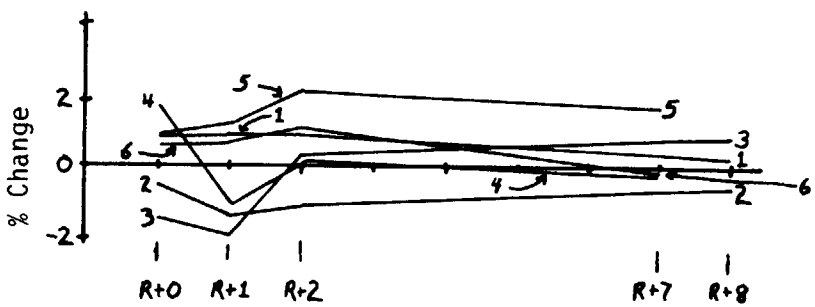


Fig. 16 Percent Change in Surface Area from BR-1

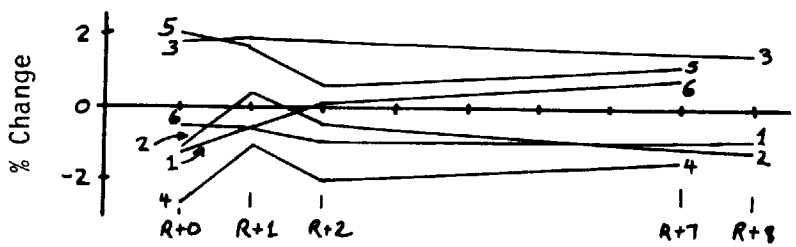


Fig. 17

Mean Percent Change in Regional Body Volume from BR-1 for all Six Subjects

Abdomen	Ab	Calves	Ca
Arms	Ar	Chest	Ch
Buttocks	B	Thighs	T

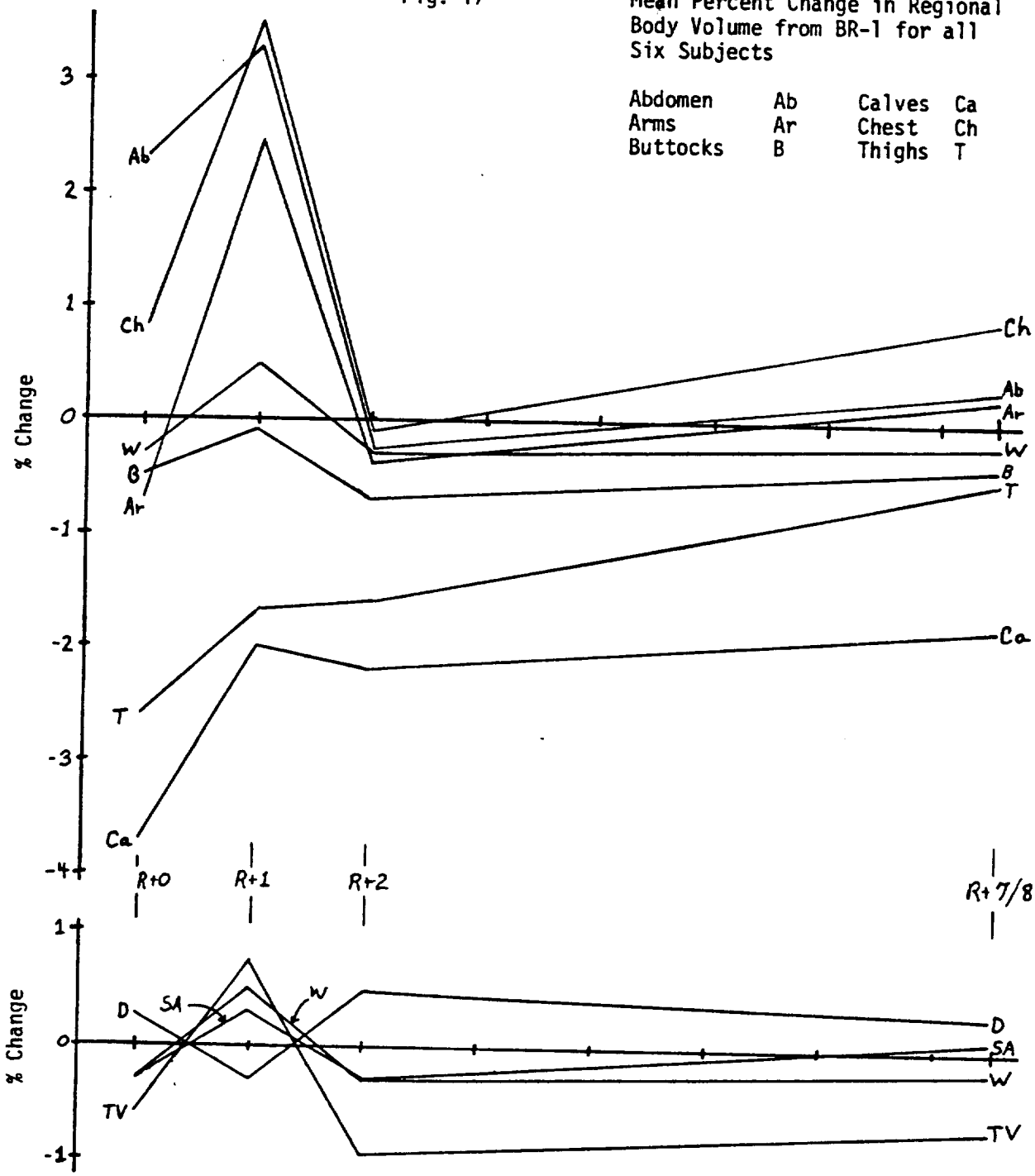


Fig. 18 Mean Percent Change in Density (D) Surface Area (SA), Total Volume (TV) and Weight (W).

Fig. 19 Mean Percent Change in Regional Body Volume from BR-1 for Weight Gainers, Subjects 3,5,6

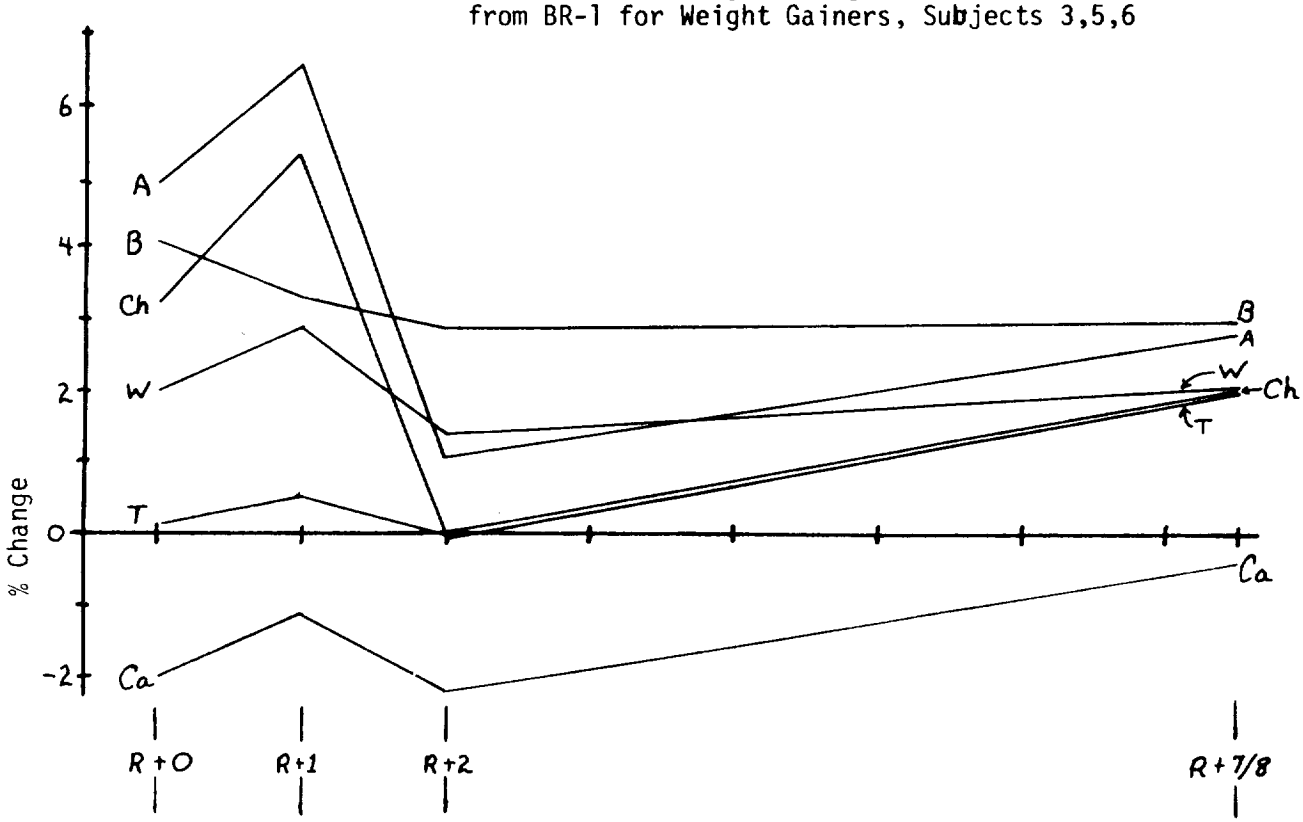
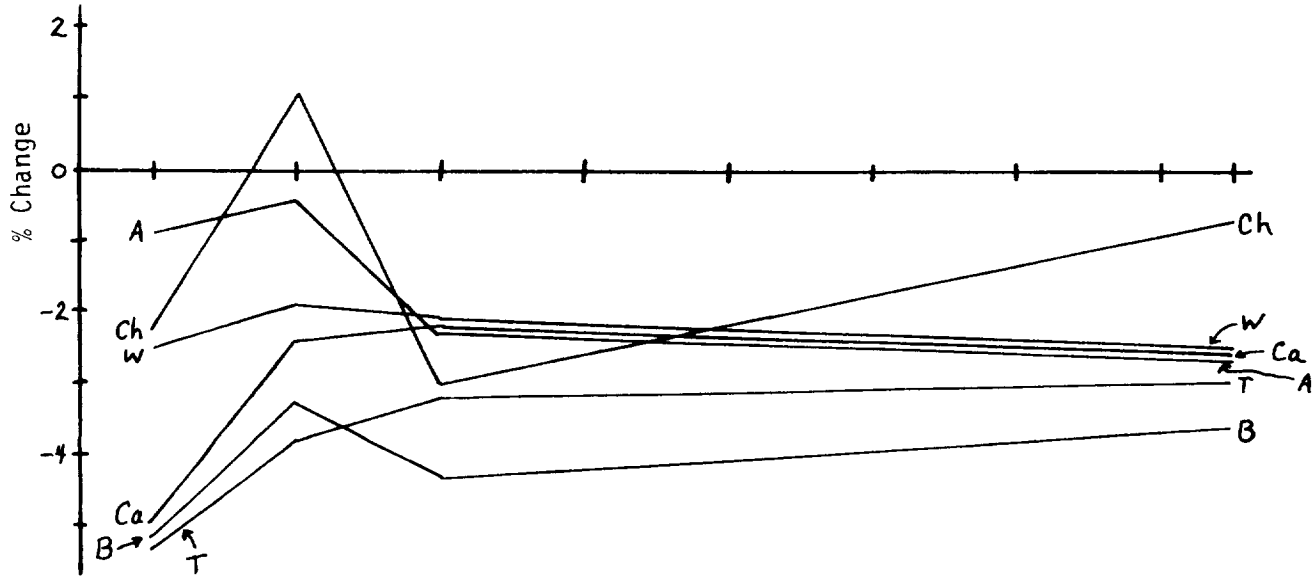


Fig. 20 Mean Percent Change in Regional Body Volume from BR-1 for Weight Losers, Subjects 1,2,4



Percent Change of Regional Body Volume from Pre Event Values;
Final Skylab Mission vs. 28-Day Bedrest

Fig. 21 Abdomen

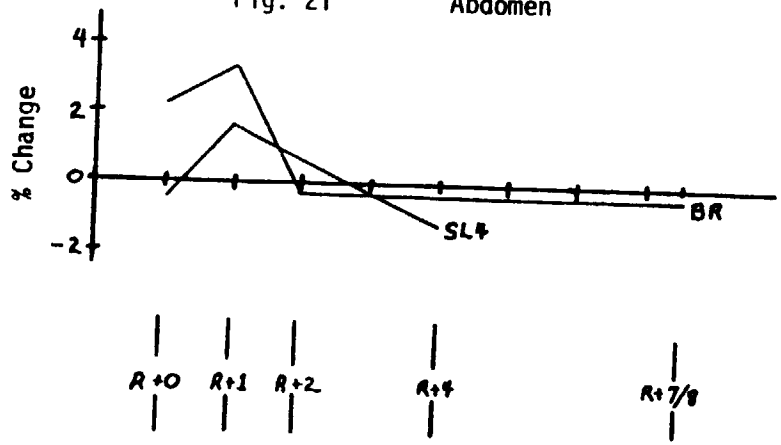


Fig. 22 Buttocks

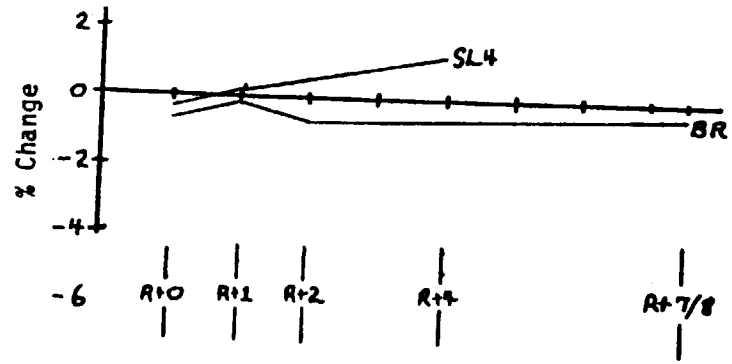


Fig. 23 Thighs

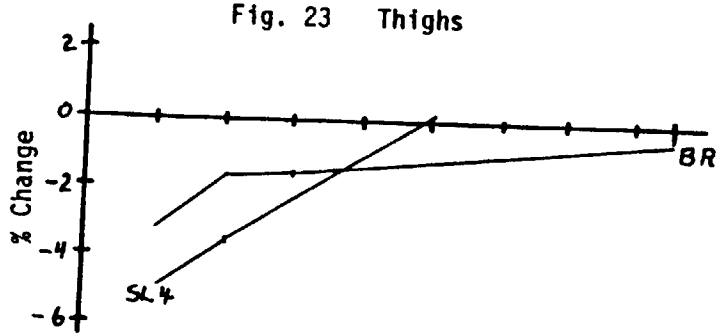
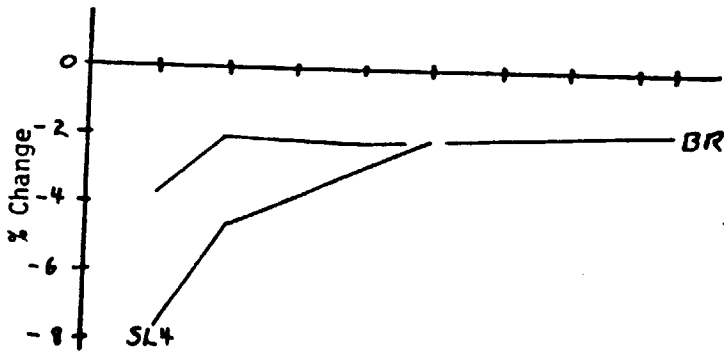


Fig. 24 Calves



Acknowledgment

The success of this project to measure body volumes of the bedrest subjects was made more certain by the efforts of John Hugg who played a major role in photographing the participants, to Jaime Cuzzi who designed the photographic equipment and a considerable portion of the computer software, and to Cheryl Miltenburger who plotted the stereo images.

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DISCUSSION

While the chest is the largest single body region, it is also the most difficult region to measure accurately. The measurements were made at the moment of minimum lung volume in a normal breathing cycle as determined by the photographer. In a situation where a discrepancy of 140 ml can mean a 1.0 percent change in chest volume, it is obviously important to account for lung volume variations.

Inspection of Figure 14A shows an inconsistency in mean density values which should not have varied more than 0.1 percent. A negligible change in body density is ascribable to changes in muscle mass and fluid volume since each has a density of 1.0. Bone mass, with a density of 1.85, probably doesn't change appreciably during a 4-week period, leaving only a change in fat volume (density 0.91) to account for body density changes. Although several subjects underwent as much as a four percent weight change during the bedrest, the mean weight for all six subjects remained almost unchanged (Figure 17) which seems to rule out the effects of fat volume changes on the mean body densities recorded in this study.

On the assumption that irregularities in lung volume recordings were the major cause of body density inconsistencies (Figure 14A), new chest and abdomen volumes were calculated (Table 12). The measured total volumes were corrected according to a formula derived to resolve differences between volumes obtained using biostereometric techniques and volumes of the same subjects obtained from hydrostatic weighing, where $V_W = -1.7946\ l + 0.9859\ V_{st}$. Using the BR-1 mean density as a standard, total volumes were

recalculated using the respective mean weight of each subject and the difference between the two new total volumes computed. One-half of each difference was added to the respective chest volume while one-fourth of each difference was added to the respective abdomen volume. Figure 14B shows the adjusted changes in these volumes. While this approach is somewhat subjective, it may provide a more accurate estimate of the changes that actually took place.

Using these new values, it seems (Figure 14B) that mean chest volume increased as a result of bedrest. The mean abdomen volume increased approximately 2.5 percent in response to bedrest, rose a bit more as a result of the ingested saline solution and then fell back to near pre-bedrest levels. This suggests that much of the fluid that disappeared from the legs may have shifted to the abdomen.

Volume changes in the buttocks reflect changes in weight, but in a more exaggerated manner. A caloric intake requirement per day per kilogram of lean body mass could be determined from these buttock volumes for comparism with the figure arrived at by Whittle et al. (1976) of 49 Kcal/day/Kg LBM for weightless conditions. Unlike the legs which gained volume in the post-bedrest period and the abdomen which lost volume, the buttocks showed no net change in volume as a result of bedrest, suggesting that this region neither lost or gained an appreciable amount of fluid. It appears that the buttocks did, however, respond to net changes in body fluid volume on day R+1 (Figure 17) in response to the one liter of ingested saline solution and day R+0 following the biostereometric measurement. The mean volume change

in the buttocks of the weight gainers dropped during the first post-bedrest day as opposed to the respective volume change in the weight losers which increased (Figures 19 and 20).

Thigh volume changes, somewhat like the changes seen in the buttocks, are related to weight changes. Figures 19 and 20 reveal the different responses seen in thigh volume as related to weight gain or loss. The mean thigh volume of the weight gainers, for the most part, showed a gain over pre-bedrest values with the low point actually coming two days following bed-rest, which points to an increase in fat in this region. The increase in thigh volume following day R+2 suggests that, indeed, lost fluid was being replaced in the thighs of the weight gainers.

In contrast, post-bedrest volume changes in the thighs of the weight losers was markedly different. The thighs in these individuals showed the greatest loss in volume for any body region in this group, which suggests that an appreciable amount of both fat and fluid were lost along with some muscle mass.

The calves, with the greatest hydrostatic pressure gradient, showed the largest overall loss in volume due to bedrest of any of the body regions (Figure 17). Calf volume showed the most significant change ($P < 0.01$) over pre-bedrest levels with a decrease of 3.7 percent. By day R+2, the mean volume was within 0.4 percent of the value attained by the end of the 8-day recovery period. Again, the contrast between the weight gainers and the weight losers is quite evident. In the weight gainers, the mean calf

volume dropped slightly below the R+0 value on day R+2 and then rose to within 0.3 percent of the pre-bedrest value. Calf volume in the weight losers, on the other hand, showed a sharp increase during the first recovery day and an additional but much smaller increase the next day, but dropped slightly by day R+8.

The accurate determination of arm volumes is greatly affected by the reproducibility of the vertical cut-off planes at the shoulders. However, the trend in changes in arm volume from BR-1 can be gauged from Figure 17 which follows closely changes seen in the abdomen and chest. Problems encountered in determining cutoff values can be overcome by adding a few strategically placed landmarks in the shoulder region prior to photography which had not been included in the present protocol.

CONCLUSIONS

In this bedrest study there was a shift in body fluid away from the lower regions of the body and some muscle atrophy was clearly apparent. The major fluid accumulation was in the abdomen and chest region, although the relative proportions are partially obscured by small variations in lung volume. Changes in weight were mainly reflected by an increase in buttocks volume (by a factor of from 1.6 to 2.0) which is consistent with previous observations that this region is a sensitive indicator of net changes in body fat. The variations in chest and abdomen volume seem to be inversely related to body density (Figure 14A) which implies not only that breathing influenced these volumes but that the expiratory reserve volume of the lungs was affected in a non-random manner by bedrest.

Interesting parallels were apparent between the response of the human body to prolonged space flight and to bedrest over a 28-day extended period. On the final Skylab mission biostereometric measurements were made on recovery day, the next day, and four days following recovery in addition to three pre-flight measurements. Figures 21 through 24 show the changes in post flight regional body volumes from the mean pre-flight values compared to the mean changes in post-bedrest volumes from values obtained the day before the bedrest began. Comparative volume changes in the thighs and calves between Skylab and Bedrest are similar although less pronounced in the bedrest subjects. Changes in buttock volumes more closely follow each other during the first two post recovery days than later in the recovery period.

SUMMARY AND CONCLUSIONS

by

Cheryl Mitchell, M.A. and Philip C. Johnson, M.D.

Bedrest is often used as a convenient analog for spaceflight, because it produces many of the same physiological effects. Through bedrest studies many changes have been documented, and a data base has been created for comparison with spaceflight data. Bedrest studies allow a larger, more diverse population to be tested with more sophisticated techniques, requiring more subject time than is frequently possible with flights. These studies also offer an opportunity to test proposed counter measures. Obvious differences in the two situations exist, however, which should be thoroughly understood before the utility of bedrest studies can be assessed.

Not found during this bedrest study was the desensitization to motion sickness occurring in all crewmembers inflight and early postflight. Post bedrest the marked deficit in postural stability and hyperreflexia seen postflight were also absent. These differences were not totally unexpected, since gravity even in the recumbent position still enables the semicircular canals to sense directional changes and since the bedrest environment, already known and familiar to the subject, does not require the central neural reorganization that the completely new weightless environment requires. The EEG sleep studies found that although bedrest produced changes which were even in certain instances clinically abnormal (e.g. decreased REM latency), that bedrest was not a good analog for studying spaceflight induced EEG changes. The sleep laboratory did not include the isolation, work load, and absence of pressure on the body of weightless spaceflight, but bedrest did produce certain psychological stresses peculiar to it. Suppression of the functional capacity of lymphocytes to mitogenic stress, seen after Skylab 3 and 4 and ASTP, was also not found.

In fact, bedrest produced a significant increase in WBC number and increased responsiveness to mitogenic stress. These findings support the theory that the suppression resulted primarily because crewmembers were not exposed to new antigenic stresses from foreign bacteria and viruses.

Other studies showed a more favorable correlation between bedrest and spaceflight changes, although in no case did bedrest exactly duplicate the spaceflight effect. Heart rates during maximum LBNP stress increased linearly with time (r=.94) during 28 days of bedrest, and leg volume decreased, showing a rapid first phase, due most likely to blood and ECF volume decreases or shifts, and a slower second phase, due to muscle atrophy. Biostereometric photos indicated that the spaceflight induced reduction of calf size (-8%) was approximately twice that produced by bedrest (-4%). Despite these similarities, bedrest did not duplicate spaceflight in producing the large shifts of fluid measured during inflight LBNPs. The increase in leg volume during maximum LBNP was 83% larger in space than on earth. In these studies no greater increase in leg volume was observed with LBNP during bedrest, even when plasma volume was expanded with saline during the crossover study. The vascular fluids must be far more labile in the gravity-less environment, and the fluid shifts are probably more dramatic, as evidenced by inflight "head fullness", LBNP induced leg distension, and postflight leg volume decreases.

ECF, measured using the $^{35}SO_4$ space, did not change significantly in either situation. The total blood volume decreases were quite similar after comparable periods of spaceflight and bedrest, although the red cell mass decrease was greater after spaceflight (15.1% compared to -6.7% after bedrest) and plasma volume decrease was greater after bedrest (-14.6% compared to -3.0%). After the 28 day Skylab II, blood volume was 92% of the control while after 28 days of bedrest blood volume was 89% of the control. The apparent blood

compartmental volume differences are partially narrowed by two findings of this study. First, plasma volume was found to have a diurnal variation, increasing about 200 ml between 7 AM and 2 PM. Since recovery plasma volumes were performed after the astronauts had been awake at least 8 hours during reentry and recovery procedures, whereas pre spaceflight and pre and post bedrest determinations were performed at 7 AM, the higher postflight plasma volumes could indicate the diurnal increase. Had the plasma volumes been 200 ml lower, the decrease after Skylab II would have been 9.5% compared with the 14.6% decrease of bedrest. Second, post bedrest red cell mass continued to decrease so that two weeks post recovery the red cell mass decrease (-12.1%) was almost twice as large as it was the last day of bedrest. It is possible that fragile or older cells,which were conserved because of the lack of exercise stress, were not conserved during spaceflight or were lost during the reentry and recovery procedures. Since the first post bedrest determination was at two weeks, we are unsure when the additional drop occurred. Post bedrest SEM red cell shape changes suggest that the lost red cells were abnormally shaped (non-discocytes). The bedrest induced increase in abnormally shaped red cells was not found on Skylab recoveries and no additional decrease in red cell mass was seen. The additional postbedrest drop makes the spaceflight and bedrest decreases quite comparable (-15.1% and-12.1%) although the time course of the changes appears different. During bedrest, the red cell mass has been found to decrease linearly with time up to 35 days,but postflight larger deficits in red cell mass were seen after the 28 day mission than the 59 or 84 day missions, so that the decrease might not be progressive after 35 days. The delayed increase in reticulocytes seen after Skylab II was not found after bedrest.

During bedrest, supine bicycle exercised heart rates were statistically significantly elevated by BR+21. Post bedrest bicycle testing (75 watt) showed elevated heart rates both in the upright and supine positions which

had not returned to prebedrest levels by R+13. During and post bedrest, cardiac outputs increased during exercise, a finding dissimilar to the findings of spaceflight and most other bedrest studies, where cardiac outputs usually remain the same or decrease. Other exercise induced changes were more variable even among the different spaceflights, so that no conclusions can be safely drawn about how well bedrest reproduced the effects of spaceflight. Isometric exercise testing showed an increased muscle fatigability post bedrest similar to that seen postflight.

Biochemical and endocrine changes of bedrest were similar in kind, but not in magnitude,to those produced by spaceflight. Like spaceflight, excretion of sodium, potassium, chloride, calcium, inorganic phosphate, cortisol, aldosterone, and ADH increased during bedrest as did plasma renin activity. Unlike spaceflight, T-3 and T-4 were not affected. Because of the pre bedrest variability in ADH, water intake and urine volume, it is impossible to determine if the Henry Gauer reflex is triggered by the transient central hypervolemia.

In addition to further documenting spaceflight induced changes, the present bedrest study, because of modifications in the Skylab protocol, allowed certain mechanistic theories of deconditioning to be analyzed. Mentioned by most investigators as contributive to deconditioning is the upward shift of vascular volume, interpreted by the body as a hypervolemia and resulting eventually in a decreased plasma volume. This homeostatic adaption of the fluid distribution to the space environment causes problems only when the astronaut or bedrest subject is suddenly resubjected to a longitudinal gravitational stress. The decrease in blood and plasma volume seen postflight or postbedrest has been associated with the LBNP and exercise changes, however, the exact relationship among the changes has not been determined.

Also important to the deconditioning of bedrest and of at least the early spaceflights is the relative inactivity of subjects or crewmembers. In most of the early missions the very athletic astronauts assiduously trained preflight, and they became abruptly inactive during flight. Muscle groups went unused, and the long bones of the body were no longer needed to support the body's weight, resulting in muscle and osseous atrophy. Not known is whether heart muscle shares in this atrophy. Heart size has been found to decrease post flight and post bedrest. These decreases have been seen even in the supine position post bedrest. Echocardiographic studies and left venticular function curves were performed or constructed only after the 84 day mission, when the inflight exercise levels were at their highest. After this mission no decrement in exercise tolerance was seen. The slight changes in stroke volume and cardiac size after this flight probably resulted from the decreased blood volume in that no significant alteration in cardiac function occurred (ventricular function curves). Skylab inflight and postflight systolic time interval analysis, however, showed decreased ejection time indexes and increased pre-ejection periods which could be explained only partially by the decreased blood volume, in that the systolic time interval changes remained abnormal even after the blood volume had returned to preflight levels. In Skylab II increased heart rates were seen inflight similar to those seen during supine exercise at 21 days of bedrest. These increases should be blood volume unrelated and are probably related to changes produced by the inactivity,in that thermally dehydrating normal subjects to produce plasma volume deficits of up to 25% does not cause increased heart rates except in the upright position. When more inflight exercise was performed in later Skylab flights, progressive increases in heart rate response to exercise were not seen. In our bedrest study, subjects showed slight lowering of

supine exercise heart rates at the beginning of bedrest, indicating that the lowered blood volume was adequate or even more suitable to the supine position. Only later (day 21) did the heart rates increase during supine exercise.

There appears, therefore, to be a factor resulting from the inactivity which contributes to the so called cardiovascular deconditioning, as well as a factor resulting from the decreased blood volume and from a possible ECF shift. Early,fluid volume deficits and redistribution are probably more important. When the literature is reviewed it appears that plasma volume decreases rapidly during bedrest reaching a 10% deficit in a few days. In our study the maximum deficit occurred at 3 weeks with a slight increase occurring between the third and fourth week. The red cell mass decrease appears linear at least up to 35 days (r=0.96). Although no significant decrease in ECF was shown at 27 days of bedrest, leg volume measurement showed an early decrease (approximately one week) too great to be accounted for only by blood volume changes, indicating an ECF shift of about 200 ml. This shift could further compromise the cardiovascular system during LBNP as fluid extravasation occurs during orthostatic or LBNP stress. Attempts to demonstrate an increased plasma extravasation during bedrest LBNPs have not been fruitful, but increases may be too slight to be measured with present techniques.

Later in bedrest, non blood volume related factors become important. Leg measurements show a continual gradual decrease in leg volume between 13 and 27 days, demonstrating muscle atrophy. Biostereometric analysis indicates that only part of the decrease is repleted by 2 days post recovery and that the legs remain smaller even at 8 days. While the major blood volume decreases occur early, the LBNP stressed heart rate increases linearly with time (r=.94), and the two parameters are not correlated at either 13 or 27 days. Heart rates during exercise (supine and upright) also remain elevated 14 days post recovery, when blood volume is close to prebedrest values, and

exercise stressed heart rates are increased during bedrest when blood volume ought to be adequate and when venous return is facilitated. The crossover study at days 13, 14 and 15 of bedrest, testing the LBNP + saline counter measure, showed that the increase in plasma volume with saline therapy alone was double that of LBNP + saline, although the LBNP + saline treatment showed the greatest protective effect with regard to LBNP testing. Plasma volume remained more elevated the morning after LBNP + saline therapy than it did after the other treatments, but LBNP stressed heart rates and leg volume measurements had returned to pretreatment levels.*

* See Red Cell Mass and Plasma Volume Report for a more thorough discussion of the results.

I. Biochemical

1. Mean urinary excretion of cortisol increased 26%, aldosterone increased 20% ($p<0.03$) and ADH increased 48% during the period of bedrest.

2. Cortisol and ADH remained elevated while aldosterone returned to prebedrest levels after the subjects were up and about.

3. Urinary excretion sodium ($p<.001$), potassium ($p<0.01$), chloride ($p<.01$), calcium ($p<.001$) and inorganic phosphate ($p<.02$) were also elevated during bedrest.

4. During the crossover urinary excretion of sodium, chloride, aldosterone, and cortisol were significantly elevated on the day of the LBNP + Saline treatment, while sodium and chloride were elevated with the saline treatment and aldosterone was decreased.

5. Plasma/serum glucose remained the same while insulin was elevated on BR+27 and during recovery. T-3 and T-4 were not significantly changed. Triglycerides were elevated not only during bedrest but on R+1. Ionized Calcium was elevated on BR+21, BR+27, R+6, and R+13.

6. Plasma angiotensin was elevated on both days 21 and 27 of bedrest.

II. Metabolic Balance

1. Subjects were in negative calcium balance prebedrest; excretion of calcium increased during bedrest.

III. Hematology and Immunology

SEM classification of red cells and erythrocyte stimulating activity.

1. There was a statistically significant and progressive decrease in the percentage of discocytes in bedrest and post bedrest (R+1) which returned to normal by R+13.

2. Erythrocyte stimulating activity of 5 of the 6 subjects peaked at BR+8 and R+0, remained high at R+6 and returned to control by R+13.

3. Reticulocyte percentages peaked at R+1 and remained high at R+13.

4. Significant increases of WBC were seen on R+0 after both the 14 and 28 day bedrest studies. There was no stress induced loss of lymphocytes on R+0, R+1, or R+3.

IV. Red Cell Mass and Body Volume Changes

1. No significant change in ECF or TBW occurred.

2. Plasma volume decreased 11.4% in 13 days, 16.4% in 21 days and 14.2% in 27 days.

3. Red cell mass decreased 3.1% in 13 days, 6.7% in 27 days and 12.1% by two weeks post bedrest.

4. No significant change in ferrokinetics occurred.

5. Saline treatment during the crossover study produced the largest plasma volume increase (+416 ml); LBNP + saline produced a 186 ml increase.

6. Plasma volume increases approximately 200 ml from 7 AM to 2 PM in normal, upright individuals on a high or low sodium diet and in supine individuals the first day of bedrest.

V. LBNP

1. Resting heart rate increased slightly during bedrest

   (Control) 56.5 bpm (21 days) 65.2 (27 days) 63.7

2. Heart rate during -50 LBNP

Prebedrest	BR+7-11	13	21	27	R+0	R+1	R+2	R+7
73.5	90.0	94.8	102.0	106.8	103.5	95.2	90.2	78.7

   Greatest increase during first 11 days 16.5 bpm; linear thereafter to end of bedrest; slight decrease between BR+27 and R+0; only slightly elevated by R+7.

3. Right arm circumference decreased .4 cm during bedrest and did not increase with LBNP and saline treatment on R+0. Left calf circumference decreased .8 cm during bedrest and increased .4 cm with treatment on R+0.

4. Left Leg Volume (resting) ml

BR-1	BR+7-11	13	21	27	R+0	R+1	R+2	R+7
7789	7600	7660	7560	7505	7620	7662	7764	7748

   Greatest decrease during first 11 days; additional gradual decline until BR+27; 115 ml increase between BR+27 and R+0; LBNP + saline treatment on R+0 increased leg volume to 7943 that PM; it decreased to 7662 by R+1.

5. Incremental increase in heart rate during -50 LBNP after various treatments:

Prebedrest	At Two Weeks (PM)			R+0 (PM)
Control	Nothing	Saline	Saline + LBNP	Saline + LBNP
+30%	+53%	+37%	+28%	+26%

During crossover, no carry over effect.

6. Stressed heart rate returned to pretreatment level by the next AM.

7. Resting leg volume after LBNP + saline treatment increased 4.5% at two weeks and 4.2% on R+0.

8. % Calf volume change during maximum LBNP stress was the same regardless of treatment

9. During -50 LBNP on R+0 post-LBNP + saline treatment, PEP/LVET ratio increased significantly.

10. Cardiothoracic ratios decreased in 4 out of 5 subjects (standard upright 6 ft. chest film).

VI. Bicycle Exercise

1. Resting heart rate increased slightly during bedrest ($p<.05$ on BR+21)

2. Supine 75 watt exercise:

   Heart rates decreased initially during bedrest, then gradually increased ($p<.05$ on BR+21). They remained elevated throughout postbedrest recovery period.

3. 5 Minute Recovery from supine exercise:

   Heart rates remained elevated from BR+14 through the end of the recovery period.

4. Upright 75 watt exercise:

   On R+0 heart rate increased 14% and remained elevated throughout the recovery period.

5. 5 Minute Recovery from upright exercise:

   Elevated 47% on R+0 and remained elevated throughout recovery period.

6. Supine 75 watt exercise:

   Although technical difficulties reduced the number of useable measurements, cardiac output and stroke volume remained elevated throughout bedrest. Post bedrest cardiac output remained elevated on R+0, R+1, R+2, and R+8, while stroke volume was significantly elevated only on R+2 and R+8.

7. Upright 75 watt exercise:

   Cardiac output was statistically significantly elevated on R+0 through R+8, while stroke volume was decreased on R+8.

8. During bedrest total peripheral resistance remained the same at rest and decreased during exercise. Post bedrest total peripheral resistance was unchanged at rest, and decreased during supine and upright exercise on R+2 and R+8.

9. During the crossover heart rates were not significantly affected by any treatment. Cardiac output appeared to be reduced during rest and exercise after both saline and LBNP + saline treatments, however, data are incomplete because of technical difficulties.

10. On R+0 upright heart rate was reduced 13 BPM at rest, 9 BPM during exercise and 13 BPM during recovery after LBNP + saline treatment.

VII. Isometric Exercise

1. Muscle fatigability to isometric contraction increased during bedrest as measured by quantity of spectral power in the lower frequencies.

VIII. Motion Sensor Data

1. The subjects would be ranked from most to least active as follows: 3, 2, 1, 6, 4, 5.

2. No correlation existed between the amount of activity and degree of deconditioning.

IX. Vestibular Systems Function

1. Susceptibility to coriolis motion sickness increased slightly in 4 out of 6 subjects on R+0, but the significance is questionable, and the increase may have been non-vestibular in origin. Subject 1 proved almost totally resistant to motion sickness, presumably as a result of streptomycin therapy as a child.

2. Results of vestibular-spinal reflex were inconclusive.

3. Static rail balancing tests revealed only short-lived and functionally insignificant alterations in post bedrest postural equilibrium performance.

X. EEG (Subjects 2 and 3 participated in these studies)

1. During bedrest, sleep latency increased. Prebedrest neither subject had difficulty falling asleep and the average sleep latencies were well below 10 minutes. Subject 2 averaged 12.6 minutes during the first half of bedrest and 35.4 in the second half, while subject 3 averaged 15 minutes and 53.4. Post bedrest the averages promptly decreased.

2. Subject 2 showed a slight but significant increase in the average percent Stage 1 postbedrest (14.3% to 19.6%). Subject 3 had slightly less Stage 1 in the first half of bedrest (6.2% to 5.2%).

3. Both subjects showed small but significant drops in percentage Stage 2 during the second half of bedrest (Subject 2 51.2% to 43.9%, Subject 3 59.4% to 51.2%). Post bedrest the values for Subject 2 remained low while those for Subject 3 returned to baseline.

4. Total time spent in Stage 3 increased during bedrest for both subjects. In the second half Subject 2 increased from a baseline of 9.7% to 12.6% and Subject 3 increased from 11.8% to 15%.

5. No significant changes were seen in Stage 4.

6. REM latency, the time elapsed between sleep onset and the first REM appearance, decreased during the second half of bedrest (Subject 2 1 hour to 0.62; Subject 3 1.86 hours to 0.85 hours).

7. The number of REM periods also increased slightly during bedrest for both subjects but this finding was not statistically significant. Post bedrest subject 2 did have a significant increase. Time spent in REM was also significantly increased in this subject during the first half of bedrest.

XI. Biostereometric Measurements

1. Post bedrest on R+0 weight remained the same while thighs (-2.6%±3.6%), calves (-3.7%±2.1%), arms (-0.7%±2.8%) decreased and abdomen (+2.3%±4.3%) increased. (Mean ± SD).

2. The six subjects separated into two groups, one which lost weight (subjects 1, 2 and 4) and one which gained weight (subjects 3, 5, and 6). The % change of the buttocks and to a lesser extent of the abdomen clearly demonstrated this separation. The buttocks and weight changes are strongly correlated.

3. The calves which demonstrated a 3.7% decrease in volume on R+0 had reconstituted about half their loss (1.7%) by R+1, but remained 1.8% down even on R+7. These measurements indicate the contribution of fluid loss and atrophy to the total decrease. The thighs showed a more linear increase with time post bedrest.

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