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FOOD CONSUMPTION ON THE GEMINI IV, V, AND VII MISSIONS

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ABSTRACT

Food for the Gemini IV mission consisted of a 4-day cycle menu which provided four meals per day, for a total of 2550 calories. An average of 2100 calories per day was ingested by the crew in flight. Food for the Gemini V mission consisted of a 3-day cycle menu which provided three meals per day (2650 calories). Because of low food consumption during the flight, the average daily intake for the crew was approximately 1000 calories. Food for the Gemini VII mission consisted of a 4-day cycle menu which provided three meals per day (2450 calories). Average daily intake by the crew during this flight was 1789 calories. The calculated caloric requirements have been compared with the calories and major nutrients actually consumed in flight. The body-weight loss of each crewman is discussed in terms of tissue loss and water loss.

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INTRODUCTION

How the nutritional requirements of the spaceman differ from those of the earth-based man has been and remains the subject of considerable conjecture (refs. 1 and 2). The development of space foods for the recent Gemini missions has already been reviewed (ref. 3), and the evolution of the space feeding concept has been reported (ref. 4). The purpose of this report, however, is to describe actual experience with space food consumption during three of the Gemini flights. Data relative to energy demands or caloric requirements are considered because, in terms of nutrition factors during space missions of up to 14 days duration, energy consumption is of major importance. This report is not intended to answer all questions on the subject, but simply to provide factual data as a basis for further evaluation and discussion.

MATERIALS AND METHODS

Because approximately 50 foods are now qualified for use in space flight, several menu combinations are possible. The storage space allotted for food is, of course, dependent upon the primary objectives of the respective mission and its expected duration.

A balanced menu is submitted in advance to the crewmembers for their consideration. Changes in the recommended menu can be made later to reflect crew preferences if these do not significantly alter the nutritional balance of the menu and/or its storage configuration. Identical meals are usually overwrapped together in sets of two, each food container specifically for one crewmember is marked with a square of white material, and each of those for the other crewmember is marked with a square of black material by which each item can be affixed to the spacecraft interior lining. The food which is eaten, its color code, and its time of consumption are communicated to ground

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centers or entered in the onboard log. In this way an accounting is provided of all food items which have been placed on board and of those which are eventually returned to earth with the spacecraft. The intake for each crewmember is ascertained by examination of the remaining food and by determination, through the entries in the log, of the food actually consumed.

So that the nutrient intake of crewmembers could also be ascertained, amounts eaten in flight were later compared with the analysis of the food provided. Food composition data used for this comparison are an average of analyses of similar food items and not analyses of the actual flight food. Therefore some minor discrepancies are to be expected. These variations are considered to be well within the probability of error of the method because of the conditions under which the information was derived. More comprehensive data on these aspects of the Gemini VII mission will be published when the results of the onboard M-7 experiment (ref. 5) become available in the near future.

The astronauts' metabolic rates during a Gemini mission have not been determined because no direct method for measuring oxygen consumption yet exists; however, the analysis of the lithium hydroxide canisters for lithium carbonate does provide information on the minimal carbon dioxide absorbed. Therefore, if a respiratory quotient of 0.82 is assumed, the average oxygen consumption for the two crewmen can be calculated (ref. 6). The average of the total calories consumed, derived from assessment of food eaten, is subtracted from total calories expended (ref. 6). Calculations have been made for the proportion of the total body-weight loss (that is, the difference between preflight and postflight body weight) which can be ascribed to a caloric or tissue-mass deficit per mission. For these calculations, 4 cal are assumed to be provided by 1 gram of tissue (ref. 7). This weight loss (tissue mass), subtracted from the total weight loss (body mass) for the mission, yields water-mass loss. Comparisons have been made to energy consumed. For each crewmember, an estimate has been made of the ratio of body-weight loss related to energy deficits or to water deficits.

RESULTS AND DISCUSSION

Typical food items are shown in figure 1, and a typical Gemini menu is listed in table I.

No two Gemini missions have had identical menus. During the Gemini IV flight, the menus of the command pilot and pilot were considerably different. On Gemini V, however, the two crewmen selected identical menus, as did the two crewmen on Gemini VII. The shorter Gemini IV mission permitted the storage of four meals per day. Storage constraints on the Gemini V spacecraft, and especially on the Gemini VII spacecraft, necessitated minimizing food volume. The consequent reduction permitted only three meals per day. No flight has returned with all food items consumed.

Gemini IV

As shown in figure 2, an average amount of food was consumed on the Gemini IV flight. The data for the first day are misleading, for the breakfast prior to lift-off is not included and only the data pertaining to actual in-flight time are recorded. The identical phenomena are present in the Gemini VII results (fig. 3). The average calories provided exceeded by only 139 the average calories expended. The amounts of calories provided (the total calories loaded on the spacecraft) may be misleading, however, because the crewmembers cannot possibly remove every fraction of food from the containers. This food residue may range from 10 to 19 percent of the amount provided.

During this mission the weight loss by the command pilot was 2.040 kg; that lost by the pilot was 3.885 kg. Estimated tissue loss by the command pilot was 17 percent of the total weight loss, or 344 g, and that lost by the pilot was 4.5 percent of the total body-weight loss, or 170 g. Thus, water losses were substantial. Water loss by the command pilot was 83 percent of his body-weight loss (1694 ml), and that by the pilot was 95 percent (3685 ml). As compared with the command pilot the pilot not only expended more energy because of his space walk, but also wore a much heavier space garment; hence, his evaporative losses were predictably greater.

Gemini V

Very little food was consumed on the Gemini V flight (fig. 4), a fact which the crew has attributed to anorexia. The daily prospect of impending reentry may have prompted the crew to unstow as little food as possible, however, so that reentry could be completed on short notice. Significant depression of appetite, which apparently occurred during the last few days of the mission, is noteworthy in that both crewmembers experienced it. Over the 8-day period, the command pilot lost only 3.345 kg and the pilot lost 3.855 kg. Of the three Gemini missions being discussed here, oxygen consumption was lowest on Gemini V and probably reflects the low level of crew activity. Estimated tissue loss by the command pilot was 56 percent of this weight loss (1870 g of his body weight) and that by the pilot was 57 percent (2190 g). Water loss was not, therefore, as significant a portion of the total weight loss as it was on the Gemini IV flight. This estimated amount of water loss was 44 percent of the body-weight loss (1475 ml) by the command pilot and 43 percent (1665 ml) of that by the pilot.

Gemini VII

Except for the first day, a fairly regular intake of calories was ingested daily by the Gemini VII crew. This intake was, however, about 400 cal per day less than that required. The remaining food on board would not have satisfied this deficit for the reason already stated regarding Gemini IV (not all the food provided was available because of the inherent residue associated with the rehydratable foods). The exercise regime, which was meticulously followed by the crew, and the increased crew activity may account for the higher metabolic rate of 2219 cal per 24 hours during the Gemini VII mission, as compared with 2010 cal for the same length of time during the Gemini V mission. The substantial body-weight loss difference between the two crewmen is significant. The command pilot lost 4.540 kg and the pilot lost 2.863 kg. The estimated tissue loss is 34.5 percent of the total body-weight loss (1557 g) for the command pilot and 50.5 percent (1453 g) for the pilot. Water loss was high for the command pilot, even though he consumed slightly more water than the pilot during the overall mission. Of the total body-weight loss by the command pilot, 65.5 percent (2.983 kg) was calculated to be water loss: the water loss by the pilot was 49.5 percent of his weight loss (1.410 kg). By comparison with other flights, especially Gemini V, the average daily loss of water was greater for the command pilot on Gemini VII. He wore his suit during a longer portion of the mission and definitely felt warmer than the unsuited pilot. The respective weight losses during the Gemini IV, V, and VII missions are summarized in table II.

Gemini Flight Data — Additional Nutrient Intake

The intake of the other selected nutrients, including protein and calcium, by the crews of Gemini IV, V, and VII is summarized in table III. Since the flight menus were balanced, decreased caloric intake was, in general, reflected by a relatively proportional decrease in other nutrients.

Food intake on the Gemini V mission was undoubtedly below that considered desirable. On Gemini flights IV and VII the intake was no more than marginal, although it was probably adequate to meet the operational requirements of the mission. Because the fruit drinks were fortified with calcium lactate for the calcium balance study (M-7 experiment), the desired calcium intake (about 950 mg/day) by the Gemini VIII crewmembers was attained (ref. 5). Without such fortification, the Gemini VII crew intake of calcium would have been considerably less than desired, as related to the bone demineralization (M-6) and calcium balance (M-7) experiments conducted on this flight.

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CONCLUSIONS

Energy and nutrient intake during the Gemini IV and VII missions were adequate but slightly less than desirable for the maintenance of body weight. On the Gemini V mission, intake nutrient by the crew was definitely inferior to that on the Gemini IV and VII missions. The ratio of body-weight losses attributable to energy or water deficits was calculated. Body-water loss on the Gemini IV mission was substantial and probably was aggravated by a markedly reduced water intake. Body-weight losses in large measure caused by water losses were observed again on the Gemini V and VII missions. Although the water intake of the command pilot on the Gemini VII mission was slightly higher than that of the pilot on the Gemini VII mission, the former, who wore his suit during a substantial part (7 days) of the flight, lost twice as much water per day as did the latter. On all flights the other nutrients, except for calcium on the Gemini VII flight, were ingested in quantities relatively proportional to the calories consumed.

TABLE I. - TYPICAL GEMINI VII MENU FOR

MISSION DAYS 2, 6, 10, AND 14

		Calories
Meal A		
Chicken and gravy		92
Beef sandwiches		268
Applesauce		165
Peanut cubes		297
Grapefruit drink		83
		905
Meal B		
Beef pot roast		119
Bacon and egg bites		206
Chocolate pudding		307
Strawberry cereal cubes		114
Orange-grapefruit drink		83
		829
Meal C		
Potato soup		220
Shrimp cocktail		119
Date fruitcake		262
Orange drink		83
		684
	Total	2418

TABLE II. - LOSSES OF WEIGHT IN WATER AND TISSUE ON THE GEMINI IV, V, AND VII MISSIONS

Losses	Gemini IV (4 days)		Gemini V (8 days)		Gemini VII (14 days)	
	Command pilot	Pilot	Command pilot	Pilot	Command pilot	Pilot
Weight loss in g per mission duration	2040	3855	3345	3855	4540	2863
Tissue loss in g per mission duration	344	170	1890	2190	1557	1453
Percent of total weight loss as tissue	17	4.5	56	57	34.5	50.5
Water loss in ml per mission	1694	3685	1475	1665	2983	1410
Percent of total weight loss as water	83	95.5	44	43	65.5	49.5
Loss of tissue in g per day (average)	86	42.5	236	274	111	104
Loss of water in ml per day (average)	424	921	184	208	213	100.5

TABLE III. - NUTRIENT INTAKES ON THE GEMINI IV, V, AND VII MISSIONS

Mission	Amounts	Energy, cal	Protein, g	Fat, g	Carbo-hydrates, g	Ash, g	Calcium, mg	Phosphorus, mg	Iron, mg	Chlorides as NaCl, g
Gemini IV										
	Provided	2549	108.9	114.3	275.1	19.8	847	1456	10.1	10.35
	Consumed by									
	White	2230	89.2	94.8	257.3	16.3	739	1308	8.6	7.96
	McDivitt	2066	90.7	88.9	238.8	16.1	676	1167	7.1	8.17
Gemini V										
	Provided	2755	96.4	116.6	330.3	20.9	849	1555	9.5	10.29
	Consumed by									
	Cooper	1075	41.9	38.3	140.9	9.6	373	723	3.8	4.70
	Conrad	915	35.8	30.6	124.2	8.2	333	556	3.4	4.06
Gemini VII										
	Provided	2333	90.2	96.2	277.0	18.5	1194	1465	9.4	8.70
	Consumed by									
	Borman	1774	67.6	69.6	219.3	14.3	945	1233	7.1	6.66
	Lovell	1804	68.3	71.8	221.2	14.4	922	1218	7.4	6.88

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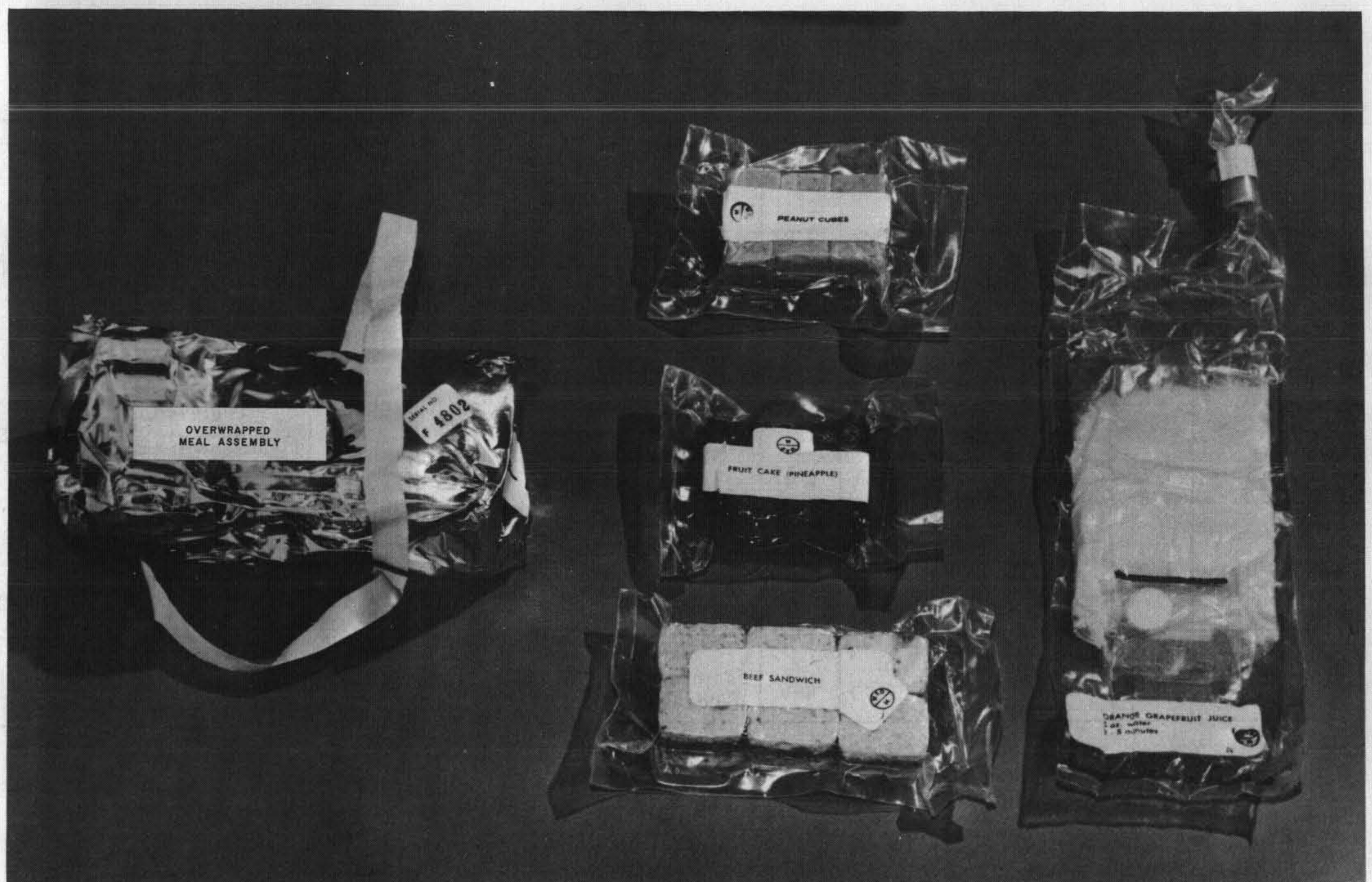

Figure 1. - Typical Gemini mission foods, in containers, and overwrapped.

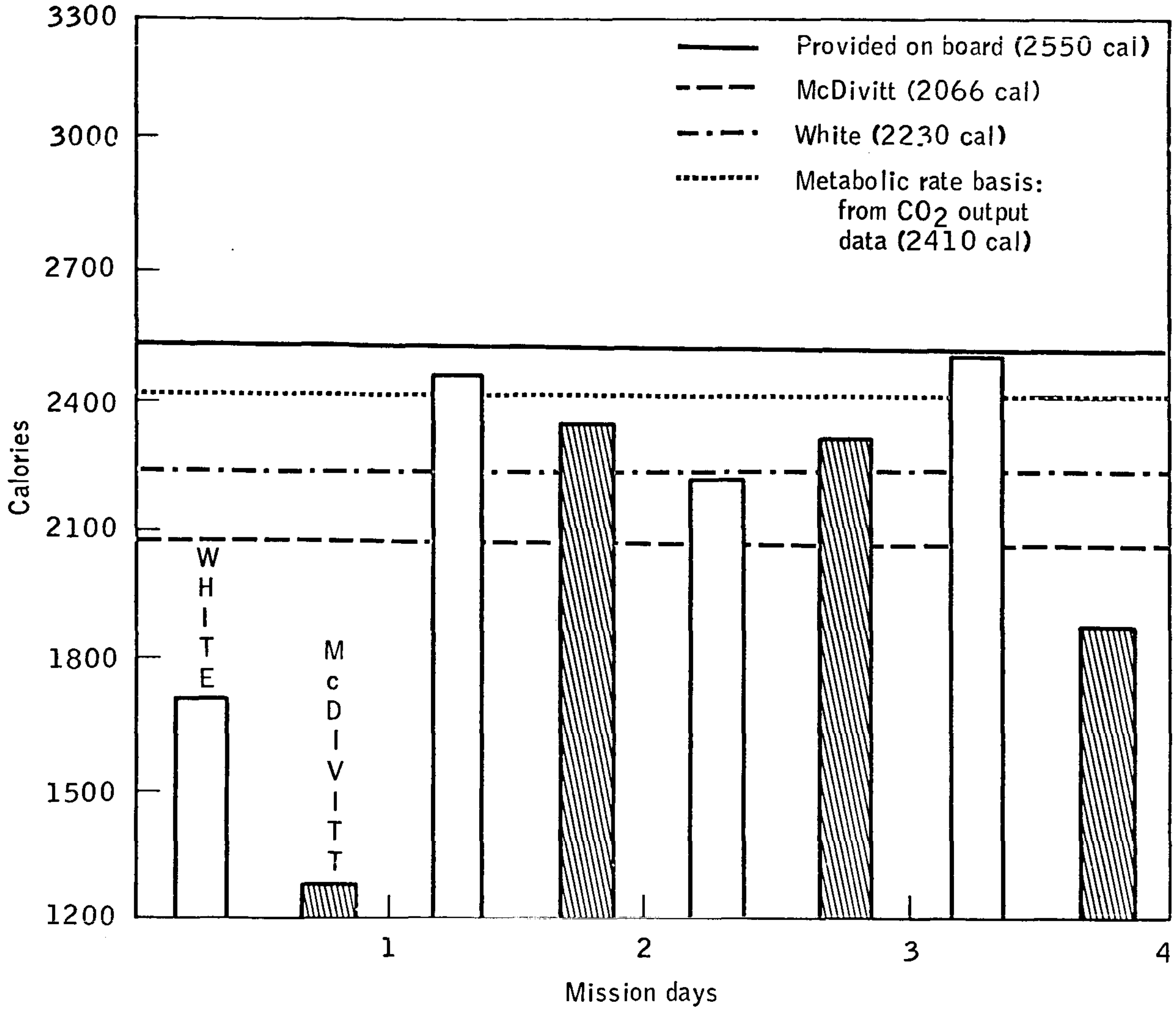

Figure 2. - Caloric intake on the Gemini IV mission.

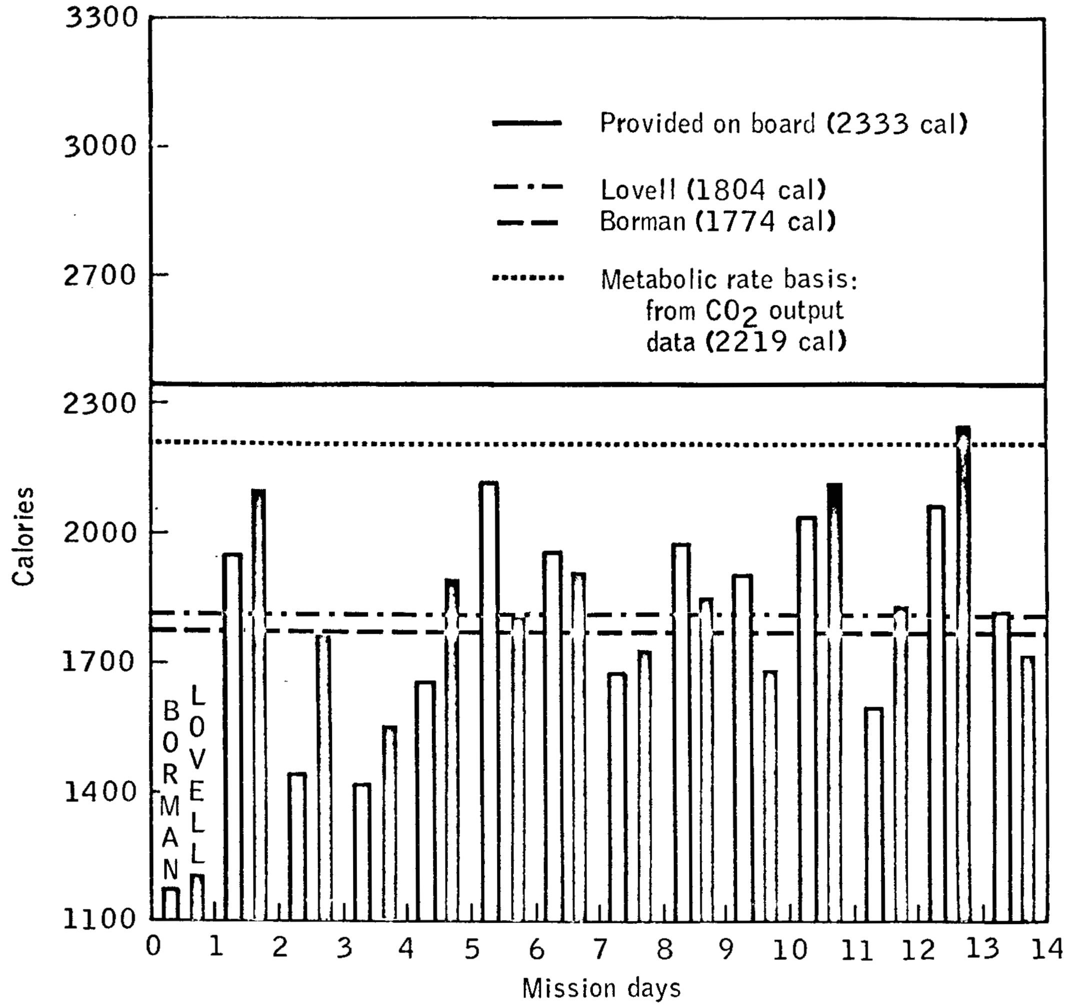

Figure 3. - Caloric intake on the Gemini VII mission.

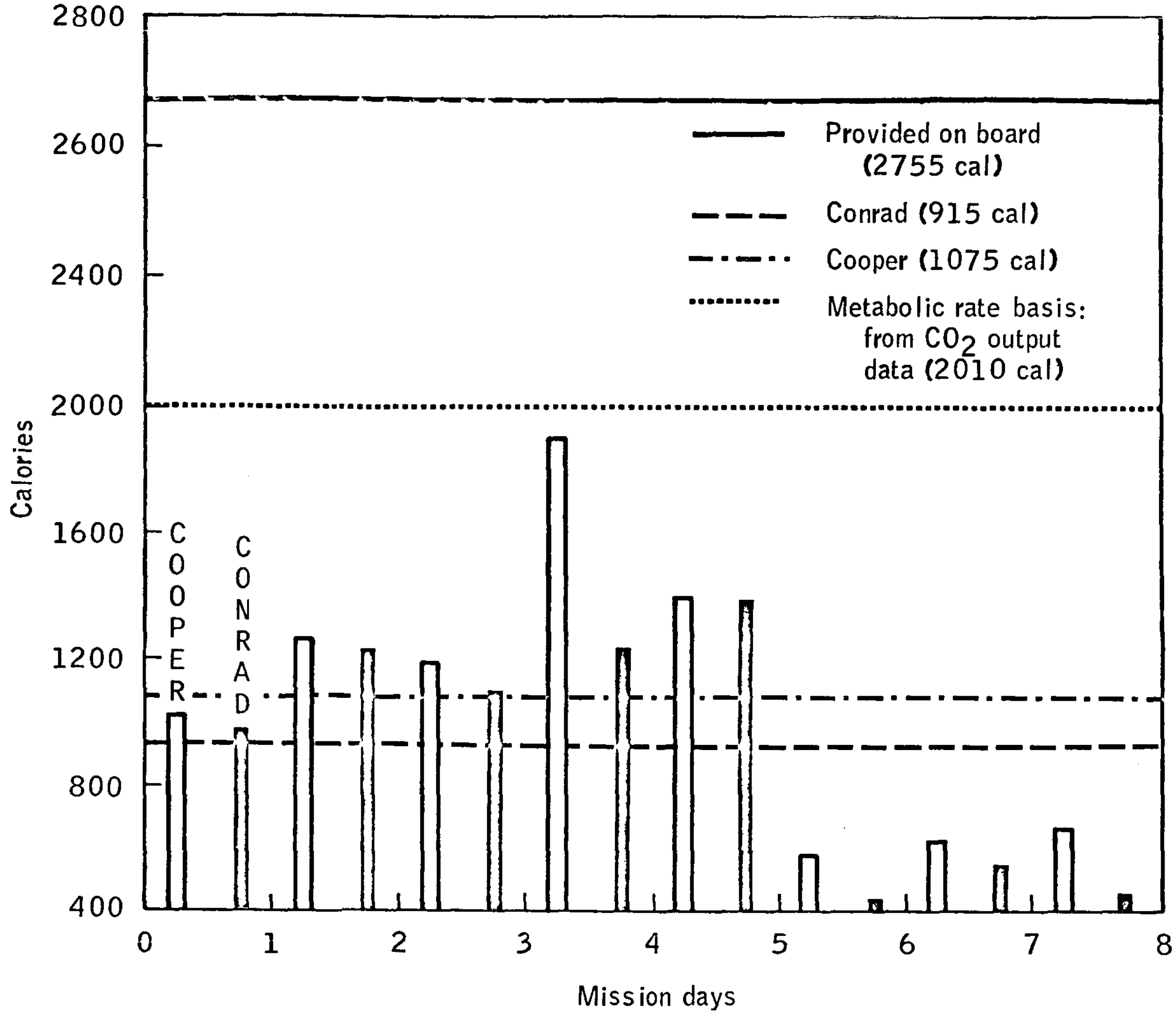

Figure 4. - Caloric intake on the Gemini V mission.

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