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FROM J. I. Leonard		TO J. A. Rummel, Ph.D./SE2	
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SUBJECT

ANALYSIS OF METABOLIC ENERGY UTILIZATION IN THE SKYLAB ASTRONAUTS

This analysis was performed in support of the metabolic and biochemical Skylab experimental program. It is part of a larger integrated metabolic balance analysis which includes analysis of Skylab water balance, electrolyte balance, evaporative water loss and body composition. Results of those studies have been previously transmitted by Technical Information Releases.

The purpose of this report is to assemble and process the metabolic data from which estimates of energy utilization can be inferred as a function of mission length. A theoretical treatment of energy balance has been included. A manuscript based on this analysis has been written (Amer. J. Physiol, in press) by NASA Principal Investigators (Rambaut, P., Leach, C., Leonard, J.). Its objective was to determine whether changes in metabolic energy utilization occur during prolonged spaceflight.

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ANALYSIS OF METABOLIC ENERGY
UTILIZATION IN THE SKYLAB ASTRONAUTS

CONTRACT NAS9-14523

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METABOLIC ENERGY ANALYSIS OF SKYLAB ASTRONAUTS

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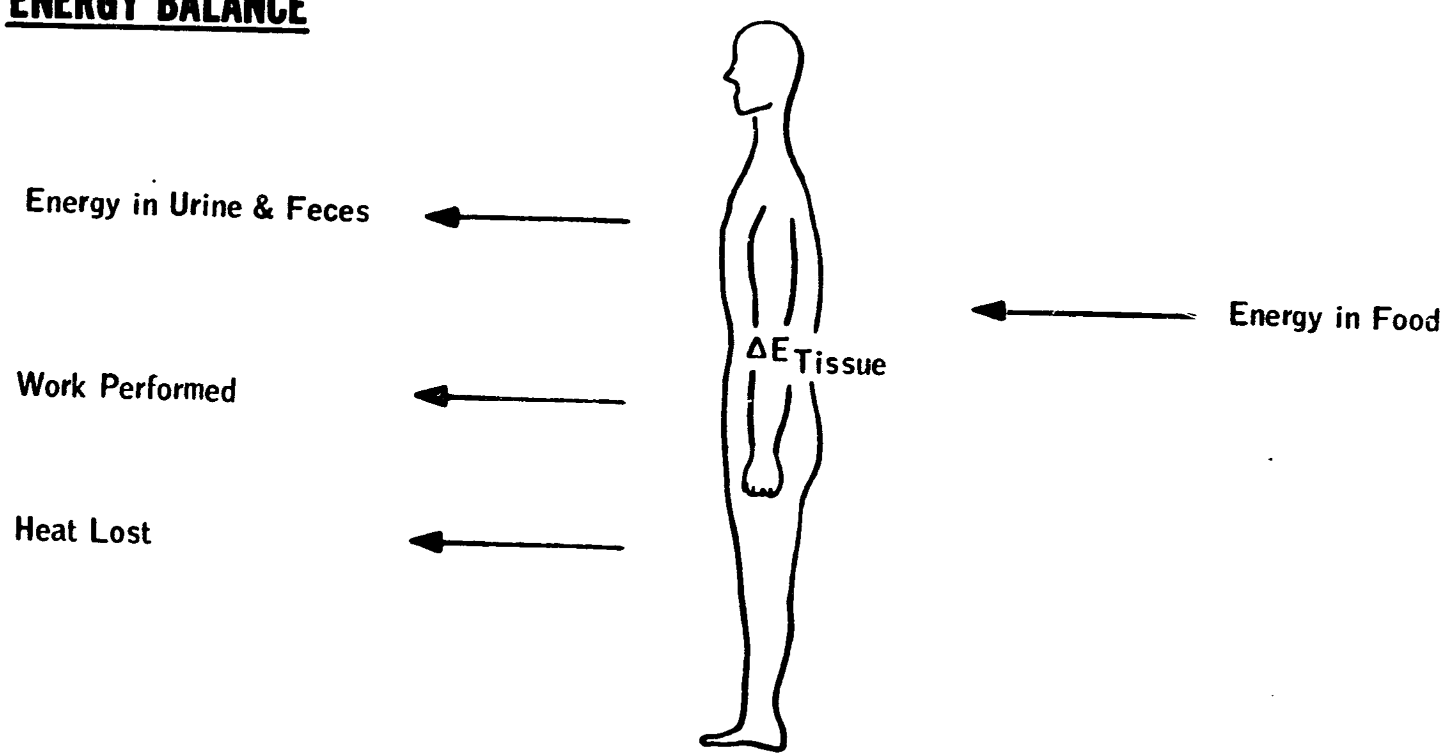
1.0 INTRODUCTION

The objective of this analysis was to determine whether changes in metabolic energy utilization occurs during spaceflight. The Skylab biomedical experiments represented the most outstanding attempt to gather information regarding man's metabolic processes for extended periods of weightlessness. Overall energy utilization was not measured directly but could be interred from an energy balance (Figure 1-1) based on caloric intake, excreted energy and metabolism of body tissues. The purpose of this report is to assemble the data which was processed in support of the analysis. A result of the analysis was a manuscript soon to be published in the American Journal of Physiology: "Changes in Metabolic Energy Utilization in Man during Spaceflight" (Rambaut, P.C., Leach, C.S. and Leonard, J.I.). No additional interpretation of the data is presented here. This work is part of a larger integrated metabolic balance analysis (Figure 1-2) which included analysis of Skylab water balance, electrolyte balance, evaporative water loss and body composition.

Section 2.0 is a theoretical analysis of energy utilization in man. The procedures for data processing, format of processed data and data requirements were based on this analysis and are shown in Section 3.0. The results of the analysis are presented in Section 4.0 in tabular and graphic format. These results are given as mean values for one or more flights combined. Individual crew subject data is presented in the appendix along with some further description of analytical techniques used in the study.

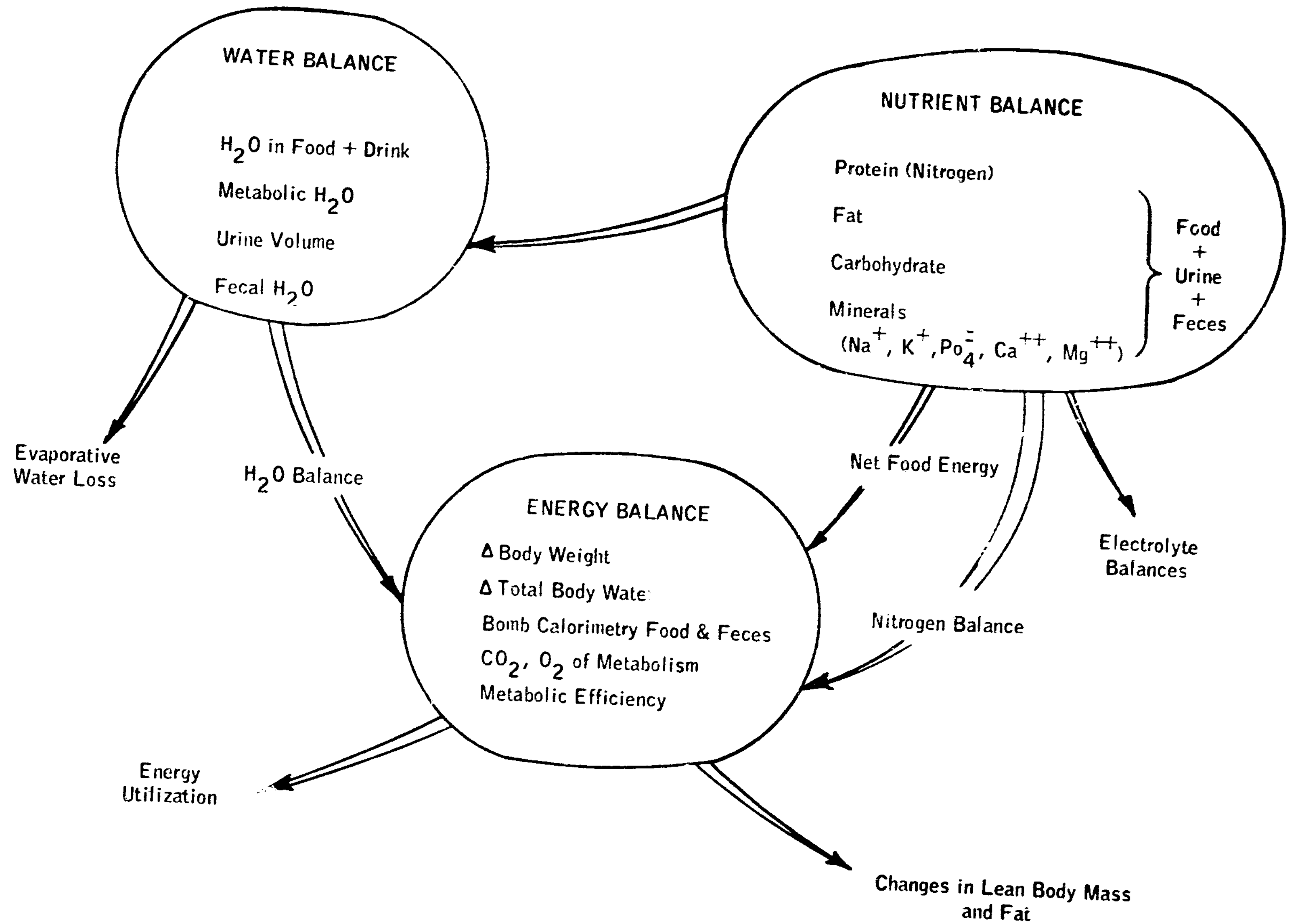
ENERGY BALANCE



$$\text{ENERGY REQUIRED} = \text{WORK} + \text{HEAT} = (E_{\text{Food}} - E_{\text{Excreta}}) + \Delta E_{\text{Tissue}}$$

$$\Delta E_{\text{Tissue}} = \Delta E_{\text{Protein}} + \Delta E_{\text{Fat}}$$

FIG. 1-1



INTEGRATED METABOLIC BALANCE ANALYSIS

FIG. 1-2

2.0 THEORETICAL ANALYSIS

A) From whole-body energy balance for a specified time interval, Δt

$$E_{food} = E_{excreta} + E_{work} + E_{heat} + \Delta E_{\substack{tissue\\stored}} \qquad (1)^{**}$$

where E_{food} = chemical energy derived from food consumed during Δt

$E_{excreta}$ = chemical energy excreted in urine, feces, sweat, etc. during Δt

E_{work} = mechanical work energy performed during Δt

E_{heat} = heat energy lost to environment during Δt

$\Delta E_{\substack{tissue\\stored}}$ = chemical energy stored in tissues during Δt

B) Food energy can be obtained from known diet constituents (protein, carbohydrates, fats) and values for energy produced by 1 gm. of each constituent.

$$E_{food} = a_1 \times CHO + a_2 * FAT + a_3 * PRO \qquad (2)$$

where* a_1 = 4.182 Kcal/gm carbohydrate consumed

a_2 = 9.461 Kcal/gm fat consumed

a_3 = 4.316 Kcal/gm protein consumed

(* values from MacHattie, JAP (1960) pp. 677)
(** See Section 2.0, Part H for Deviation of Energy Equation)

Values for $E_{excreta}$ are not available at present time.

$E_{excreta}$ may be estimated by assuming that a small fraction, γ, of the consumed diet food is not metabolized and is excreted.

$$\gamma = \frac{E_{excreted}}{E_{food}} \approx \frac{\text{mass dry feces}}{\text{mass dry solid food}} \tag{3}$$

Define η = efficiency of digestion and metabolism of consumed diet food

$$= 1 - \gamma \approx 1 - \frac{\text{mass dry feces}}{\text{mass dry solid food}} \tag{4}$$

Then

$$E_{excreta} = \gamma E_{food} \tag{5}$$

and

$$E_{food\ net} = E_{food} - E_{excreta} = E_{food} - \gamma E_{food} \tag{6}$$

$$= (1 - \gamma)\ (E_{food}) = \eta E_{food}$$

or

$$E_{food\ net} = \eta\ (\alpha_1 * CHO + \alpha_2 * FAT + \alpha_2 * PRO) \tag{7}$$

C) Chemical energy in the form of stored tissue may be determined from a mass balance in which body mass (WGT) is a sum of the weight of water of the body (TBW) and the weight of dry tissue elements (TIS):

$$WGT = TBW + TIS \tag{8}$$

For changes in these quantities over a time interval, Δt:

$$\Delta TIS = \Delta WGT - \Delta TBW \tag{9}$$

where Δ = (value at end of Δt) − (value at start of Δt)

Assume dry tissue weight is composed of the weights of three elements: Fat tissue (FTIS), protein tissue (PTIS) and major minerals (MIN).

$$TIS = FTIS + PTIS + MIN \tag{10}$$

and further that the minerals of major concern are the heavy minerals, Phosphate (PHOS), Calcium (CAL) and magnesium (MAG), so that

$$MIN = PHOS + CAL + MAG \tag{11}$$

The changes in these quantities over the time interval, Δt, is given by combining (10) and (11)

$$\Delta TIS = \Delta FTIS + \Delta PTIS + \Delta PHOS + \Delta CAL + \Delta MAG \tag{12}$$

Combining (9) and (12)

$$\Delta TIS = \Delta WGT - \Delta TBW = \Delta FTIS + \Delta PTIS + \Delta PHOS + \Delta CAL + \Delta MAG \quad (13)$$

Each of the quantities on the right side of (13) can be estimated from a balance equation (except for FTIS) in which

$$\Delta X = X_{diet} - X_{urine} - X_{fecal} \quad (14)$$

$$= \text{Change in body stores (mass) of } X \text{ over the interval } \Delta t.$$

where

$$X = \text{PHOS, CAL, or MAG} \quad (15)$$

ΔPTIS (Protein balance) is obtained from diet, urine and fecal nitrogen using the relationship

$$PTIS = NIT * 6.25$$

and

$$\Delta PTIS = 6.25 \ (NIT_{diet} - NIT_{urine} - N_{fecal} \quad (16)$$

ΔFTIS (fat balance) is not known directly but may be obtained indirectly from (13):

$$\Delta FTIS = \Delta TIS - \Delta PTIS - \Delta PHOS - \Delta CAL - \Delta MAG \quad (17)$$

Finally, the energy stored in (consumed by) body tissue can be found by assuming energy deposits are located in only fat and protein tissues:

$$\Delta E_{\substack{tissue\\stored}} = \Delta E_{Fat} + \Delta E_{Protein} \quad (18)$$

$$= \Delta FTIS \times 9.461 \frac{Kcal}{gm\ fat} + \Delta PTIS * 4.316 \frac{Kcal}{gm\ Protein}$$

D) Analysis of Caloric Requirement

From (1) and (6)

$$E_{work} + E_{heat} = E_{food\ net} - \Delta E_{\substack{tissue\\stored}}$$

or

$$E_{Req} = \underset{\text{by daily activity}}{\text{Energy Required}} = E_{food\ net} + \Delta E_{\substack{tissue\\consumed}} \tag{19}$$

The components of E_{Req} should be compared between Preflight and Inflight periods.

In order to make conclusions regarding the caloric requirement of weightless space flight, it will be necessary to assume that the work performed and heat lost by the crew in space was similar to that of the preflight control period. Unfortunately the data supporting this assumption is somewhat equivocal.

In addition, since work generating tissue (mainly muscle) may be decreasing during flight, the caloric requirement may be less merely for this reason. The values of E_{req} should therefore be normalized on the basis of lean body mass; i.e.,

$$E'_{req} = E_{req}/\text{Lean Body Mass} \tag{20}$$

E) Estimation of Lean Body Mass

Estimations of lean body mass changes will be needed for the three one-month inflight intervals. This data were not measured directly inflight. However, there are three alternative methods for estimating lean body mass (LBM) during the flight phases:

a) From total body water (TBW)
(Ref: Johnson, et al., Nutr. Metabol. (1974).

$$LBM_i = TBW_i/0.73 \tag{21}$$

where

$$TBW_i = TBW_o + \sum_i^3 TBW_i \tag{22}$$

i refers to the mean value during any of the specified one-month inflight intervals, (i = 1,2,3)

o refers to the directly measured TBW during preflight control.

TBW_i is the average total body water change during each of the inflight periods. It can be estimated from the water balance analysis in which the mass balance equation has been adjusted for skin losses to obtain agreement with directly measured TBW (preflight) — TBW (postflight) changes. (See Section F.)

b) From total body potassium (TBK)

(Ref.: Edmonds, et al, Clinical Science and Mol. Med. (1975))

$$\Delta LBM_i = \Delta TBK_i / KF \qquad (23)$$

where

$$TBK_i = TBK_o + \sum_i^3 \Delta TBK_i \qquad (24)$$

KF = average Meg K^+/Kg Fat Free Mass

and can be determined during preflight period from TBD_o and $LBM_o = TBW_o/0.73$.

Edmonds uses value of 65 and preliminary Skylab calculations show $KF = 57.8 \pm 2.26$ (sd)

ΔTBK_i = average TBK loss during each of the inflight periods. It can be estimated from a K^+ balance corrected for measured K^+ changes; i.e.,

$$\Delta TBK_i = K^+_{diet} - K^+_{urine} - K^+_{fecal} - K^+_{skin}$$

where

K^+_{skin} is estimated by comparing ΔTBK (inflight) from balance equation with that measured directly; i.e.,

$$K^+_{skin} = K^+_{diet} - K^+_{urine} - K^+_{fecal} \qquad (25)$$

$$- \Delta TBK \text{ (inflight, direct)}$$

c) From Nitrogen Balance

(Ref. Hegsted, Jrl. Nutrition (1976))

$$LBM_i = LBM_o + \sum_i^3 \Delta PTIS_i/0.18 \qquad (26)$$

where

$\Delta PTIS$ is the average monthly changes in body protein and given by equation (16).

LBM_0 = Preflight LBM measured by methods (A) or (B) above.

The nitrogen balance can be corrected for skin losses as was done for potassium above by using

$$N_{skin} = N_{diet} - N_{urine} - N_{feces} - \Delta LBM(\text{Inflight}) \times 0.18/6.26 \qquad (27)$$

where

ΔLBM (Inflight) can be obtained from method (A) or (B) above.

F) Estimation and Correction of Errors in Metabolic Balances

The most important information in this analysis is represented in Equations (16) - (19). The errors associated with estimating inflight energy requirements (E_{req}) are those associated with determining protein loss (ΔPTIS, Eq. 16) and fat loss (ΔFTIS, Eq. 17). As Hegsted has noted, in any metabolic balance analysis the errors become more severe and more apparent when average daily losses or gains are extrapolated over long periods of time. These errors can be corrected to some extent, however, when independent measurements are performed to determine changes in body composition. In Skylab, some of these independent measurements have been accomplished. With regard to the present analysis the following table lists the independent measurements associated with each metabolic balance and it is suggested these data be used to correct the metabolic balances whenever possible.

Metabolic Quantity Used in Daily Balance	Independent Data (Pre/Postflight)
Water (ΔTBW)	Total Body Water Biosteriometric Analysis Leg Volume LBNP data
Potassium (ΔTBK)	Total Body Potassium Intracellular Water
Nitrogen (ΔPTIS)	Total Body Potassium Total Body Water
Phosphorus (ΔPHOS)	None
Calcium (ΔCAL)	Bone Mineral Measurement
Magnesium (ΔMAG)	None

The basic assumption in such a correction is that there is a systematic error in the balance equation which represents unmeasured losses from the skin. Thus, for a daily balance on arbitrary element X,

$$\Delta X = X_{diet} - X_{excreta} - X_{skin} \tag{28}$$

Only the first two terms on the right have been measured on a day-to-day basis. However, if the change in total body quantity of X is known from direct preflight and postflight measurements (i.e., call this quantity ΔX (Inflight,direct)), then we may write

$$\Sigma X_{skin} = \Sigma X_{diet} - \Sigma X_{excreta} - \Delta X \text{ (inflight,direct)} \tag{29}$$

where

ΣX = the sum of all daily inflight values

= (average daily value)x(days of mission)

= $\bar{X} \times N$

Having computed ΣX_{skin} the average daily value can be found:

$$\bar{X}_{skin} = \overline{\Sigma X}_{skin}/N$$

which can be used as a linear estimation of X_{skin} in equation (28).

Since values of ΔX are required only on a monthly basis it is recommended that monthly average values be computed for each term on the right side of Equation (28), rather than using daily values and averaging the resultant ΔX_i 's.

G) Estimation of Errors in Computing Dry Tissue Weight

Calculation of the change in total dry tissue weight, ΔTIS can be found from Equation (9). This involves using the quantities that compose the water balance (i.e., water intake, urine, evaporative loss, etc.). A more fundamental equation can be found by combining mass and fluid balances as follows:

Gain in body water is given by:

$$\Delta TBW = H_2O\ (\text{intake}) + H_2O\ (\text{met}) - \text{Urine} - H_2O(\text{fecal}) - \text{Evap} \quad (28)$$

Gain in body mass is given by:

$$\begin{aligned} \Delta WGT = {} & \text{Food (dry)} + H_2O_{(\text{intake})} - \text{Urine} - \text{Urine(solids)} \\ & - H_2O(\text{fecal}) - \text{Feces(dry)} - \text{Evap} + O_2(\text{intake}) \\ & - CO_2(\text{out}) \end{aligned} \quad (29)$$

Subtracting and substituting into Equation (9)

$$\begin{aligned} \Delta TIS &= \Delta WGT - \Delta TBW \\ &= \text{Food(dry)} - \text{Urine(solids)} - \text{Feces(dry)} + O_2(\text{intake}) \\ &\quad - CO_2(\text{out}) - H_2O(\text{met}) \end{aligned} \quad (30)$$

O_2(intake), CO_2(out) and H_2O(met) can be expressed in terms of weights of carbohydrate, fat, and protein eaten according to well accepted stoichiometric relationships:

$$\begin{aligned} O_2\ (\text{intake}), \text{gms} &= 1.429\ (.829\ CHO + 2.019\ FAT + 0.965\ PRO) \\ CO_2\ (\text{out}), \text{gms} &= 1.977\ (.829\ CHO + 1.427\ FAT + 0.781\ PRO) \\ H_2O\ (\text{met}), \text{gms} &= (0.6\ CHO + 1.07\ FAT + 0.41\ PRO) \end{aligned} \quad (31)$$

These can be substituted into Equation (20) and combined to give

$$\Delta TIS = \text{Food (dry)} - \text{Urine (solids)} - \text{Feces (dry)} - \eta\,(1.054\ CHO + 1.006\ FAT + 0.575\ PRO) \tag{32}$$

The digestion efficiency, η, is included to better estimate the metabolized food components from the diet food values.

This equation demonstrates that the change in dry tissue weight does not need to be associated with the random errors involved in measuring body mass, water intake, urine volume, and evaporative water loss (as suggested by Equation (9)). The random errors in each of the terms amounts to no more than several grams/day at most. Thus, ΔTIS should also be accurate to a few grams/day. However, there is a systematic error involved in Equation (32) that may be much more serious than any random error. This is the failure to account for the solids excreted from the skin (sweat solids, sebaceous residues and desquamated skin) which, if known, should be subtracted to the right side of Equation (32). Indications from Skylab and other sources are that this error is of the order of 10-40 gm/day which is extremely large compared to the expected value of zero for ΔTIS under steady-state conditions.

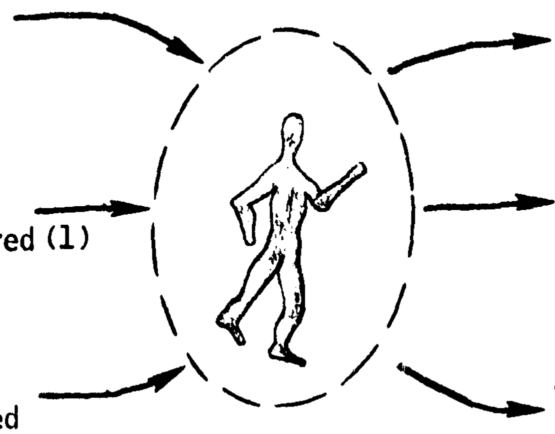
An equation for estimating this total dry skin loss (M_{skin}) can be obtained as follows:

Subtract M_{skin} from the right side of Equation (32) and solve for its value in terms of ΔWGT and ΔTBW as suggested in Equation (30).

$$M_{skin} = \Delta TBW - \Delta WGT + \text{Food (dry)} - \text{Urine (solids)} - \text{Feces (dry)} - \eta(1.054\ CHO + 1.006\ FAT + 0.575\ PRO) \tag{33}$$

Using the value of ΔTBW (inflight,direct) from isotope, dilution studies and using total accumulative inflight values for all the other quantities for each man, the resultant value of M_{skin} represents the subject's total skin losses for the entire mission. This value can then be divided by the appropriate number of days to obtain a linear approximation of th daily or monthly average skin loss.

H) DERIVATION OF HUMAN WHOLE-BODY ENERGY BALANCE



From First Law of Thermodynamics

$$dU = \delta Q - \delta W$$

dU		δQ		δW
internal energy of system		heat added to system		work performed by system

or

$$U_2 - U_1 = Q_{added} - W_{performed} \qquad (1)$$

where U_1 = internal energy of system at start of process (i.e. beginning of day (1))

$= E_{food} + E_{stored}$ (Assumes all food is presented at time (1))

U_2 = internal energy of system at end of process (i.e., beginning of day (2))

$= E_{excreta} + E_{stored(2)}$ (Assumes all food is consumed and all excreta released by time (2))

Thus

$$W_{performed} - Q_{added} = E_{food} - E_{excreta} + E_{stored(1)} - E_{stored\,(2)}$$

Let $\Delta E_{stored} = E_{stored(1)} - E_{stored\,(2)}$

= Net Catabolism if > 0

= Net Anabolism if < 0

$$W_{performed} - Q_{added} = (E_{food} - E_{excreta}) + \Delta E_{stored} \qquad (2)$$

$$E_{stored} = \text{storage of many forms of energy}$$

$$= \text{heat energy} \quad (\text{mass} \times C_p \times \text{Temp})$$

$$+ \text{kinetic energy} \quad (\text{Mass} \times \text{Vel.}^2/2)$$

$$+ \text{static electric energy} \quad (\text{Cap.} \times \text{Volt}^2/2)$$

$$+ \text{potential gravitational energy} \quad (\text{mass} \times g)$$

$$+ \text{potential chemical energy stored in high energy bonds of tissue} \quad (\Delta F = -RT\ln k) \tag{3}$$

It is assumed that all except the last term (potential chemical energy of tissues) is either negligible (i.e., static electric energy or kinetic energy) or does not change significantly (i.e., true of heat energy if body temperature or mass does not change). In addition, it is not necessary to have knowledge of the <u>total</u> stored energy in tissue since the term in Equation (2), ΔE_{stored}, refers to a change in tissue composition and energy.

It may also be assumed the most important storage depot of chemical energy exists in fat and protein molecules of tissues; i.e.,

$$\Delta E_{store} = \Delta E_{fat} + \Delta E_{protein} \tag{4}$$

where ΔE_{fat} = energy derived from fat catabolism

$\Delta E_{protein}$ = energy derived from protein catabolism

Equation (2) can be rewritten

$$E_{food} = E_{excreta} + W_{performed} - Q_{added} - \Delta E_{\substack{fat\\comsumed}} - \Delta E_{\substack{protein\\consumed}} \tag{5}$$

or

$$E_{food} = E_{excreta} + W_{performed} + Q_{\substack{lost\ to\\environment}} + \Delta E_{\substack{fat\\stored}} + \Delta E_{\substack{protein\\stored}} \tag{6}$$

This form of the energy balance illustrates that the chemical energy of food provides all the energy needs of the body.

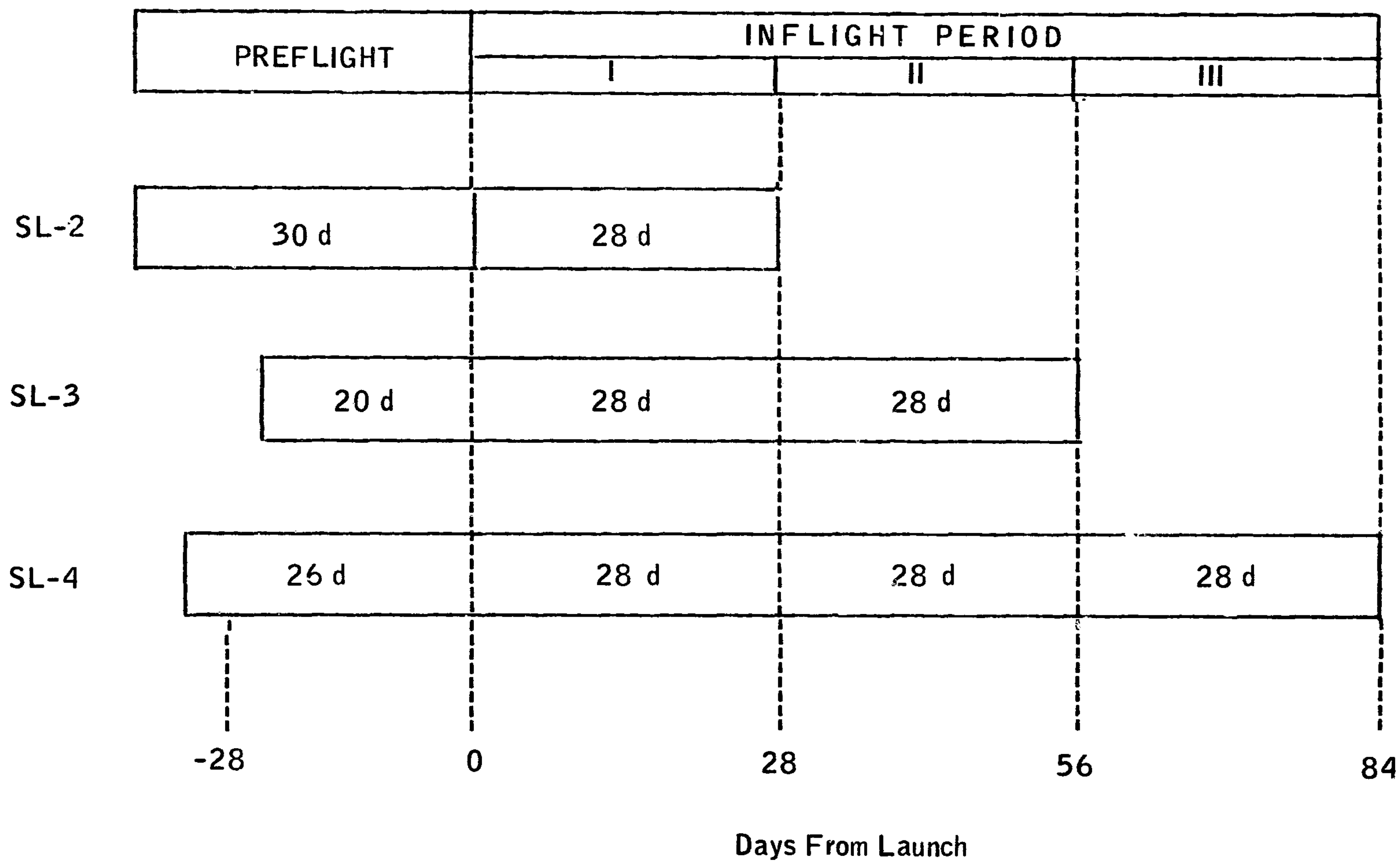
3.0 DATA ANALYSIS PROCEDURE, FORMAT AND REQUIREMENTS

This analysis includes all nine Skylab crewmen, representing 3 crews of 3 men each, who occupied the orbiting workshop between May 1973 and February 1974. The first crew (SL-2) remained onboard for 28 days, the second (SL-3) for 59 days, and the third (SL-4) for 84 days. In this analysis of the data the missions have been divided into 28-day periods. (Figure 3-1). The first mission has only one such period, the second has two and the third has three. Data obtained on the last 3 days of the SL-3 mission is not included. The length of the preflight period for the SL-2, SL-3 and SL-4 missions was 30, 20 and 26 days respectively. Data from the first day of the preflight period is not included. The julian days used to segment these periods are given in Table 3-1.

Changes in body composition and energy utilization in any particular period is expressed as the mean value for all crewmen who contributed to that period. (Tables 3-2 and 3-3). Thus a total of 9 crewmen were involved in the preflight period as well as in the first inflight period, six in the second inflight period and three in the third inflight period. The means are expressed together with their standard deviation and tests of significance (using Student t-test) involve a comparison between inflight period and that preflight period involving the same group of crew members.

The data required for this analysis is shown in part in Table 3-4. Food energy was measured directly by bomb calorimetry as well as computed from the carbohydrates, fat and proteins in the diet. Fecal calories were also measured directly. Caloric value of urine excreted was obtained from the energy content of measured urinary nitrogen.

These data permitted a calculation of metabolic efficiency as well as net energy derived from food. The water balance data was taken directly from the water balance analysis which has been previously reported. This analysis required much additional data not shown here such as urine volume, water in food, water drunk, fecal water, dry fecal weight, etc.



GROUPING OF DATA FOR ENERGY BALANCE ANALYSIS

FIG. 3-1

ENERGY BALANCE DATA ANALYSIS

TABLE 3-1: PERIODS OF ANALYSIS

(INCLUDES ALL DATA
EXCEPT 1st DAY PREFLIGHT)

PERIOD	FLIGHT	START DAY	END DAY	14 DAYS
PREFLIGHT	SL-2	115	144	30
	SL-3	189	208	20
	SL-4	294	319	26
INFLIGHT I	SL-2	145	172	28
	SL-3	209	236	28
	SL-4	320	347	28
INFLIGHT II	SL-2	-	-	0
	SL-3	237	264	28
	SL-4	348	375	28
INFLIGHT III	SL-2	-	-	0
	SL-3	-	-	0
	SL-4	376	403	28

ENERGY BALANCE DATA ANALYSIS

TABLE 3-2 : DATA FORMAT

MAN	PERIODS			
	PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
1	-	-	0	0
2	-	-	0	0
3	-	-	0	0
4	$\bar{x} \pm sd$	-	-	0
5	-	-	-	0
6	-	-	-	0
7	-	-	-	-
8	-	-	-	-
9	-	-	-	-
AVG:	$\bar{\bar{x}}$	-	-	-
SEM:	$S\bar{x}$	-	-	-

Each Element (9 x 4 = 36 elements) in table above bottom line represents the mean $\pm$ sd of a data quantity (See Table III) for the specified period. Each period represents a series of consecutive days (See Table I) each day of which is associated with a data value for every quantity shown in Table III. Values below the bottom line in table above represent the grand mean $\pm$ 1 SEM for each column.

ENERGY BALANCE DATA ANALYSIS

TABLE 3-3 : DOY USED FOR ANALYSIS
(N = No. of days per subject in each period)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1 2 3	115 - 144 N = 30	145 - 172 N = 28		
SL-3	4 5 6	189 - 208 N = 20	209 - 236 N = 28	237 - 264 N = 28	
SL-4	7 8 9	294 - 319 N = 26	320 - 347 N = 28	348 - 375 N = 28	376 - 403 N = 28
AVG: SEM:					

ENERGY BALANCE DATA ANALYSIS

TABLE 3-4 : DATA REQUIRED

Raw data listed below will be averaged according to format shown in Table II:

	Data Element	Source
1	Calcium diet	SMEDEP data base (43)*
2	Calcium urine	" " " (7)
3	Calcium fecal	Whedon data book
4	Phosphorus diet	SMEDEP data base (44)
5	Phosphorus urine	" " " (6)
6	Phosphorus fecal	Whedon data book
7	Magnesium diet	SMEDEP data base (46)
8	Magnesium urine	" " " (5)
9	Magnesium fecal	Whedon data book
10	Potassium diet	SMEDEP data base (47)
11	Potassium urine	" " " (4)
12	Potassium fecal	Whedon data book
13	Nitrogen diet	Whedon data book
14	Nitrogen urine	" " "
15	Nitrogen fecal	" " "
16	Daily body mass change	Water balance analysis using Whittle data base
17	Daily water balance (adjusted for agreement with TBW direct measurements)	
18	Daily energy derived from food	

* (No. in parenthesis refers to SMEDEP data base index)

4.0 ENERGY BALANCE ANALYSIS RESULTS

The analysis proceeded according to the theoretical treatment of Section 2.0 and the format shown in Section 3.0. The sequence of analysis was as follows:

a.) Assembleage of bomb calorimetry data (diet and feces) averaged for each crewman in each flight period. Computation of caloric value of food from known amounts of food constituents. Computation of caloric value excreted in urine from known amounts of urinary nitrogen. (See Appendix D.)

b.) Computation of metabolic efficiency from food and fecal calories and mass. (See Tables 4-3 and 4-4.) Computation of net caloric intake (diet - excreta). (See Appendix D.) Computation of oxygen consumption and respiratory quotient (RQ) from dietary constituents. (See Table 4-5.)

c.) Assemblage of mass balance data (body weight changes, body water changes) obtained from mass and water balance analysis for each crewman in each flight period (Appendix B). Computation of solid tissue losses (protein plus fat) for each crewman. (Appendix B). Summarize partitional changes in total body mass for all crewmen (Table 4-1).

d.) Computation of body protein changes from nitrogen balance. Computation of body fat changes. Computation of caloric content of these metabolic changes (Appendix C).

e. Assemblage of metabolic balance data (diet, urine, feces,) averaged for each crewman in each preflight or flight period. This was performed for nitrogen, potassium, calcium, magnesium and phosphorus. The SMEDEP data base was used extensively for this purpose as well as additional data from Dr. Whedon's data base which was subsequently added to the SMEDEP data base. (See Appendix F.)

f.) Computation of net metabolic balance (intake - excreta) for each of these body constituents as a function of mission length. (See Appendix E and Table 4-2.)

g.) Computation of potassium balance corrected for skin losses. This analysis uses potassium balance and total body potassium data. These values were used as an index of lean body bass changes during flight and to normalize energy utilization with respect to changes in body composition (Appendix A).

h. Summarize components of energy balance (food, excreta, protein catabolism, fat catabolism) and net energy utilized (Tables 4-6, 4-7, and 4-8 and Figure 4-1).

i.) Hard copy microfilm plots of net energy utilization on a continuous daily basis for each Skylab crew and for all crews combined (Figures 4-2 to 4-6). This analysis was performed subsequent to the rest of the study and used the software associated with the water balance analysis.

TABLE 4-1

PARTITIONAL CHANGES IN TOTAL BODY MASS DURING 3-MONTH SPACEFLIGHT

	Inflight Period	n	Average Daily Changes: Preflight	Average Daily Changes: Inflight	Average Daily Changes: Shift from Preflight	Total Period Change	Cumulative Shift from Preflight
Total Body Mass (gm)	I	9	- 9.26 ± 43.39	- 79.37 ± 33.63	-70.11	-1963	-1963
	II	6	8.33 ± 42.73	- 2.38 ± 11.22	-10.71	-300	-2263
	III	3	0.00 ± 30.77	15.48 ± 4.13	15.48	433	-1830
Body Water (gm)	I	9	10.72 ± 35.62	- 48.59 ± 27.10	-59.31	-1661	-1661
	II	6	19.12 ± 36.16	16.67 ± 24.75	-2.45	-69	-1730
	III	3	- 5.82 ± 19.07	15.51 ± 10.22	21.33	597	-1133
Body Tissue, dry (gm)	I	9	- 19.98 ± 30.53	- 30.77 ± 31.63	-10.79	-302	-302
	II	6	- 10.79 ± 25.84	- 19.05 ± 27.01	-8.26	-231	-533
	III	3	5.82 ± 12.25	- 0.032 ± 8.883	-5.85	-163	-697

TABLE 4-2

METABOLIC BALANCES AND CUMULATIVE LOSSES

Crew Averages and SEM

	Inflight Monthly Period	n	Daily Preflight Control Balance	Daily Inflight Balance	Shift from Preflight Balance *	Total Monthly Change **	Cumulative Shift from Preflight ***
Nitrogen (gm)	I	9	3.19 ±0.53	-1.74 ±0.67	-4.93	-138.00	-138.00
	II	6	3.14 ±0.62	0.21 ±0.52	-2.93	- 82.00	-220.00
	III	3	2.77 ±0.56	0.17 1.32	-2.60	- 72.8	-292.8
Potassium (meq)	I	9	16.95 ± 2.80	4.03 ±2.67	-12.92	-361.8	-361.8
	II	6	15.96 ±2.70	9.26 ±7.65	- 6.70	-187.6	-549.4
	III	3	14.90 ± 2.60	8.66 ±5.86	- 6.24	-174.7	-724.1
Phosphorus (mg)	I	9	179.62 ±112.80	-23.78 ±118.00	-203.4	-5695	-5695
	II	6	210.00 ± 97.6	64.04 ± 68.65	-146.0	-4087	-9782
	III	3	151.14 ± 65.03	19.65 ± 67.45	-131.5	-3682	-13464
Calcium (mg)	I	9	7.47 ±193.07	-18.41 ±78.00	-25.88	-725	-725
	II	6	-55.06 ±202.60	-169.58 ±131.32	-114.52	-3207	-3931
	III	3	-230.97 ± 79.24	-167.91 ± 80.14	63.06	+1766	-2165

TABLE 4-2 (Continued)

	Inflight Monthly Period	n	Daily Preflight Control Balance	Daily Inflight Balance	Shift from Preflight Balance *	Total Monthly Change **	Cumulative Shift from Preflight ***
Magnesium (mg)	I	9	25.53 ±32.29	16.15 ±14.06	- 9.38	-263	-263
	II	6	9.64 ±24.53	24.92 ±25.55	15.28	428	165
	III	3	- 9.65 ±17.55	14.87 ±11.64	24.63	690	855

* Shift from Control, Δ = Inflight Balance - Control Balance

** Total Monthly Change, $L_i = \Delta \times 28$ days

*** Cumulative Shift $= \sum_{i=1} L_i$

TABLE 4-3

METABOLIC EFFICIENCY FROM FOOD AND FECAL (BOMB) CALORIES*

	Preflight		Inflight	
Man	Mean	sd	Mean	sd
1	0.946	$\pm$0.046	0.958	
2	0.950		0.959	
3	0.950		0.958	
4	0.957		0.959	
5	0.954		0.948	
6	0.954		0.948	
7	0.949		0.950	
8	0.953		0.967	
9	0.960		0.955	
	.952		.956	
	$\pm$ .004		$\pm$ .006	

$$\text{*Efficiency} = 1 - \frac{\text{fecal calories (bomb)}}{\text{food calories (bomb)}}$$

Std. deviation of each value, $S_{eff} = \sqrt{(1 - \text{Eff}) \left[\left(\frac{S_x}{\bar{X}}\right)^2 + \left(\frac{S_y}{\bar{Y}}\right)^2 \right]}$

X = food calories

Y = fecal calories

TABLE 4-4

METABOLIC EFFICIENCY FROM FOOD AND FECAL SOLIDS*

Man	Preflight Mean	Preflight sd	Inflight	Postflight
1	0.967		0.966	0.968
2	0.954		0.966	0.947
3	0.961		0.965	0.972
4	0.967		0.965	0.982
5	0.958		0.960	0.953
6	0.959		0.959	0.967
7	0.950		0.955	0.948
8	0.960		0.969	0.973
9	0.963		0.961	0.959
AVG.	0.959		0.963	0.963
SEM	±0.006		± .004	± .012

*Efficiency $= 1 - \frac{\text{fecal solids}}{\text{food solids}}$

TABLE 4-5

ENERGY BALANCE
(O_2 Consumption and RQ Calculated from Diet)

Subject	Preflight VO_2 (l/min)	Preflight RQ	Inflight VO_2	Inflight RQ	Postflight VO_2	Postflight RQ
SL-2/CDR	.36	.86	.36	.89	.42	.86
SPT	.39	.88	.37	.90	.37	.88
PLT	.39	.87	.35	.90	.42	.88
SL-3/CDR	.36	.87	.35	.91	.38	.87
SPT	.37	.86	.35	.90	.40	.85
PLT	.52	.88	.48	.92	.53	.89
SL-4/CDR	.40	.87	.41	.88	.39	.88
SPT	.39	.87	.39	.89	.42	.88
PLT	.41	.86	.42	.87	.44	.86
AVG. + SD	.40 $\pm$.05	.87 $\pm$.008	.39 $\pm$.04	.90 $\pm$0.015	.42 $\pm$.05	.87 $\pm$.01

$$RQ = \frac{CO_2 \text{ produced from non-protein diet (liters)}}{O_2 \text{ consumed for non-protein diet (liters)}}$$

$$= (.829\ CHO + 1.427\ FAT)/(.829\ CHO + 2.019\ FAT)$$

$$VO_2 = .95\ (.829\ CHO + 2.019\ FAT + 0.965\ PRO)$$

TABLE 4-6

Components of Energy Balance — Skylab Average
(Kcal/day)

Inflight Period

Energy Source or Sink	I (n=9)	II (n=6)	III (n=3)
Food Ingested			
Control	2979 ± 358	3067 ± 411	3145 ± 54
Inflight	2770 ± 371	3115 ± 389	3281 ± 111
Shift from Control	-209	48	137
Feces			
Control	143 ± 19	140 ± 23	145
Inflight	119 ± 26	145 ± 33	147 ± 29
Shift from Control	- 24	5	3
Urine			
Control	126 ± 25	127 ± 26	128 ± 11
Inflight	152 ± 22	151 ± 29	153 ± 5
Shift from Control	26	24	25
Protein Catabolism			
Control	- 86 ± 14	- 85 ± 17	- 75 ± 15
Inflight	47 ± 18	- 6 ± 14	- 5 ± 36
Shift from Control	133	79	70
Fat Catabolism			
Control	378 ± 297	288 ± 250	109 ± 84
Inflight	188 ± 303	193 ± 276	11 ± 132
Shift from Control	-190	-95	-98
Net Energy Utilized +			
Control	3002 ± 312	3003 ± 268	2906 ± 69
Inflight	2734 ± 201	3006 ± 248	2988 ± 167
Shift from Control	-268 ± 161**	3 ± 76	81 ± 114
Δ%	-8.9%	0.1%	2.8%
Net Energy Utilized /Eq. TBK+			
Control	834 ± 78	844 ± 85	831 ± 39
Inflight	807 ± 61	895 ± 78	932 ± 49
Shift from Control	-27 ± 41*	51 ± 46**	101 ± 76
%	-3.0%	6.3%	12.4%

+ Net Energy Utilized = Food Ingested − Feces − Urine + Protein Catabolism + Fat Catabolism

* $p < 0.1$

** $p < .05$

TABLE 4-7

Net Energy Utilized
(Kcal)

Inflight Period

Preflight Control	I (n=9)	II (n=6)	III (n=3)
SL-2	3001 ± 457	-	-
SL-3	3099 ± 383	3099 ± 383	-
SL-4	2906 ± 69	2906 ± 69	2906 ± 69
Skylab Mean	3002 ± 312	3003 ± 268	2906 ± 69
Inflight			
SL-2	2724 ± 321	-	-
SL-3	2721 ± 229	3139 ± 307	-
SL-4	2756 ± 66	2872 ± 76	2988 ± 167
Skylab Mean	2734 ± 201	3006 ± 248	2988 ± 167
Shift from Control			
SL-2	-278 ± 146*	40 -	-
SL-3	-378 ± 207*	40 ± .94	-
SL-4	-150 ± 31**	-33 ± 39	82 ± 114
Skylab Mean	-268 ± 161***	3 ± 76	82 ± 114
Δ%			
SL-2	-8.92 ± 3.71*	-	-
SL-3	-11.83 ± 5.84*	1.52 ± 3.36	-
SL-4	- 5.15 ± 1.01 **	-1.15 ± 1.34	2.79 ± 3.91
Skylab Mean	- 8.72 ± 4.47 ***	-0.55 ± 3.23	2.79 ± 3.91

* $p < .1$

** $p < .02$

*** $p < .01$

TABLE 4-8

Net Energy Utilized/Body K^+

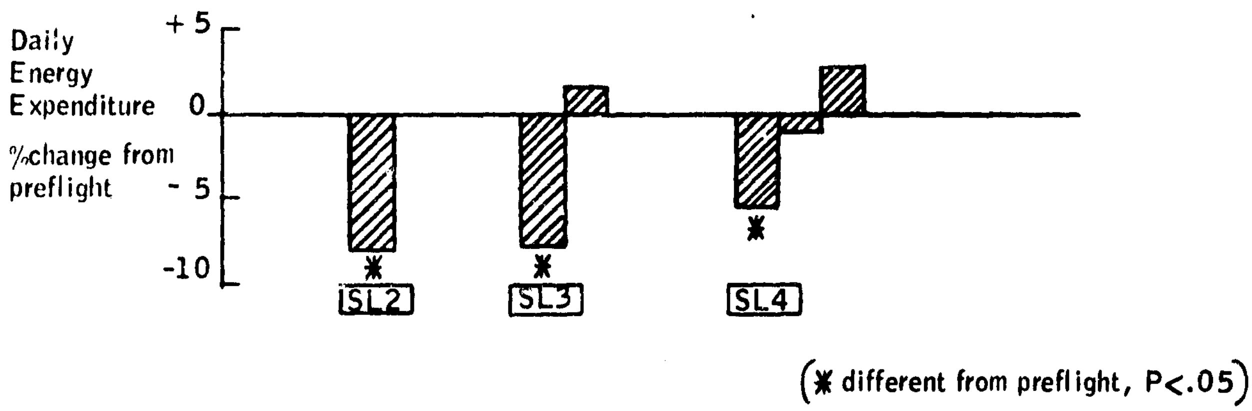
(Kcal/day-Eq. body K^+)

Inflight Period

Preflight Control	I (n=9)	II (n=6)	III (n=3)
SL-2	813 ± 73	-	-
SL-3	857 ± 126	857 ± 126	-
SL-4	831 ± 39	831 ± 39	831 ± 39
Skylab Mean	834 ± 78	844 ± 85	831 ± 39
Inflight			
SL-2	802 ± 55	-	-
SL-3	806 ± 106	900 ± 116	-
SL-4	814 ± 23	891 ± 40	932 ± 49
Skylab Mean	807 ± 61	895 ± 78	932 ± 49
Shift from Control			
SL-2	-11.8 ± 42.5	-	-
SL-3	-51.4 ± 57.3	42.3 ± 46.9	-
SL-4	-16.7 ± 17.0	59.6 ± 53.6	100.8 ± 75.9
Skylab Mean	-26.6 ± 41.2*	51.0 ± 46.1**	100.8 ± 75.9
Δ %			
SL-2	- 1.27 ± 4.97	-	-
SL-3	- 5.76 ± 6.24	5.18 ± 5.74	-
SL-4	- 1.95 ± 1.91	7.32 ± 6.69	12.38 ± 9.48
Skylab Mean	- 2.99 ± 4.61*	6.25 ± 5.70**	12.38 ± 9.48

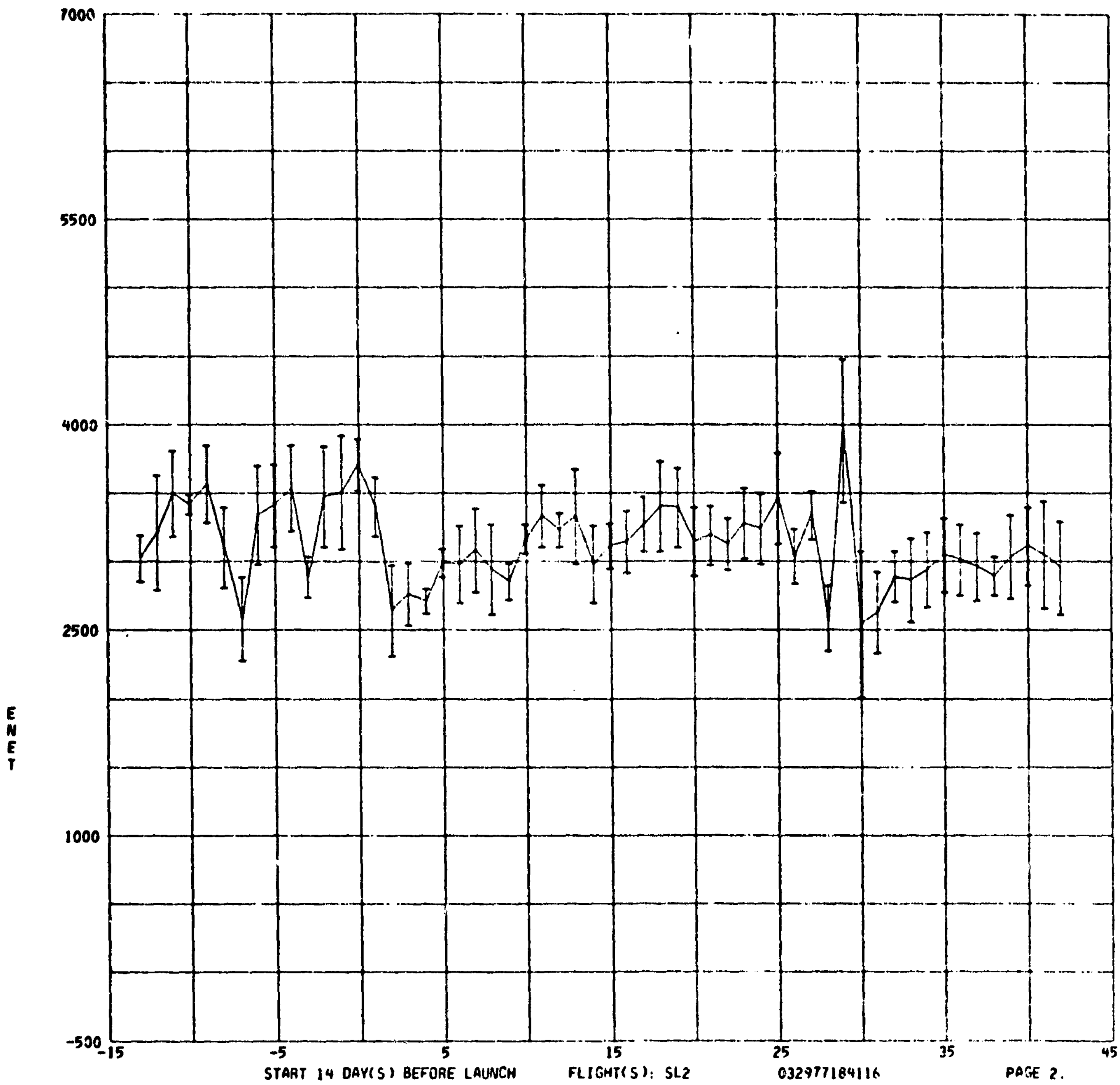
* $p < .1$

** $p < .05$



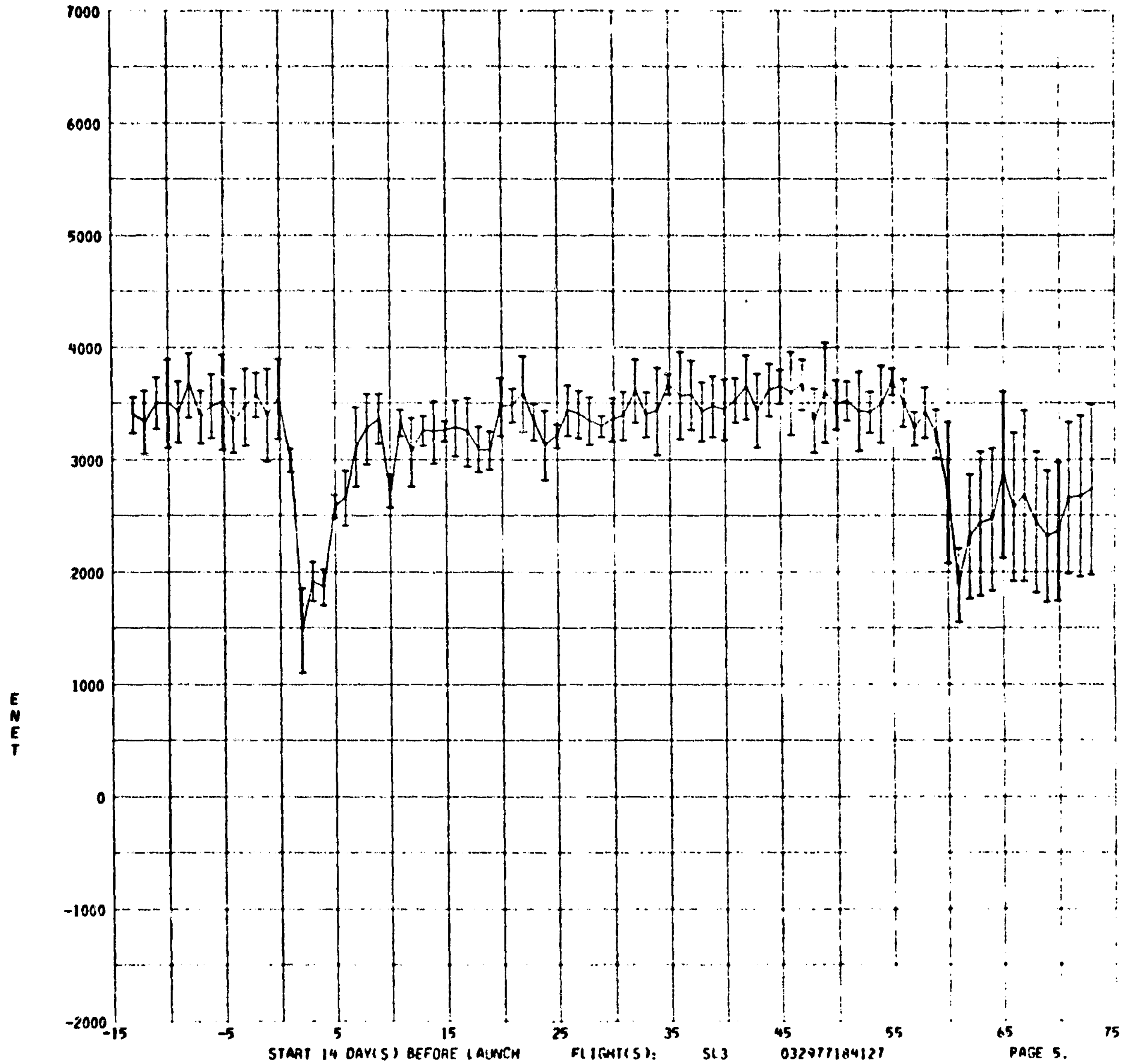
MONTHLY ENERGY EXPENDITURE
CHANGES DUE TO SPACEFLIGHT FOR EACH SKYLAB MISSION

FIG. 4-1



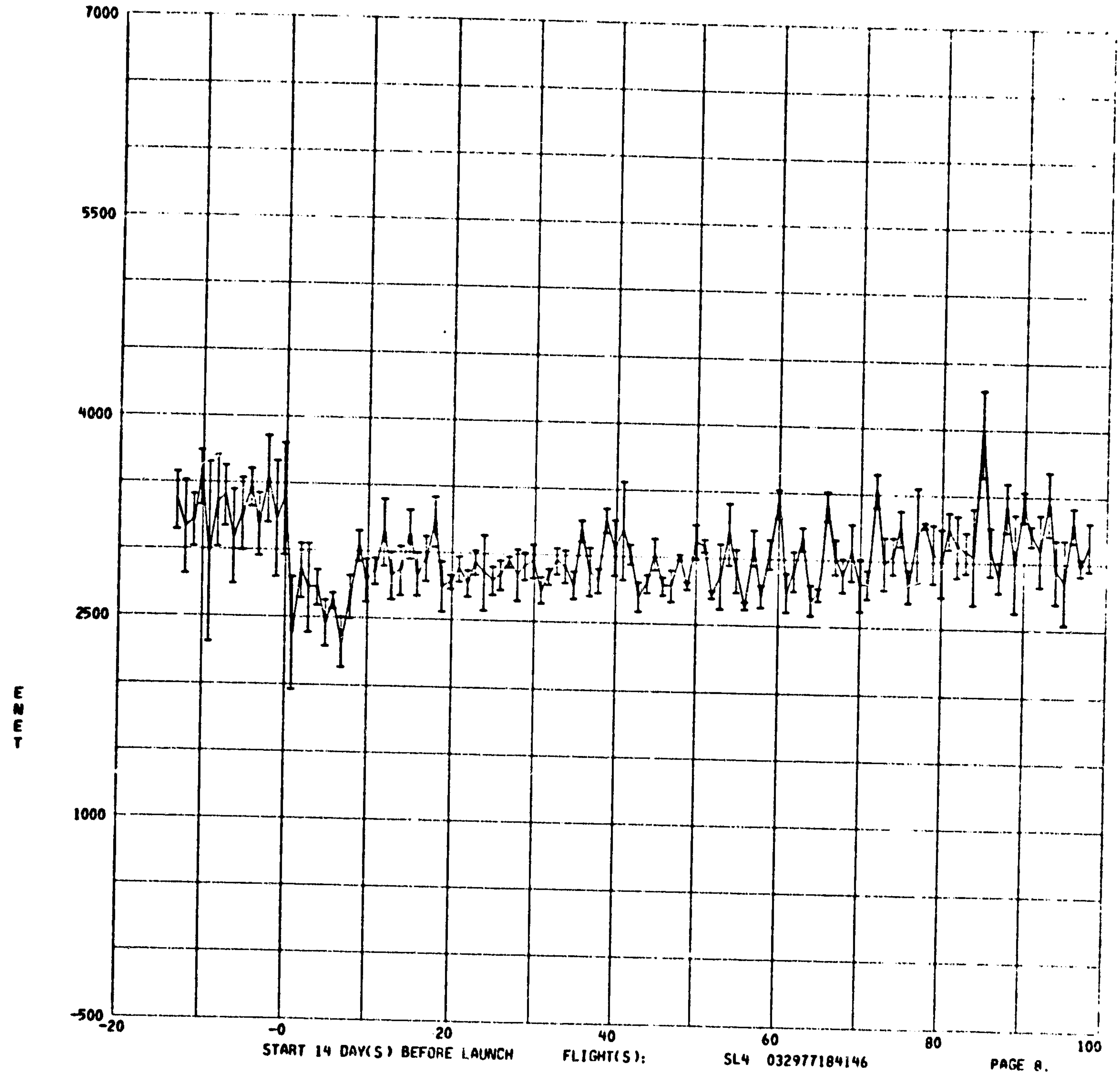
AVERAGE NET ENERGY UTILIZATION DURING IST SKYLAB MISSION

FIG. 4-2



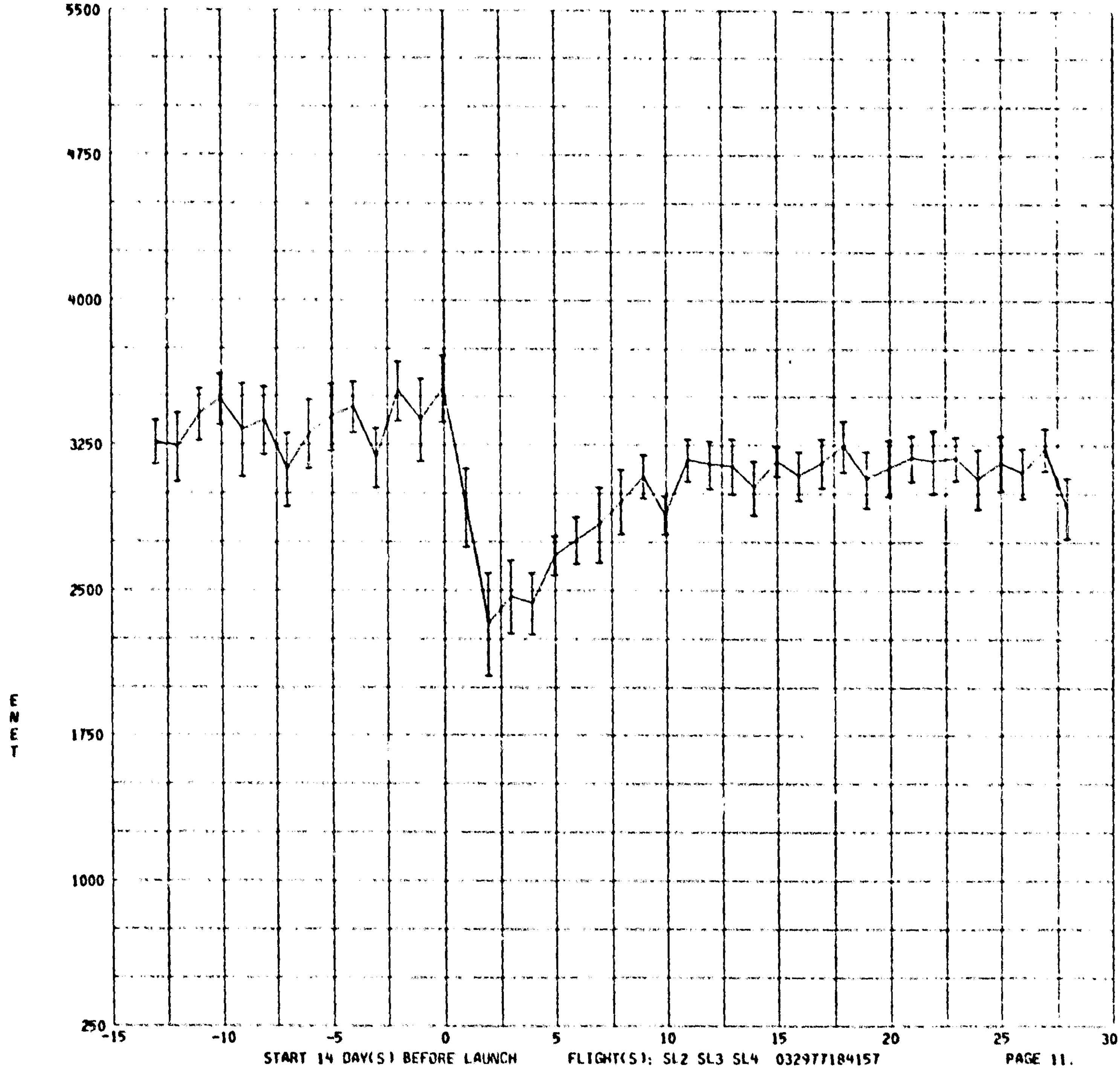
AVERAGE NET ENERGY UTILIZATION DURING 2ND SKYLAB MISSION

FIG. 4-3



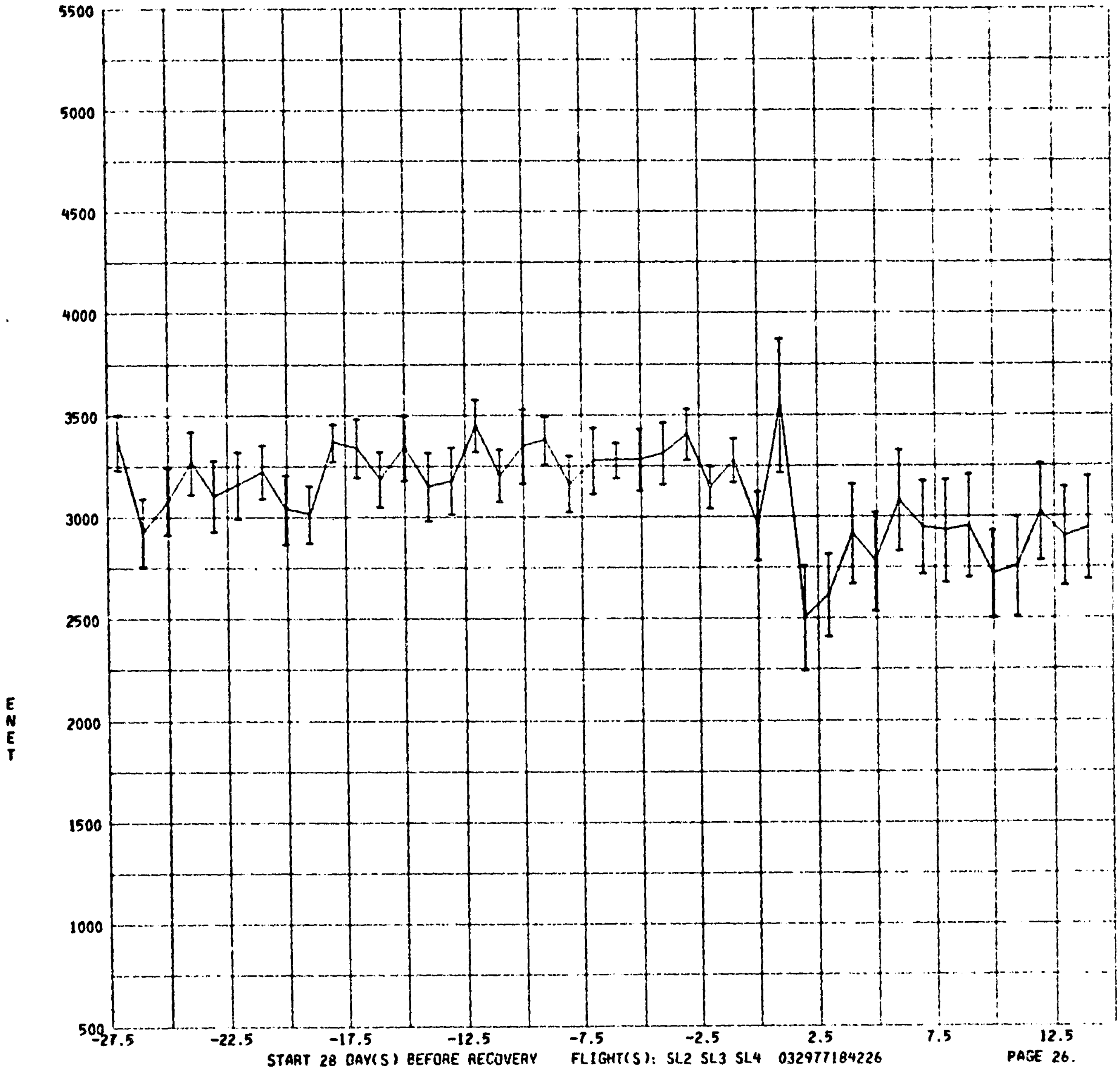
AVERAGE NET ENERGY UTILIZATION DURING 3RD SKYLAB MISSION

FIG. 4-4



AVERAGE NET ENERGY UTILIZATION FOR ENTIRE SKYLAB CREW (N = 9) DURING PREFLIGHT AND IST MONTH INFLIGHT

FIG. 4-5



AVERAGE NET ENERGY UTILIZATION FOR ENTIRE SKYLAB CREW (N = 9) DURING LAST MONTH INFLIGHT AND POSTFLIGHT PERIOD

FIG. 4-6

APPENDIX A:

MÉTHOD AND ANALYSIS FOR CORRECTING POTASSIUM BALANCE FOR SKIN LOSSES

APPENDIX A

METHOD AND ANALYSIS FOR CORRECTING POTASSIUM BALANCE FOR SKIN LOSSES

Object: Correction of Potassium Balance for Skin Losses Based on Comparison of Metabolic Balance with Directly Measured Total Body Potassium Changes.

Background: The original uncorrected K^+ balance (KBal) predicts that after 84 days there was a total shift (i.e., loss) of total body K^+ (TBK) of 724 meq from average preflight values. (See Table A-1). However, direct TBK measurements reveal that average inflight shift from control was only 230 meq K^+.

The discrepancy between these two measurements, one direct and the other indirect, is thought to be caused by skin losses of K^+ which were not accounted for in the metabolic balance. However, if the daily K^+ skin losses during the preflight period were identical to inflight skin losses the prediction of mean K^+ shift (i.e., (inflight balance — preflight balance) x no. of days) would not be altered (i.e., 724 meq loss) by including skin losses in the balance since the same value would be subtracted and then added in the calculation of K^+ shift.

Thus, an obvious conclusion one is left with to explain the discrepancy mentioned above is that K^+ skin losses were greater preflight than inflight. Failure to account for this in the metabolic balance will result in over estimation of the total K^+ loss.

Calculation of K+ Skin Losses: To test this hypothesis, it is necessary to estimate preflight and inflight skin losses separately by comparison of the indirect metabolic K^+ balance and direct preflight and postflight TBK measurements. The relationship relating these is derived below:

$$\Delta \text{TBK(direct)} = \text{K(diet)} - \text{K(urine)} - \text{K(fecal)} - \text{K(skin)} \quad (1)$$
$$= \text{KBal (uncorrected)} - \text{K(skin)}$$

or

$$\text{K(skin)} = \text{KBal (uncorrected)} - \Delta \text{TBK(direct)} \quad (2)$$

Table A-2 lists the preflight TBK measurements from which the individual values of ΔTBK (preflight) may be computed. Table A-3 shows the calculations of ΔTBK (inflight). Table A-4 shows the average values of KBal (Uncorrected).

Each term in equation (2) refers to meq K^+ during the period defined by the first and last TBK measurement. Thus,

For Preflight K(skin), Δ = 20-day period between earliest and latest preflight measurements.

For Inflight K(skin), Δ = 28, 56, or 84-day period between last preflight measurement and earliest post-flight measurement.

The average daily value of K^+ skin loss, $\overline{K}$(skin), meq/day, is determined by dividing K(skin) by the appropriate number of days in the time interval of concern.

Table A-5 summarizes the calculations for preflight and inflight K^+ skin losses.

The magnitude of the increase of Preflight K^+ skin losses above inflight (17.21 − 11.62 = 5.59 meq/day) when extrapolated over the longest mission (5.59 x 84 days = 470 meq) is great enough to account for almost the entire discrepancy of 724 − 230 = 494 meq between the uncorrected metabolic balance method and the direct TBK measurements.

Calculation of corrected K^+ Balance:

Using the inflight $\overline{K}$(skin) values in Table A-5, it is possible to obtain a corrected daily average K^+ balance

$$\overline{K}\text{Bal (corrected)} = \overline{K}\text{Bal (uncorrected)} - \overline{K}\text{(skin)} \tag{3}$$

These are presented in Table A-6. From these values the monthly loss and total accumulative losses, ΔK^+, at the end of each month of the mission can be easily obtained as follows:

$$\Delta K^{+}_{i},\text{meg} = \text{total accumulative loss (or gain) at end of inflight period } i, \quad (i = \text{I, II, III})$$

$$= \sum_{i}^{m} (\overline{K}\,\text{Bal(corrected)}) \times N_i$$

These are given in Table A-7.

Absolute values of TBK can be determined by subtracting the monthly losses from the directly measured TBK(preflight mean) which have been tabulated in Table III. These values of TBK during the flight are shown in Table VIII. It might be desirable to use the values of TBK at the midpoint of each flight period. The method of calculating these is outlined on the attached "Sample Calculations" which also gives the details of all the computations performed in this analysis.

TABLE A-1

METABOLIC BALANCES AND CUMULATIVE LOSSES

Crew Averages and SEM

	Inflight Monthly Period	n	Daily Preflight Control Balance	Daily Inflight Balance	Shift from Preflight Balance *	Total Monthly Change **	Cumulative Shift from Preflight ***
Nitrogen (gm)	I	9	3.19 ±0.53	-1.74 ±0.67	-4.93	-138.00	-138.00
	II	6	3.14 ±0.62	0.21 ±0.52	-2.93	- 82.00	-220.00
	III	3	2.77 ±0.56	0.17 1.32	-2.60	- 72.8	-292.3
Potassium (meq)	I	9	16.95 ± 2.80	4.03 ±2.67	-12.92	-361.8	-361.8
	II	6	15.96 ±2.70	9.26 ±7.65	- 6.70	-187.6	-549.4
	III	3	14.90 ± 2.60	8.66 ±5.86	- 6.24	-174.7	-724.1
Phosphorus (mg)	I	9	179.62 ±112.80	-23.78 ±118.00	-203.4	-5695	-5695
	II	6	210.00 ± 97.6	64.04 ± 68.65	-146.0	-4087	-9782
	III	3	151.14 ± 65.03	19.65 ± 67.45	- 131.5	-3682	-13464
Calcium (mg)	I	9	7.47 ±193.07	-18.41 ±78.00	-25.88	-725	-725
	II	6	-55.06 ±202.60	-169.58 ±131.32	-114.52	-3207	-3931
	III	3	-230.97 ± 79.24	-167.91 ± 80.14	63.06	+1766	-2165

TABLE A-1 (Continued)

	Inflight Monthly Period	n	Daily Preflight Control Balance	Daily Inflight Balance	Shift from Preflight Balance *	Total Monthly Change **	Cumulative Shift from Preflight ***
Magnesium (mg)	I	9	25.53 ±32.29	16.15 ±14.06	- 9.38	-263	-263
	II	6	9.64 ±24.53	24.92 ±25.55	15.28	428	165
	III	3	-9.65 ±17.55	14.87 ±11.64	24.63	690	855

* Shift from Control, Δ = Inflight Balance - Control Balance

** Total Monthly Change, $L_i = \Delta \times 28$ days

*** Cumulative Shift $= \sum_{i=1} L_i$

TABLE A-2

CHANGES IN TBK FROM PREFLIGHT AVERAGE

Man	n	Preflight Mean		sd	Postflight	ΔTBK
1	5	3269	±	43	2998	-271
2	5	3917	±	52	3678	-239
3	5	3867	±	64	3528	-339
4	4	3339	±	22	3151	-188
5	4	3062	±	30	3029	-33
6	4	4647	±	98	4485	-162
7	3	3228	±	31	3108	-120
8	3	3673	±	100	3348	-325
9	3	3614	±	64	3169	-445
AVG		3624			3388	-236
SEM		±484			±471	±125

TABLE A-3

TOTAL BODY POTASSIUM, TBK (Meg K^+)

Man	F-20 & F-21	F-14 & F-16	F-7 & F-8	F-1 & F-2
1	3252	3309	3280	3301 3202
2	3876	3969	3937	3849 3952
3	3822	3839	3949	3920 3803
4	3333	3367	3314	3340
5	3094	3080	3034	3039
6	4536	4602	4687	4760
7	3228	3258		3197
8	3758	3698		3562
9	3612	3678		3551
AVG	3612	3644		3607
SEM	± 448	± 463		± 521

TABLE A-4

CREW AVERAGES FOR UNCORRECTED POTASSIUM BALANCE (meq/day)

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	19.27	6.24		
	2	20.80	3.18		
	3	16.75	4.20		
SL-3	4	14.66	0.79	9.35	
	5	16.17	0.92	13.17	
	6	20.20	5.16	21.77	
SL-4	7	12.29	1.84	0.83	2.45
	8	14.94	4.95	8.08	9.42
	9	17.48	8.95	2.33	14.10
AVG:	(1-9)	16.95	4.03	9.26	8.66
SEM:		± 2.80	± 2.67	± 7.65	± 5.86
	(4-9)	15.96 ± 2.70			
	(7-9)	14.90 ± 2.60			

TABLE A-5

ESTIMATION OF PREFLIGHT AND INFLIGHT POTASSIUM SKIN LOSSES*

MAN	PREFLIGHT** Direct ΔTBK (meq)	PREFLIGHT** Uncorrected KBal (meq/day)	PREFLIGHT** $\overline{K}$ (Skin) (meq/day)	INFLIGHT Direct ΔTBK (meq)	INFLIGHT Uncorrected KBal (meq/day)	INFLIGHT M days	INFLIGHT $\overline{K}$ (Skin) (meq/day)
1	0	19.27	19.27	-271	6.24	28	15.92
2	+25	20.80	19.55	-239	3.18	28	11.72
3	+40	16.75	14.75	-339	4.20	28	16.31
4	+7	14.66	14.31	-188	5.07	56	8.43
5	-55	16.17	18.92	-33	7.05	56	7.63
6	+224	20.20	9.00	-162	13.47	56	16.36
7	-31	12.29	13.84	-120	1.37	84	3.14
8	-196	14.94	24.74	-325	7.48	84	11.35
9	-61	17.48	20.53	-445	8.46	84	13.76
AVG	5	16.95	17.21	-236	6.28		11.62
SEM	±111	±2.80	±4.67	±125	±3.50		± 4.55

$$* \overline{K}\ (\text{Skin}) = \left[\sum_{i=1}^{M} \text{KBal}_i\ (\text{Uncorr.}) \times N_i - \Delta\ \text{TBK (Direct)} \right] \Big/ \sum_{i=1}^{M} N_i$$

(M = Monthly Period = 1, 2, 3)

** N = 20 Days for All Preflight Measurement

TABLE A-6

CREW AVERAGES FOR Potassium Balance (Corrected for Skin Losses) meq/day

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	0.00	-9.68		
	2	1.25	-8.54		
	3	2.0	-12.11		
SL-3	4	0.35	-7.64	0.92	
	5	-2.75	-6.71	5.54	
	6	11.2	-11.20	5.41	
SL-4	7	-1.55	-1.30	-2.31	-0.69
	8	-9.80	-6.40	-3.27	-1.93
	9	-3.05	-4.81	-11.43	0.34
AVG:	1-9	0.35 $\pm$5.54	-7.60 $\pm$ 3.32	-0.86 $\pm$6.37	-0.76 $\pm$1.14
SEM:	4-9	-0.02 $\pm$6.9			
	7-9	- 4.8 $\pm$ 4.39			

K^+Bal (corrected) = K^+Bal (uncorrected) - K (skin)

TABLE A-7

CREW AVERAGES FOR Monthly TBK Changes* (meq)

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	0	-271		
	2	+25	-239		
	3	+40	-339		
SL-3	4	+7	-214	+26	
	5	-55	-188	+155	
	6	+224	-314	+152	
SL-4	7	-31	-36	-65	-19
	8	-196	-179	-92	-54
	9	-61	-135	-320	+10
AVG:		-5	-213	-24	-21
SEM:		±111	± 93	±179	±32

Cumulative Shift from Preflight: -208 -227 -243

*TBK Changes = KBal (corrected) x N (days)

TABLE A-8

CREW AVERAGES FOR TOTAL BODY POTASSIUM (meq)*

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	3269	2998		
	2	3917	3678		
	3	3867	3528		
SL-3	4	3339	3125	3151	
	5	3062	2874	3029	
	6	4647	4333	4485	
SL-4	7	3228	3192	3127	3108
	8	3673	3494	3402	3348
	9	3614	3479	3159	3169
AVG:		3624	3411	3392	3208
SEM:		±484	± 438	±549	±125

*TBK = TBK(Preflight) - ΔTBK(Inflight)

Inflight Values Refer to end of designated period.

Sample Calculation (Garriot, SL2/SPT) MAN 5:

1.) Preflight Skin Loss

$$\Delta \text{TBK(direct, Preflight)} = \overset{\text{F-1}}{\overline{3039}} - \overset{\text{F-20}}{\overline{3094}} = -55 \text{ meq}$$

$\overline{K}$Bal (uncorrected), Preflight = 16.17 meq/day

$\overline{K}$(Skin) = 16.17 - (-55/20 days) = 18.92 meq/day

2.) Inflight Skin Losses

ΔTBK(direct, inflight) = -33 meq

$\overline{K}$Bal (uncorrected) Inflight I = 0.92 meq/day
" II = 13.17 meq/day

$$\overline{K}\text{(Skin)} = \frac{.92 \times 28 \text{ days} + 13.17 \times 28 \text{ days} - (-33)}{56 \text{ Days}}$$

$$= 7.63 \text{ meq/day}$$

3.) Corrected K^+ Balances

$\overline{K}$Bal(corrected, Preflight) = 16.17 - 18.92 = -2.75 meq/day

$\overline{K}$Bal (corrected, Inflight) I = .92-7.63 = -6.71
II - 13.17-7.63 = 5.54

4.) Monthly Inflight Losses

Inflight I Loss = -6.71 x 28 = -188 meq

Inflight II Gain = +5.54 x 28 = +155 meq

Sample Calculation (continued)

5.) Total Body K+ during Mission

TBK Preflight Mean (direct) =	3062 meq
Inflight I Δ TBK =	- 188
TBK at end of Period I =	2874 meq
Inflight II Δ TBK =	+155
TBK at end of Period II =	3029

You might want to use value of TBK at midpoint of each inflight period.

In that case

Inflight I (midpoint) $= 3062 - \frac{188}{2} - 2968$

Inflight II (midpoint) $- 2874 + \frac{155}{2} = 2952$

TABLE B-1

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Body Mass Changes

(gm/day)

		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	30	-30.00	377.06	28	-39.29	465.78						
	2	30	-46.67	358.62	28	-96.43	484.75						
	3	30	-56.67	330.55	28	-114.29	411.65						
SL-3	4	20	5.00	372.01	28	-96.43	390.14	28	-14.29	308.78			
	5	20	-35.00	531.41	28	-110.71	415.75	28	- 3.57	319.12			
	6	20	80.00	548.30	28	-96.43	697.87	28	-10.71	310.72			
SL-4	7	26	30.77	342.66	28	-14.29	309.98	28	- 3.57	324.87	28	17.86	320.94
	8	26	-30.77	406.71	28	-67.86	352.82	28	.00	495.91	28	17.86	410.11
	9	26	.00	292.58	28	-78.57	422.61	28	17.86	288.10	28	10.71	314.28
	AVG.	(1-9)	- 9.26			-79.37			- 2.38			15.48	
	SEM.		± 43.39			± 33.63			± 11.22			± 4.13	
		(4-9)	8.33										
			±42.73										
		(7-9)	0.00										
			±30.77										

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												
	AVG.												
	SEM.												

TABLE B-2

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Water Balance (adjusted for measured TBW)

(ml/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	30	-13.5842	369.747	28	-14.9640	456.393						
	2	30	32.6449	350.938	28	-10.3017	478.113						
	3	30	-32.2558	320.267	28	-73.7966	413.174						
SL-3	4	20	35.2213	364.934	28	-51.7797	374.051	29	28.1697	286.938			
	5	20	17.1559	520.898	29	-45.3459	410.314	28	57.6770	309.566			
	6	20	79.8072	546.197	28	-76.2848	687.522	28	-.791718	301.926			
SL-4	7	25	14.6671	346.291	28	-24.0051	313.420	28	-13.0416	315.982	28	9.66059	328.474
	8	26	-23.0413	396.335	28	-58.1999	347.146	28	9.09277	497.509	28	27.3070	409.937
	9	26	-9.09435	284.755	28	-32.6604	406.909	28	18.3061	268.946	28	9.55760	313.640

		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
AVG.	(1-9)	10.72	-48.59	16.67	15.51
SEM.		±35.62	±27.10	±24.75	±10.22
	(4-9)	-19.12			
		±36.16			
	(7-9)	- 5.82			
		±19.0			

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												

AVG.

SEM.

TABLE B-3

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Dry Tissue Weight (Adjusted for Measured TBW)
(gm/day)

		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	30	-11.4152	25.1404	28	-24.3217	24.6636						
	2	30	-79.3116	34.3004	28	-75.1268	30.3130						
	3	30	-24.4103	37.5310	28	-40.4891	15.7603						
SL-3	4	20	-30.2213	26.9450	28	-44.6493	25.6185	28	-42.4554	28.5231			
	5	20	-52.1559	16.9210	28	-65.3685	24.2492	28	-61.2424	25.6575			
	6	20	.192774	13.2220	28	-20.1427	24.7035	28	-9.92257	26.3713			
SL-4	7	26	16.1021	17.3622	28	9.71941	15.9171	28	9.47014	29.2989	28	3.19655	28.6803
	8	26	-7.72798	21.4662	28	-9.65718	29.4964	28	-9.09277	26.0051	28	-9.44984	30.1903
	9	26	9.09435	33.1375	28	4.03891	30.5003	28	-1.04895	35.3148	28	1.15669	30.5139
AVG.	(1-9)		- 19.98			- 30.77			- 19.05			- 0.032	
SEM.			± 30.53			± 31.63			± 27.01			± 8.883	
	(4-9)		- 10.79										
			± 25.84										
	(7-9)		5.82										
			± 12.25										

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												
AVG.													
SEM.													

APPENDIX C

CREW DATA: ENERGY DERIVED FROM CATABOLISM OF BODY TISSUE

TABLE C-1

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR CHANGES IN BODY PROTEIN MASS (gm/day) ΔPTIS*

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	21.19	- 2.43		
	2	22.19	- 9.88		
	3	17.94	- 7.06		
SL-3	4	19.25	- 14.00	2.01	
	5	21.44	- 13.81	4.11	
	6	25.38	- 14.94	5.24	
SL-4	7	20.81	- 13.25	- 3.17	- 6.75
	8	13.81	- 13.69	1.58	0.290
	9	17.25	- 9.00	-1.74	9.69
AVG:	(1-9)	19.92	- 10.90	1.34	1.08
SEM:		± 3.33	± 4.17	± 3.26	± 8.25
	(4-9)	19.66			
		± 3.93			
	(7-9)	17.29			
		± 3.50			

* $\Delta PTIS = 6.25 \; NBAL = 6.25 \; (N_{diet.} - N_{urine} - N_{fecal})$

TABLE C-2

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR CHANGES IN BODY FAT, ΔFTIS*

(gm/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	- 32.61	- 21.89		
	2	-101.50	- 76.25		
	3	- 42.35	- 33.43		
SL-3	4	- 49.47	- 30.65	- 44.47	
	5	- 73.60	- 51.56	- 65.36	
	6	- 25.19	- 5.20	- 15.16	
SL-4	7	- 49.47	22.97	12.64	14.95
	8	- 21.54	4.03	- 10.67	- 9.74
	9	- 8.16	13.09	0.691	- 8.53
AVG:	(1-9)	- 39.90	- 19.88	- 20.39	- 1.11
SEM:		± 31.39	± 32.01	± 29.19	±13.92
	(4-9)	- 30.45			
		± 26.42			
	(7-9)	- 11.47			
		± 8.89			

* ΔFTIS = ΔTIS − ΔPTIS

TABLE C-3

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR ENERGY DERIVED FROM PROTEIN METABOLISM, ΔE_{Pro} (gm/day)*

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	− 91.46	10.49		
	2	− 95.77	42.64		
	3	− 77.43	30.47		
SL-3	4	− 83.08	60.42	− 8.67	
	5	− 92.54	59.60	−17.74	
	6	−109.54	64.48	−22.62	
SL-4	7	− 89.82	57.19	13.68	29.13
	8	− 59.60	59.09	− 6.82	− 1.25
	9	− 74.45	38.84	7.51	−41.82
AVG:	(1-9)	− 85.97	47.02	− 5.78	− 4.65
SEM:		± 14.36	±17.98	±14.08	±35.60
	(4-9)	− 84.84			
		± 16.98			
	(7-9)	− 74.62			
		± 15.11			

* $\Delta E_{Pro} = -\Delta PTIS * 4.316$

"+" = energy derived from protein metabolism

"−" = energy stored in protein

TABLE C-4

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR ΔE_{Fat}, ENERGY DERIVED FROM FAT METABOLISM, ΔE_{Fat}* (Kcal/day)

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	308.52	207.10		
	2	960.29	721.40		
	3	400.67	316.28		
SL-3	4	468.04	289.98	420.73	
	5	696.33	487.81	618.37	
	6	238.32	49.20	143.43	
SL-4	7	44.56	-217.32	-119.59	-141.44
	8	203.79	-38.13	100.95	92.15
	9	77.20	-123.84	-6.54	80.70
AVG:	(1-9)	377.52	188.05	192.89	10.47
SEM:		± 296.94	±302.81	±276.14	±131.68
	(4-9)	288.04			
		± 249.96			
	(7-9)	108.52			
		± 84.11			

$$^{*}\Delta E_{Fat} = -\Delta FTIS \times 9.461 \frac{\text{Kcal}}{\text{gm fat}}$$

\+ Value = energy derived from fat catabolism

\- Value = energy stored by fat anabolism

TABLE C-5

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR TOTAL ENERGY DERIVED FROM TISSUE, ΔE_{Tis} METABOLISM (Kcal/day) *

FLT.	MAN	PERIODS: PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	217.06	217.59		
	2	864.52	764.04		
	3	323.24	346.75		
SL-3	4	384.96	350.40	412.06	
	5	603.79	547.41	600.63	
	6	128.78	113.68	120.81	
SL-4	7	- 45.26	- 160.13	- 105.91	- 112.31
	8	144.19	20.96	94.13	90.90
	9	2.75	- 85.00	0.97	38.88
AVG:	(1-9)	291.56	235.08	187.12	5.82
SEM:		± 292.86	± 300.55	± 266.51	± 105.56
	(4-9)	203.20			
		± 246.76			
	(7-9)	33.89			
		± 98.49			

$^{*}\Delta E_{Tis} = \Delta E_{Fat} + \Delta E_{Pro}$

TABLE C-6

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR NET ENERGY UTILIZED, E_u *

(Kcal/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	2601	2478		
	2	3499	3087		
	3	2904	2606		
SL-3	4	2740	2600	2888	
	5	3056	2578	3049	
	6	3502	2986	3481	
SL-4	7	2828	2682	2788	2804
	8	2961	2779	2892	3029
	9	2928	2807	2937	3131
AVG:	(1-9)	3002	2734	3006	2988
SEM:		± 312	± 201	± 248	± 167
	(4-9)	3003			
		± 268			
	(7-9)	2906			
		± 69			

* $E_u = E_{\text{Food Net (bomb)}} + \Delta E_{TIS}$

TABLE C-7

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR NET ENERGY UTILIZED/TOTAL BODY POTASSIUM (Kcal/meg K^+)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	0.7957	0.8266		
	2	0.8933	0.8393		
	3	0.7510	0.7387		
SL-3	4	0.8206	0.8320	0.9165	
	5	0.9980	0.8970	1.0066	
	6	0.7536	0.6891	0.7761	
SL-4	7	0.8761	0.8402	0.8916	0.9022
	8	0.8062	0.7954	0.8501	0.9047
	9	0.8102	0,8068	0.9297	0.9880
AVG:	(1-9)	0.8339	0.8072	0.8951	0.9316
SEM:		± .0779	± .0612	± .0778	± .0488
	(4-9)	0.8441			
		± .0849			
	(7-9)	.8308			
		± .0393			

APPENDIX D

CREW DATA: ENERGY DERIVED FROM FOOD AND EXCRETED IN FECES AND URINE

TABLE D-1

ENERGY BALANCE DATA ANALYSIS

(Diet) *
Monthly Crew Averages for Calculate Food Calories

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	30	2775.94	190.27	28	2753.61	229.89						
	2	30	3021.68	510.77	28	2890.57	264.37						
	3	30	3029.07	295.62	28	2743.62	247.73						
SL-3	4	20	2723.66	155.84	28	2667.59	327.98	28	2881.32	133.75			
	5	20	2845.68	202.72	28	2462.17	520.50	28	2965.27	220.61			
	6	20	3996.99	187.20	28	3413.74	807.74	28	4050.27	230.22			
SL-4	7	26	3062.81	326.75	28	3071.84	267.19	28	3115.70	261.33	28	3155.20	319.51
	8	26	2998.38	270.84	28	2939.68	211.31	28	2948.93	207.88	28	3111.58	202.30
	9	26	3099.88	213.68	28	3092.25	333.07	28	3170.04	215.72	28	3309.11	255.16
	AVG.		3061.57			2892.79			3168.59			3191.96	
	SD		375.08			279.11			435.86			103.77	

* Kcal = 4.182 CHO + 9.461 Fat + 4.316 Pro

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												
	AVG.												
	SEM.												

TABLE D-2

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Bomb Calorimetry Food Calories
(SMEDEP Data Base) (kcal/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT Mean	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I Mean	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II Mean	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III Mean	INFLIGHT III SD
SL-2	1	22	2632	128	27	2498	180						
	2	20	2901	388	25	2580	197						
	3	26	2881	285	26	2497	216						
SL-3	4	17	2561	155	28	2475	317	28	2697	148			
	5	15	2688	186	28	2288	494	28	2733	203			
	6	16	3716	174	28	3228	752	28	3747	212			
SL-4	7	26	3152	355	28	3165	276	28	3204	271	28	3237	313
	8	25	3088	291	28	3013	233	27	3041	245	28	3199	230
	9	26	3194	211	28	3182	342	28	3266	215	28	3408	270
AVG:			2979			2770			3115			3281	
SEM:			358			371			389			111	

TABLE D-3

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Food Calories, Calculated/(Bomb x 0.96)

FLT.	MAN	PERIODS							
		PREFLIGHT		INFLIGHT I		INFLIGHT II		INFLIGHT III	
		N	Ratio	N	Ratio	N	Ratio	N	Ratio
SL-2	1	30/22	1.055	28/27	1.102				
	2	30/20	1.042	28/25	1.120				
	3	30/26	1.051	28/26	1.099				
SL-3	4	20/17	1.064	28/28	1.078	28/28	1.068		
	5	20/15	1.059	28/28	1.076	28/28	1.085		
	6	20/16	1.076	28/28	1.057	28/28	1.081		
SL-4	7	26/26	0.972	28/28	0.971	28/28	0.972	28/28	0.975
	8	26/25	0.971	28/28	0.976	28/27	0.970	28/28	0.973
	9	26/26	0.971	28/28	0.972	28/28	0.971	28/28	0.971
AVG:			1.029		1.050		1.025		0.973
SEM:			.044		.061		.059		.002

Note: Calculated Food Calories computed from

$$\text{Kcal Diet} = .96 \left[4.182(\text{CHO}) + 9.461\ (\text{Fat}) + 4.316\ (\text{PRO})\right]$$

where factor 0.96 is estimated metabolic efficiency.

The ratio computed above is divided by 0.96 which effectively removes the efficiency factor from calculation (i.e., sets efficiency = 1.0)

TABLE D-4

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Fecal Calories (Bomb)
(Kcal/day)

		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	30	142.31	182.76	28	105.96	120.57						
	2	30	157.83	147.81	28	107.14	155.91						
	3	30	143.27	217.15	28	104.31	81.47						
SL-3	4	20	109.75	130.00	28	104.11	120.84	28	114.24	147.78			
	5	20	124.81	69.67	28	114.31	112.26	28	144.41	136.95			
	6	20	170.56	101.65	28	165.90	103.41	28	191.51	128.92			
SL-4	7	26	159.51	53.48	28	158.60	103.39	28	158.00	124.48	28	167.26	153.63
	8	26	145.59	142.48	28	92.34	129.60	28	99.94	130.66	28	114.24	134.85
	9	26	129.27	144.71	28	117.90	149.83	28	161.62	210.71	28	159.19	150.35
	AVG.		142.54			118.95			144.95			146.90	
	SD		18.98			25.62			33.42			28.57	

Monthly Crew Averages for Urine Calories (Derived)*
(Kcal/day)

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	30	105.52		28	132.10							
	2	30	108.79		28	149.64							
	3	30	156.95		28	134.00							
SL-3	4	20	95.72		28	121.35		28	107.24				
	5	20	111.20		28	143.10		28	141.13				
	6	20	171.57		28	190.40		28	195.13				
SL-4	7	26	119.45		28	164.26		28	152.22		28	153.77	
	8	26	125.39		28	162.54		27	142.85		28	146.54	
	9	26	139.92		28	172.26		28	167.79		28	157.29	
	AVG.		126.06			152.18			151.06			152.53	
	SD		25.31			22.05			29.36			5.48	

* Kcal = 8.6 Kcal/gm Urine N x Urine N

TABLE D-5

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Net Food Calories* (Kcal/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1		2384			2260							
	2		2634			2323							
	3		2581			2259							
SL-3	4		2355			2250			2476				
	5		2452			2031			2448				
	6		3373			2872			3360				
SL-4	7		2873			2842			2894			2916	
	8		2817			2758			2798			2938	
	9		2925			2892			2936			3092	
AVG.			2710			2499			2819			2982	
SD			325			336			337			96	

* Food (bomb) - Fecal (bomb) - Urine (Est.)

Monthly Crew Averages for Net Food Calories* (Kcal/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1		2528.11			2515.55							
	2		2755.06			2633.79							
	3		2728.85			2505.31							
SL-3	4		2518.19			2442.13			2659.84				
	5		2609.67			2204.76			2679.73				
	6		3654.86			3057.44			3663.63				
SL-4	7		2783.85			2748.98			2805.48			2834.17	
	8		2727.40			2684.80			2706.14			2850.80	
	9		2830.69			2802.09			2840.63			2992.63	
AVG.			2792.96			2621.65			2892.58			2892.53	
SD			341.59			243.32			384.46			87.08	

*Food (calc) - Fecal (Bomb) - Urine (Est.)

TABLE D-6

DIET FOOD CALORIES (BOMB)

Daily Crew Averages
(Kcal/day)

Man	Preflight			Inflight			Postflight		
	N	Mean	sd	N	Mean	sd	N	Mean	sd
1	22	2632	± 128	27	2498	± 180			
2	20	2901	± 388	25	2580	± 197			
3	26	2881	± 285	26	2497	± 216			
4	17	2561	± 155	56	2586	± 250			
5	15	2688	± 186	56	2511	± 378			
6	16	3716	± 174	56	3488	± 553			
7	26	3152	± 355	84	3202	± 287			
8	25	3088	± 291	83	3085	± 237			
9	26	3194	± 211	84	3285	± 281			
MEAN									
SEM									

TABLE D-7

FECAL CALORIES (BOMB)

Daily Crew Averages
(Kcal/day)

Man	Preflight N	Preflight Mean	Preflight sd	Inflight N	Inflight Mean	Inflight sd	Postflight N	Postflight Mean	Postflight sd
1	30	142.3	± 182.8	28	106.0	± 120.9	14	137.0	± 214.3
2	30	144.5	± 143.1	28	107.1	± 155.9	14	181.5	± 281.8
3	30	143.3	± 217.2	28	104.3	± 81.5	14	100.8	± 141.2
4	20	109.8	± 130.0	59	107.1	± 138.8	17	67.3	± 118.9
5	20	124.8	± 69.7	59	131.8	± 124.5	17	147.6	± 169.5
6	20	170.6	± 101.7	59	180.5	± 117.0	17	178.8	± 111.8
7	26	159.5	± 53.5	84	161.3	± 127.3	18	163.5	± 88.9
8	26	145.6	± 142.5	84	102.2	± 130.5	18	89.4	± 118.2
9	26	129.3	± 144.7	84	146.2	± 171.8	18	151.5	± 166.3
MEAN									
SEM									

APPENDIX E

CREW DATA: NET METABOLIC BALANCES FOR NITROGEN, POTASSIUM, CALCIUM, MAGNESIUM AND PHOSPHORUS

TABLE E-1

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Nitrogen Balance (gm/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	3.39	-0.39		
	2	3.55	-1.58		
	3	2.87	-1.13		
SL-3	4	3.08	-2.24	0.32	
	5	3.43	-2.21	0.66	
	6	4.06	-2.39	0.84	
SL-4	7	3.33	-2.12	-0.51	-1.08
	8	2.21	-2.19	0.25	0.05
	9	2.76	-1.44	-0.28	1.55
AVG:	(1-9)	3.19	-1.74	0.21	0.17
SEM:		±0.53	±0.67	±0.52	±1.32
	(4-9)	3.14 ±0.62			
	(7-9)	2.77 0.56			

TABLE E-2

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Potassium Balance (meq/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	19.27	6.24		
	2	20.80	3.18		
	3	16.75	4.20		
SL-3	4	14.66	0.79	9.35	
	5	16.17	0.92	13.17	
	6	20.20	5.16	21.77	
SL-4	7	12.29	1.84	0.83	2.45
	8	14.94	4.95	8.08	9.42
	9	17.48	8.95	2.33	14.10
AVG:	(1-9)	16.95	4.03	9.26	8.66
SEM:		± 2.80	±2.67	± 7.65	± 5.86
	(4-9)	15.96 ± 2.70			
	(7-9)	14.90 ± 2.60			

TABLE E-3

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Calcium Balance (mg/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	252.03	43.30		
	2	48.38	114.12		
	3	97.17	- 14.16		
SL-3	4	103.59	- 82.28	-116.49	
	5	72.26	-153.49	-283.76	
	6	186.71	- 77.26	- 49.67	
SL-4	7	-184.61	4.74	- 67.78	- 77.73
	8	-322.47	-12.53	-121.95	-195.03
	9	-185.84	11.90	-377.80	-230.98
AVG:	(1-9)	7.47	-18.41	-169.58	-167.91
SEM:		±193.07	±78.00	±131.32	± 80.14
	(4-9)	- 55.06 ±202.60			
	(7-9)	-230.97 ± 79.24			

TABLE E-4

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Phosphorus Balance (mg/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	262.80	- 74.87		
	2	103.65	-132.36		
	3	- 10.06	-256.00		
SL-3	4	247.17	- 37.45	48.70	
	5	186.27	55.84	96.47	
	6	373.58	65.53	177.96	
SL-4	7	199.12	- 10.04	14.[illegible]7	-55.32
	8	77.06	45.73	65.[illegible]	38.84
	9	177.02	129.57	-18.85	75.42
AVG:	(1-9)	179.62	-23.78	64.04	19.65
SEM:		±112.80	±118.00	±68.65	±67.45
	(4-9)	210.00			
		± 97.62			
	(7-9)	151.14			
		± 65.03			

TABLE E-5

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Magnesium Balance (mg/day)

FLT.	MAN	PERIODS			
		PREFLIGHT	INFLIGHT I	INFLIGHT II	INFLIGHT III
SL-2	1	80.24	30.83		
	2	46.11	39.97		
	3	45.61	13.32		
SL-3	4	31.54	4.85	45.07	
	5	19.89	17.32	28.17	
	6	35.69	12.46	58.11	
SL-4	7	- 3.25	0.24	15.56	13.69
	8	-29.64	- 0.58	17.79	3.86
	9	3.61	26.91	-15.18	27.05
AVG:	(1-9)	25.53	16.15	24.92	14.87
SEM:		±32.29	±14.06	±25.55	± 11.64
	(4-9)	9.64 ±24.53			
	(7-9)	- 9.76 ±17.55			

APPENDIX F

CREW DATA: DIET, URINE AND FECAL DATA FOR METABOLIC BALANCES

TABLE F-1

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Nitrogen Diet (gm/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	30	16.7467	1.19539	28	15.1107	1.52712						
	2	30	17.7000	1.99845	28	16.9036	1.16666						
	3	29	17.4759	2.05959	28	15.5286	1.34305						
SL-3	4	20	15.2250	.907793	28	13.0929	2.13493	28	14.0464	1.06405			
	5	20	17.9950	1.05305	28	15.6500	3.37485	28	12.5429	1.09433			
	6	20	[illegible].0200	1.16058	28	21.6750	6.42182	28	25.6925	1.56913			
SL-4	7	26	[illegible].3231	1.96353	28	13.7964	2.34386	28	13.0214	2.37258	28	18.7500	2.43333
	8	26	18.0115	1.[illegible]0507	28	17.6214	1.29196	27	17.7630	1.52471	28	18.1321	1.45934
	9	26	20.2346	1.39526	28	19.5250	2.79187	28	20.6393	2.08173	28	21.2536	2.12332
AVG.			18.7534			17.2115			19.2843			19.3785	
SEM.			3.0784			2.5505			3.8282			1.6530	

Monthly Crew Averages for Nitrogen Urine (gm/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	30	12.2733	3.13038	28	15.3571	4.84695						
	2	30	12.6567	3.25531	28	17.3964	5.24620						
	3	29	13.2517	3.94073	28	15.5736	4.82642						
SL-3	4	20	11.1300	.879055	28	14.1107	2.54389	28	12.4679	1.62459			
	5	20	12.9250	1.39732	28	16.6429	4.35366	28	16.4143	1.50326			
	6	20	19.3500	2.20991	28	22.1393	3.88638	28	22.6929	2.21342			
SL-4	7	26	13.3885	1.25262	28	19.0964	2.52901	28	17.7000	1.69967	28	17.8786	1.64370
	8	26	14.5308	1.83630	28	18.9000	2.82699	27	16.6074	2.44256	28	17.0357	2.17663
	9	26	16.2731	2.61053	28	20.0250	3.53822	28	19.5107	3.59365	28	18.2929	3.24892
AVG			14.1032			17.694			17.5655			17.7357	
SEM.			2.6354			2.5638			3.4153			.6407	

TABLE F-2

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Nitrogen Fecal
(gm/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	30	1.09333	1.20175	28	1.14286	1.33623						
	2	30	1.49000	1.46672	28	.939286	1.45127						
	3	29	1.35172	1.79456	28	1.03214	.949360						
SL-3	4	20	1.02000	1.25639	28	1.22500	1.43235	28	1.25714	1.61622			
	5	20	1.64500	.921369	28	1.21429	1.17635	28	1.47143	1.37406			
	6	20	2.01500	.937115	28	1.92500	1.23876	28	2.16071	1.41666			
SL-4	7	26	2.10769	.731532	28	1.81786	1.15311	28	1.32857	1.37497	28	1.94643	1.75763
	8	26	1.23308	.948813	29	.914286	1.27038	27	.903704	1.22427	28	1.05000	1.22217
	9	26	1.25385	1.43701	28	1.04286	1.35931	28	1.40714	1.34068	28	1.41071	1.32925
	AVG.		1.46552			1.26151			1.50478			1.46905	
	SEM.		.38862			.36091			0.44008			.45105	

Monthly Crew Averages for

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												
	AVG.												
	SEM.												

TABLE F-3

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Potassium Diet (meq/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	101.091	8.32246	27	102.148	7.15597						
	2	20	103.550	14.1290	25	100.320	6.17603						
	3	26	97.3462	14.2893	26	99.3077	15.7296						
SL-3	4	17	97.1176	18.3469	28	92.3929	11.3732	28	89.0357	13.2651			
	5	15	94.6667	6.65117	28	77.7500	15.4095	28	89.3929	4.31771			
	6	16	146.062	8.90295	28	123.333	29.7823	28	144.143	11.3095			
SL-4	7	26	97.5385	7.04404	28	99.1786	6.02497	28	99.2500	5.54361	28	100.071	9.02231
	8	25	84.1200	3.91918	28	88.5000	3.30662	27	89.0000	7.46273	28	90.2857	3.47155
	9	26	108.115	13.7239	28	93.9286	11.1053	28	98.8214	6.67807	28	103.321	10.3604
AVG.			103.29			96.32			101.69			98.06	
SEM.			17.34			13.26			21.34			6.99	

Monthly Crew Averages for Potassium Urine (meq/day)*

* mg - 39.0 × meq

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	71.5000	14.1244	27	85.6667	15.6156						
	2	20	71.7000	17.9886	25	89.1200	17.4268						
	3	26	70.4615	18.3177	26	85.0769	16.9255						
SL-3	4	17	75.6471	23.0026	28	74.2857	15.6628	28	72.1429	12.9635			
	5	15	65.1333	11.6794	28	66.1786	17.4739	28	64.0714	10.2340			
	6	16	105.250	18.3358	28	99.4286	15.7090	28	99.7143	16.1196			
SL-4	7	26	71.1154	15.7438	28	83.3214	17.2198	28	85.0000	8.93184	28	84.3929	10.6748
	8	25	57.6800	15.3262	28	74.7143	14.9539	27	72.1481	13.9165	28	71.5357	11.2694
	9	26	81.2692	22.5185	28	76.2143	17.7271	28	86.0357	16.7321	28	79.9286	12.6255
AVG.			74.4174			81.5563			79.8521			78.6191	
SEM.			13.2660			9.8344			12.8612			6.5279	

TABLE F-4

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Potassium Fecal (meq/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	30	10.2200	12.9587	28	10.2429	11.9735						
	2	30	11.0467	11.5751	28	8.02143	12.8117						
	3	29	10.1379	15.9552	28	10.0286	8.13260						
SL-3	4	20	6.81000	3.70231	28	7.31429	3.76630	28	7.54643	10.0653			
	5	20	13.3650	7.54950	28	10.6500	10.3046	28	12.6500	12.0102			
	6	20	20.6050	10.9758	28	13.3000	12.6990	28	22.6607	15.2875			
SL-4	7	26	14.1269	4.82316	28	14.0214	3.37140	28	13.4214	10.5430	28	13.2250	12.2931
	8	26	11.4962	10.2543	28	8.83571	12.5573	27	8.77407	12.3344	28	9.33214	11.2526
	9	26	9.36923	11.1648	28	8.77143	11.9439	28	10.4464	13.7576	28	9.79643	9.41710
AVG.			11.92			10.74			12.58			10.79	
SEM.			3.90			3.59			5.42			2.13	

Monthly Crew Averages for ____________

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1												
	2												
	3												
SL-3	4												
	5												
	6												
SL-4	7												
	8												
	9												
AVG.													
SEM.													

TABLE F-5

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Calcium Diet (mg/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	793.318	15.0131	27	818.370	31.6497						
	2	20	809.450	92.3725	25	834.840	52.9526						
	3	26	822.846	55.4182	26	811.615	79.5447						
SL-3	4	17	735.324	31.4786	28	711.964	92.1273	28	744.750	45.4065			
	5	15	781.067	37.7992	28	789.607	90.3219	28	936.750	68.3071			
	6	16	1277.12	30.7178	28	1166.07	303.366	28	1278.21	29.7002			
SL-4	7	26	853.462	173.042	28	881.714	175.260	28	894.500	192.914	28	906.679	196.355
	8	25	879.040	134.718	28	905.393	143.328	27	921.556	135.244	28	952.036	157.739
	9	26	897.385	139.361	[illegible]	928.393	178.337	28	963.[illegible]21	140.932	28	1063.79	189.529
	AVG.		872.224			872.052			940.681			974.168	
	SEM.		159.849			128.064			182.416			80.860	

Monthly Crew Averages for Calcium Urine (meq/day)*

* mg = meq x 40.08/2

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	11.7909	1.76498	27	20.1630	4.61087						
	2	20	6.84500	1.31488	25	11.1040	2.11078						
	3	26	7.21923	2.11150	26	18.7115	4.04873						
SL-3	4	17	7.08235	1.08180	28	10.4964	2.69807	28	10.7357	2.09058			
	5	15	11.7267	1.75844	28	22.0607	7.48303	28	24.1571	3.50728			
	6	16	10.2000	1.01390	28	14.7821	3.17677	28	14.3393	1.38706			
SL-4	7	26	6.33077	1.59324	28	8.88571	2.05042	28	10.4429	1.75572	28	10.2750	1.35226
	8	25	6.65200	1.39407	28	10.3393	2.60218	27	12.4556	2.11284	28	12.7429	2.21968
	9	26	6.65769	1.86744	28	12.4000	3.07463	28	14.5571	2.39032	28	13.2571	1.84319
	AVG.		8.2838			14.3825			14.5313			12.0917	
	SEM.		2.2749			4.7935			5.0632			1.5941	

TABLE F-6

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Calcium Feces
(mg/day)

FLT.	MAN	PERIODS											
		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
		n	means	sd	n	means		n	means	sd		means	sd
SL-2	1	30	305.5	343.2	28	371.0	430.9		0			0	
	2	30	623.9	750.1	28	498.2	727.0		0			0	
	3	30	581.0	789.6	28	450.8	[illegible]65.3		0			0	
SL-3	4	20	490.3	624.3	28	583.9	689.5	28	646.1	825.6		0	
	5	20	473.8	270.5	28	501.0	496.8	28	636.4	603.5		0	
	6	20	886.0	417.1	28	947.1	596.2	28	1030.5	667.6		0	
SL-4	7	26	910.2	347.4	28	698.9	458.0	28	753.0	555.4	28	778.5	703.9
	8	26	1068.2	863.69	28	701.2	955.0	28	793.9	1039.3	28	891.7	1058.0
	9	26	949.8	1168.3	28	668.0	854.2	28	1054.4	1375.8	28	1029.1	974.7
AVG: (1-9)			698.7			602.2			819.1			899.8	
SEM:			261.6			173.3			183.5			125.5	

TABLE F-7

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Phosphorus Diet (mg/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	1558.36	72.1292	27	1626.11	112.432						
	2	20	1669.50	141.319	25	1660.96	122.335						
	3	26	1650.46	109.161	26	1660.42	188.351						
SL-3	4	17	1526.94	48.9802	28	1389.11	212.170	28	1457.64	27.6046			
	5	15	1662.07	74.2443	28	1598.36	256.629	28	1814.39	108.973			
	6	16	2544.37	169.752	28	2246.96	600.795	28	2594.50	173.923			
SL-4	7	26	1659.77	96.0726	28	1720.50	136.210	28	1711.36	132.406	28	1694.86	162.654
	8	25	1710.60	145.719	28	1744.00	115.154	[illegible]	1745.22	125.656	28	1782.14	127.046
	9	26	1757.27	113.067	28	1800.68	246.397	28	1848.75	171.735	28	1925.82	162.971
AVG.			1748.82			1716.34			1861.48			1800.94	
SEM.			306.46			230.43			384.43			116.62	

Monthly Crew Averages for Phosphorus Urine (mg/day)

FLT.	MAN	PREFLIGHT N	PREFLIGHT MEAN	PREFLIGHT SD	INFLIGHT I N	INFLIGHT I MEAN	INFLIGHT I SD	INFLIGHT II N	INFLIGHT II MEAN	INFLIGHT II SD	INFLIGHT III N	INFLIGHT III MEAN	INFLIGHT III SD
SL-2	1	22	1000.36	113.135	27	1352.48	165.266						
	2	20	1083.35	212.337	25	1358.72	158.289						
	3	26	1156.62	162.212	26	1524.88	224.089						
SL-3	4	17	904.471	113.473	28	989.357	191.521	28	932.143	212.351			
	5	15	1126.60	120.215	28	1180.32	278.208	28	1236.82	185.196			
	6	16	1415.19	197.700	28	1364.93	326.610	28	1462.14	245.546			
SL-4	7	26	827.154	146.622	28	1189.64	257.329	28	1157.89	155.796	28	1161.68	106.353
	8	25	958.840	173.469	28	1210.57	189.390	27	1132.85	180.526	28	1162.58	157.369
	9	26	1022.65	188.379	28	1272.21	279.514	28	1298.50	297.981	23	1216.00	150.158
AVG.			1055.08			1271.45			1201.72			1180.06	
SEM.			170.95			152.24			176.59			31.13	

TABLE F-8

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Phosphorus Feces

(mg/day)

FLT.	MAN	PERIODS											
		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
		n	means	sd	n	means	sd	n	means	sd	n	means	sd
SL-2	1	30	294.7	397.6	28	348.5	420.4		0			0	
	2	30	482.5	585.2	28	434.6	620.6		0			0	
	3	30	503.9	857.5	28	391.5	314.2		0			0	
SL-3	4	20	375.3	466.0	28	437.2	523.7	28	476.8	605.6		0	
	5	20	349.2	205.3	28	362.2	362.4	28	481.1	465.4		0	
	6	20	755.6	339.9	28	816.5	547.2	28	954.4	626.9		0	
SL-4	7	26	633.5	211.3	28	540.9	347.1	28	538.7	392.2		588.5	526.9
	8	26	674.7	570.1	28	487.7	678.5	28	547.2	692.5		580.8	680.14
	9	26	557.6	669.8	28	398.9	513.1	28	579.1	759.1		634.4	616.7
AVG:			514.1			468.7			596.2			601.2	
SEM:			156.5			143.8			179.9			29.0	

TABLE F-9

ENERGY BALANCE DATA ANALYSIS

Monthly Crew Averages for Magnesium Diet (mg/day)

		PREFLIGHT			INFLIGHT I			INFLIGHT II			INFLIGHT III		
FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	22	293.955	37.3090	27	309.815	44.3587						
	2	20	300.050	33.796-	25	300.160	35.3561						
	3	26	276.269	34.1755	26	266.346	40.8038						
SL-3	4	17	271.529	26.6250	28	253.357	43.7765	28	269.393	15.1446			
	5	15	298.200	26.9370	28	274.250	53.1404	28	315.607	42.7580			
	6	16	443.312	10.3197	28	422.429	115.458	28	496.250	39.5770			
SL-4	7	26	300.192	34.4477	28	298.214	25.2797	28	303.796	35.4154	28	301.429	34.5965
	8	25	280.920	50.5692	28	282.536	72.6700	27	282.111	68.5820	28	290.857	67.2589
	9	26	330.346	48.9887	28	309.536	53.8238	28	329.071	37.6966	28	337.786	43.3772
	AVG.		310.586			301.849			332.703			310.024	
	SEM.		52.748			49.276			83.014			24.617	

Monthly Crew Averages for Magnesium Urine (meq/day)*

* mg = meq x 24.312/2

FLT.	MAN	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
SL-2	1	22	10.2182	1.59004	27	11.2852	1.72776						
	2	20	8.94500	1.28492	25	11.4960	1.08108						
	3	26	9.63846	2.23698	26	11.8731	1.54624						
SL-3	4	17	7.60000	.830662	28	8.35000	2.35663	28	5.73571	2.64886			
	5	15	9.56000	1.25060	28	10.9929	2.61320	28	10.4750	1.92000			
	6	16	9.30625	1.38908	28	9.77857	2.44076	28	9.97500	1.44135			
SL-4	7	26	7.94231	1.42103	28	11.4000	1.63684	28	10.0714	2.21139	28	9.76786	1.94023
	8	25	6.94009	1.17189	28	10.4571	1.89256	27	8.68889	1.49521	28	9.43571	1.92916
	9	26	9.35769	1.93167	28	11.9143	1.84806	28	12.7714	2.15404	28	10.4179	3.30107
	AVG.		8.956			10.839			9.60290			9.87382	
	SEM.		1.176			1.154			2.3188			0.4996	

TABLE F-10

ENERGY BALANCE DATA ANALYSIS

CREW AVERAGES FOR Magnesium Feces
(mg/day)

FLT.	MAN	PERIODS: PREFLIGHT n	PREFLIGHT means	PREFLIGHT sd	INFLIGHT I n	INFLIGHT I means	INFLIGHT I sd	INFLIGHT II n	INFLIGHT II means	INFLIGHT II sd	INFLIGHT III n	INFLIGHT III means	INFLIGHT III sd
SL-2	1	30	89.5	114.6	28	141.8	157.9		0			0	
	2	30	145.2	151.1	28	120.4	173.5		0			0	
	3	30	113.5	156.7	28	108.7	87.0		0			0	
SL-3	4	20	147.6	179.7	28	147.0	176.9	28	154.6	198.7		0	
	5	20	162.1	89.3	28	123.3	125.0	28	160.1	152.6		0	
	6	20	287.2	133.5	28	291.1	181.5	28	318.1	208.9		0	
SL-4	7	26	206.9	71.2	28	159.4	98.0	28	165.8	127.0	28	169.0	153.1
	8	26	226.2	201.8	28	156.0	224.7	28	158.7	203.2	28	172.3	203.1
	9	26	207.4	231.2	28	137.8	177.3	28	189.0	245.2	28	184.1	173.9
AVG:			176.2			153.9			191.1			175.1	
SEM:			61.4			54.1			63.4			7.94	