

SOME MEDICAL ASPECTS OF SMEAT
AS OBSERVED BY THE CREWMEMBER PHYSICIAN

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Pre-Test

In addition to IMSS training, other medically related activities during this period were participation in design reviews and surveillance of test aspects which would affect crew health. These included environmental control system, food and water, waste, safety, and medical coverage. No involvement in clinical aspects of crew health was attempted until a mission flight surgeon was assigned approximately one month prior to test start. At that time all health aspects external to the chamber were also primarily relegated to him. Items in chamber design pertinent to this surveillance included: General physical layout, construction of items with injury potential such as sharp corners and edges, obstructions, protruding elements and ECS system, especially regarding quality control of gases. In some cases standards had to be modified for N_2 and CO_2 for human use. An overall quality assurance program for which one man was responsible was instituted. Other rules established insured that all gases were connected during the day shift and were installed only under the supervision of that individual responsible for quality assurance. This person reported directly to the mission surgeon on ECS performance and safety.

Water System - Establishment of a quality assurance program with one man having responsibility which included his being present at all filling and transfers. Again, this individual reported to the mission surgeon.

Wiring, Fire Detection and Suppression - Surveillance to insure that insofar as possible standard chamber practices were followed.

Ancillary Medical Personnel and Facilities - There were several periods of emergency training in which all elements of the rescue and medical emergency facilities were exercised with resulting modifications and personnel additions and changes.

Coordination of many medical aspects of equipment and experimental procedures with the PI's and PCS's was attempted.

After Dr. Ross's assignment as mission surgeon, various aspects of crew health were coordinated and mutually agreed upon including: Presence of SPT at all remaining pre-test physicals; a schedule of regular telephonic communication schedules to discuss in-chamber examinations and observations which were held every three-four days for the first week or so and approximately every week after that; coordination in event of medical contingencies; establishment of test data to be transmitted to the crew.

Significant pre-chamber findings are included in the mission surgeon's report. The only clinical items worthy of comment at time of entrance were a resolving acne of the CDR and an established and continuing weight loss by the SPT.

In-Test

Complete physicals were performed on days 213, 221, 226, 235, 250, and 263 by the SPT on the CDR and PLT. In addition, several attenuated exams were performed as well as examinations of any reported complaints, or of any observed signs. These complete physicals were made attempting to simulate S.L. (Skylab) facilities and using IMSS instruments and are further described in the crew report. All systems were covered except anal and genital areas which were omitted in the absence of complaints.

Physical Findings-(CDR)

Oral temperature ranged from 98.2 to 98.4°F.

Blood pressure seated, right arm 120/80 with no significant change.

Heart rate (HR) mean - 59 - there was a slight increase from approximately 55 to 60 BPM during the test with a range of 50 to 65 BPM.

Positive findings were limited to integument, lymph nodes, and throat and nasal areas. On entry there was a clearing acne rosacea between the eyebrows, a few small discrete pustules scattered over the upper back and shoulder areas, and injected nasal mucosa with moderately swollen turbinates.

On day 213 there had been clearing of both acne and pustules with decreased nasal congestion. Bilateral small, swollen posterior sub-mandibular nodes were present. A beard was growing at this time.

Day 221 saw further clearing except for right sub-mandibular nodes. There was an injected, eroded 1 cm. diameter area around a follicle on the left sub-mandibular area. By day 226 the acne had cleared and only four - five discrete pustules with red bases were present in the left scapular area. A "beard" folliculitis was present on the right lateral maxillary area which had formed a confluent indurated base while the previously involved area had enlarged slightly. Phisohex washes were started and the patient admonished to avoid "picking" it. There was remarkable clearing overnight and plans for cultures were dropped. The patient stated that this folliculitis was an intermittent condition of long standing with spontaneous resolution. On day 250 lips were chapped with both upper and lower lips showing areas of erosion of mucosa.

By day 263 several infected follicles were resolving on the right upper lip. A few scattered pustules were usually present over the scapular and shoulder areas.

It was noted that the CDR displayed peripheral vascular hyper-reactivity including a flushed mottling of the upper back during exercise, marked flushing of pressure areas after leaning against a chair back, and a rather striking dermatographia over the entire back which would persist for several minutes. There were no symptoms or signs associated with this and no vascular abnormalities could be demonstrated. This was first noted one - two days after entry to the chamber. It persisted two - three weeks and cleared slowly though not completely by chamber exit. There was no evidence of this at normal atmospheric pressure.

Physical Findings-(PLT)

Oral temperature ranged from 97.5 to 98.2°F.

Heart rate (HR) - 72 BPM - Avg. - seated - remained unchanged throughout test.

Blood pressure - 120/75 right arm, seated.

Positive findings on physical were limited to ENT and integument. On entry the PLT had a number of discrete 2 - 3 mm. pustules scattered over the upper back and shoulders which cleared almost completely over the next two physicals. There was marked whitish-gray "furring" of the tongue which slowly cleared and by day 45, this had virtually disappeared. On entry, nasal mucosa and turbinates were moderately

swollen and injected with slight amounts of whitish discharge especially on the left. This congestion and discharge slowly cleared and by day 250, only a slight clear discharge was present.

Personal Observations of SPT

Oral temperature ranged from 97.1 to 97.4°F.

Blood pressure seated, left arm 110/75 - 105/70.

Heart rate (HR) - seated - 53 - 56 avg. - 55.

Oral

On day 10 symptoms of a pulpitis in the upper left anterior molar developed with slight to moderate pain not requiring analgesics but with sensitivity to pressure and temperature changes. Chewing on the left side was avoided and the symptoms largely cleared over the next few days but would recur whenever that area was used. These symptoms cleared completely in approximately six weeks after leaving the chamber. A full crown had been replaced on the tooth approximately one year prior to the test.

Integument

Six days prior to the end of test a number of broad-based white pustules 2 - 4 mm. in diameter developed over the left face and forehead. The distribution suggested infection from the pillow. Cultures were made of the infected area, pillow and nares. All copiously grew a pure culture of a slightly pleomorphic gram positive cocci. Cultures were passed from the chamber with requests for more definitive identification. The pillow cover was changed and Phisohex was used in washing. There was gradual disappearance of the lesions over the next 10 days which are assumed to have arisen from nasal crustings shed on the pillow which in turn were rubbed into the face.

At the end of the elevated temperature period there was a marked recurrence of old athlete's foot infection with fissures and erosion of the lateral and anterior plantar area of the right foot. This was probably exacerbated by going barefoot for comfort during the elevated temperature period. It was washed more frequently and Tinactin used twice daily with very slow clearing by the fourth week post-test.

Medication and Drugs

Only the following items were used. Nasal emollient was employed for complaints of nasal drying and irritation in the PLT with improvement. It was of no use for relief of the CDR's chapped lips nor was Alph - Keri. Tinactin was used for a recurrence of a long standing fungal infection with reasonably good result. The most used item was Phisohex which appeared to be useful in two skin infections as well as a general disinfectant. An effective emollient for chapped lips should be included for this condition is likely to recur. Description of the drugs in the check list was felt to be adequate.

Laboratory and Tests

Results are reported under their respective experiment sections. A major problem was obtaining results of analyses performed outside the chamber in spite of a previously established transmission protocol.

Psychological

No specific studies of this aspect were performed. It is always risky for the subject to attempt psychological evaluation of a situation in which he is subjectively involved, but the following observations are felt to be valid.

There was no perceptible evidence of serious stress at any point during the test. Inter-personal relationships remained excellent. There were differences of opinion on a variety of subjects but some working consensus was always obtained and followed. At no time was an angry or irritable word exchanged between crewmembers.

There was slight consternation after it seemed the test would be terminated early and was then extended. The most obviously stressful aspects of the test were those times when it appeared that data was being lost after considerable effort on the part of the crew to gather it, especially if it had involved difficulty on their part. Examples of this were: Continued runs with faulty gear which was apparently not being repaired; obviously erroneous lab data such as the polyethylene glycol when many hours were expended counting pills to check that the material was correctly consumed at each meal (a nuisance in itself); or seeing incorrect data repeated that had been previously corrected by the subjects. Also stressful was the impression that arose from some situations that the crew were being used as experimental animals rather than participating investigators in an experiment. Some investigators were never able to accept or tolerate any view of

the situation other than investigator - subject.

There was unquestionably some polarization of "we" (the crew) against "them" (the outside world) which probably served as a useful protective device against isolation. No feeling of spatial isolation was felt at any time by any crewmember. There have been some release mechanism involved in the leg pulling of exterior personnel by the crew.

In addition to the surprising absence of stress, there was an unexpected dedication to the SMEAT mission and not just as a job to be done. It was striking to observe the way two individuals who had been trained primarily as military pilots could conscientiously apply themselves to not only going through medical investigative routine but also to making every personal effort to understand and gain the maximum from all aspects of the test. This was deeper than military professionalism. Not one deliberate deviation from a diet, collection procedure or protocol, no matter how onerous, was observed. Indeed the rare mistake or lapse always brought real consternation and renewed efforts.

Medical Incidents

The EKG electrode adhesive discs have produced more or less severe sensitivity reactions in some crewmembers since project Mercury. This sensitivity continued on SMEAT. Differing batches of this tape have widely varying irritant capacities but, apparently, it has not been possible to discover or correct manufacturing variations. For example, the initial batches produced reactions only on the CDR but later the PLT developed reactions to different tape. In the chamber the discs produced reactions on all three crewmen at first. Later, we were instructed to delete scrubbing the area with Zerphrarin^R wipes. This produced an improvement and only the SPT and PLT were having moderate reactions by the end of the test. However, reactions were still present and this cannot be considered a "fix" especially in view of the marked reactions of some S.L. crewmembers to this tape.

The most marked reactions typically occur at the axillary and sternal sites with minimal reaction on the back and neck. It is a typical contact dermatitis and consists of an erythema, slight edema and in marked cases tiny blebs, limited to the immediate area of contact beneath the discs. In severe cases there will be denuding of the epidermis, marked injection, and sometimes secondary infections. Milder cases have only reddening of the area with increased pigmentation. These reactions can occur in 30 minutes' time and produce no symptoms other than itching or in cases with damaged skin, burning on

application. After approximately two weeks in the chamber, it was necessary to relocate the electrodes for one or two runs on the PLT to allow healing. Reaction to the electrode paste was never seen.

Another sensitivity reaction occurred with the ML33 electrode paste itself. The CDR and SPT used this equipment, which has paste impregnated sponge electrodes mounted in an elastic cap, for three times without difficulty. On the fourth usage the CDR, after two - three hours exposure, experienced an increasingly severe generalized headache which cleared in approximately one hour after removal of the cap. The following morning there appeared to be some diffuse induration around the frontal electrode sites. These symptoms and signs recurred on repeated attempts to use the equipment in chamber and forced the substitution of the PLT as a subject. Definite diffuse induration, several cm. in diameter, was present around the frontal and parietal sites with an indentation under the electrode proper without reddening or other signs. No itching or pain was related to the immediate site.

The SPT had similar symptoms, though mild enough to continue the experiment. The PLT developed no symptoms. Patch tests were conducted by taping split electrodes to the forehead of all three crewmembers. Unfortunately, the tape provided had a heavy elastic component whose pressure effects made other results equivocal.

Atmospheric Irritants

Approximately 12 days after test start, the SPT noted a sense of vague irritation in the posterior naso-pharynx which was sometimes accompanied by an occasional cough. This continued in an intermittent fashion with development of nasal "stuffiness", a slight clear discharge and conjunctival irritation and itching. The CDR developed similar symptoms several days later. These continued in an intermittent and variable fashion throughout the test and could not be related to any other event, time or location. The PLT was never affected. Although it was assumed that Li OH dust was responsible for this and changes were made in cannister processing, there was no real improvement. The cause was in fact never positively identified.

Virtually no physical trauma occurred during the test in spite of frequent near misses or glancing blows from improperly fitted cabinet doors falling open as one passed. One finger was lightly scraped during a climb to the second deck and numerous small nicks about the thumb and index fingers accrued from opening the extremely tough outer covering of the drink containers with a sharp knife. None of these

showed any indication of infection. The SPT also occasionally suffered small nicks in attempts to clean the urine volume measuring system and in spite of the filth of this machine, there was never any reaction.

A number of changes in phonation, transmission, and reception related to atmospheric pressure occurred. The first change to be noted at 5 PSI is the quietness and consequent impression of distance from sound sources. A slight hoarseness is noticeable by external as well as internal chamber personnel and becomes more pronounced with prolonged or moderately loud speaking. In an effort to quantitate these effects records were made and will be analyzed for spectral content. No difficulty in communication was encountered from either reduced amplitude or changed frequency components. An interesting psycho-acoustic phenomena occurred in that after several weeks the reduced sound level was perceived as normal. This was obviously a central phenomena since no audiometric threshold shift occurred. On chamber exit sounds were not perceived as abnormally loud as might have been expected. Another aspect of this is that all crewmen were unable to whistle. After several weeks, two of the crewmen could make feeble whistling noises but even at test end this did not approach normal ability.

Medical examination was affected in that auscultatory sounds were markedly reduced with possibly some reduction in low frequencies. It was impossible to appreciate sounds from mediate percussion at normal distances and required much closer approach of the examiner's ear to the struck finger. Except the possibly reduced low frequency content and reduced amplitude, no changes in the quality of normal breath and heart sounds could be appreciated. Standard diagnostic maneuvers such as vocal fremitus and "E" sounds remained normal.

Changes Associated with the Diet

On beginning the diet some 30 days prior to chamber entry, two changes were noticed in all three subjects. Flatulence was markedly increased and the stools became soft and unformed but not liquid. The loose stools were simply a personal hygiene problem. Stool quantity, both total and individual defecation, was markedly reduced. Outside the chamber this flatulence was simply a social hazard but inside, as the day passed, it became an increasing nuisance until it reached a peak after the evening meal. Some idea of the magnitude of the normal problem may be judged from the PLT who used a hand counter to document some 64 passages during one typical 12-hour period. Another time the SPT recorded 38 such passages offensive both to the subject and associates in one three-hour period. Occasionally, some food item would produce gas and abdominal discomfort to a degree that interfered with

duties. Soups and pea soup in particular seemed to be involved in this, though the offenders were never identified with certainty. Pea soup was associated with several bouts of cramps, gas, and slight nausea in the SPT before it was dropped from his menu. Two such occasions proceeded to bouts of rather violent diarrhea. The particular cans of food which caused this upset were not studied; however, duplicate items were examined and proved to be well within the allowed microbiological limit. This did not allow for the normal heating time which would provide an incubation period for any organisms present. Post-chamber, there was a marked decrease in gas formation, but it still remained in an episodic form. One had an impression that some adaptation to the food had occurred but had been a very slow process with a time constant of months.

The most marked physiological change in SMEAT was the 19-pound weight loss, incurred by the SPT during some 90 days of eating the recommended SMEAT diet. The following is a somewhat detailed description of this process.

TABLE I.

CREW WEIGHTS

	<u>Start Diet</u>	<u>Enter Chamber</u>	<u>Exit Chamber</u>	<u>End Diet</u>
CDR	159	157 1/2	154 3/4	156
SPT	209	204	193 1/4	190*
PLT	185 ³ / ₄	185 1/2	185 1/2	184 1/2

* Diet was terminated one week prior to end of planned termination.

The SPT's normal weight was 207 pounds, unchanged from that at which he had played collegiate football. He was in reasonably good condition at the time of starting the diet with maximum O_2 uptakes above 50 ml/Kg./min.¹, capable of sustaining 400 watts/min.² for three minutes on a bicycle ergometer and with jogging mile times of 7:30 - 7:40 mins./mile to 7:50 - 8:00 mins./mile for three - four mile runs. This status required eight - ten miles/week jogging interspersed with two - three runs/week on a bicycle ergometer for 45 minutes to more than an hour at 300 to 275 watts/min. loads, and some weight lifting

¹All uptakes quoted are either measured at 170 heart rate or extrapolated to that value.

and handball. His diet was high protein with relatively little carbohydrate.

His inchamber exercise plan was to maintain ergometer performance and cardiovascular status with whatever loads and times were required. This was discussed with pertinent investigators and no objections were raised.

Pre-test, repeated attempts were made at every level to point out the inadequacy of the proposed diet especially after marked losses and acute hunger during the two trial periods. At that time no interest was evidenced by MO71/MO73 investigators in exercise, previous diets, or physical condition. Weight was 209 pounds when beginning the diet with the two pounds above normal accumulated by numerous dietary excesses during the last week before the diet began. After the first week on the diet, a more or less stable loss of approximately one and one-half pounds/week was established. During this period prior to chamber entry, time for normal amounts of exercise was simply not available; otherwise, the pre-test loss would have been much greater.

Body composition was determined by radioisotope studies just prior to chamber entry and are given in Table VI of the MO73 report. No other measurements¹ of body size, configuration or composition were made except some extremely crude trunk and extremity girth measurements by the SPT. During this pre-chamber period the basic diet was frequently augmented with up to four cans per day of non-restricted "sugar cookies." Hunger was constant. No modifications were offered or introduced by the experiment investigators.

In the chamber the SPT set the exercise at approximately 15×10^3 watts/min./day, a level estimated to be roughly equivalent to the total work energy expenditure immediately pre-SMEAT, not at the much higher level before the diet was begun. Rate of weight loss, except for a period of one week when no ergometer was available for exercise, remained constant at the pre-chamber level. After two weeks in the chamber, original work level could only be sustained by reducing work loads and increasing duration, i.e. performance levels dropped. Shortly after this time, there was cramping of the lower legs associated with flexion of the feet. This was a phenomenon never previously experienced, even transiently, but which persisted for some three weeks

¹ One valid girth measurement is that of the maximum calf diameter which was recorded for each MO92 run.

after ending the diet. There has been no recurrence. Electrolyte levels were unavailable since a protocol for determination procedures had not been agreed upon by the investigators.

On day 21 the SPT was requested¹ for the first time to increase his caloric intake at least 300 calories/day utilizing the "free" food items. At that time the only such high carbohydrate items which could be tolerated were sugar cookies and mints but the diet was augmented approximately 375 calories/day with these items, except for one week when they became intolerable. In spite of acute hunger it became a problem of force feeding to ingest and retain this material as well as a diet formed in large part by vanilla wafers, puddings, crackers, jams, lemon drops, and imitation fruit beverages. This relatively small caloric increment did little to arrest the weight loss. At approximately 196 pounds all factors were considered with the mission surgeon and a contingency electrolyte sample run. The mission surgeon agreed to allow continuation of the diet until reaching 192 - 193 pounds.

TABLE II. . AVERAGE DAILY INTAKE OF CALORIES
ABOVE BASE LINE BY SPT IN CHAMBER

<u>Week</u>	<u>Total Sugar Cookies Cans</u>	<u>Total Mints Cans</u>	<u>Total Calories</u>	<u>Daily Average Calories</u>
1 - 7	10		1500	214
8 -14	9		1350	192
15 -21	3		450	64
22 -28*	7	12	2742	392
29 -35	11	9	2919	419
36 -42	5	19	2529	361
43 -49	1	10	1560	223
50 -56	2	14	2274	358
	<u>38</u>	<u>64</u>		

*Subject was instructed to increase intake to 300 calories above base line at this time.

¹SMEAT uplink message dated August 17, 1972.

Immediately post-chamber, large quantities of butter were added to every conceivable (and some inconceivable to the SPT) food item. If the item were rendered inedible; for example, rehydrated barbeque floating in butter, then it became a matter of eat it or else do without the food and take mineral capsules. Some items were impossible to consume. At this time maximum O_2 uptakes were down to 47 ml/Kgm. Maximum ergometer work loads were six - seven percent down; prolonged performances were markedly reduced with jogging times for three - four miles in the 10 - 11 minute region. At chamber exit repeat radio-isotope studies of body composition calculated from Table VI of M073 revealed an inchamber loss of 2.4 KG lean body mass and 4.8 KG loss of fat with a body fat percentage of about 10 percent or a reduction of about four percent. An independent specific gravity lean body mass determination by the Cooper Clinic confirmed the 10 percent body fat figure to a small fraction of a percent. It should be noted that these were end of chamber and not end of diet determinations which would have shown even greater losses. At this time a regimen of three - five miles/day of jogging was instituted since it was felt that the deconditioning might conceivably have resulted from confinement. Weight loss continued and the SPT consented to the mission surgeon's termination of the diet at 190 pounds. Additional food was found and the diet became ad lib S.L. food. Although large quantities of lobster, beef, fruit, and vegetables produced a weight gain of two pounds in seven days and the first hunger-free day in three months, there was no improvement in physical performance for approximately two weeks after beginning normal foods. Leg cramps took even longer to clear.

After final S.L. diet termination, weight gain was one - two pounds/week on a meat, fresh fruit, and vegetable diet (even with running five - eight miles/day). The diet was deliberately restricted in quantity to avoid replacement of lost lean body mass with fat. Carbohydrates were initially intolerable to taste. After approximately six weeks, pre-S.L. diet performance indices were exceeded.

Comments

It was obvious that the diet was inadequate to maintain weight and avoid severe hunger from the two trial diet periods. The 19-pound weight loss only further confirmed this. Questions have been raised whether the SPT's exercise was excessive, especially after sugar cookies, lemon drops, and mints failed to stem the loss.

One can only answer that O_2 uptakes of 50 ml/Kg. or 400 w/min. work load performance cannot be maintained without relatively large amounts of work, that the work loads were normal or even modest for the subject,

that no one had raised objections pre-test and that in spite of this work, physical condition deteriorated.

The loss has been interpreted as simply excess fat. The first six - seven pounds may well have been in this category; however, such an interpretation beyond this amount is contradicted by the radioisotope and specific gravity studies. A simple fat loss should have resulted in at least a 10 percent improvement in maximum O_2 uptake when, in fact, there was an approximately five percent decrement. The creatinine data did not support a negative nitrogen balance but, unfortunately, there are aspects of this data which make the values questionable. The loss of 2.4 Kgm lean body mass as shown by the radioisotope studies was completely consistent with the entire picture.

The real significance of this is its relation to S.L. There are prime crewmembers as large, who require quantities of food as great and maintain physical condition as well or better than the SPT. An operational mission is not the place to perform a weight reduction program nor especially can any induced reduction in condition be tolerated. The diet as constituted for SMEAT with fixed and inviolable mineral and protein levels is probably adequate for individuals requiring no more than 2800 - 2900 calories/day. Beyond that increasing quantities of "free"¹ carbohydrates are required. There are limits to which such items can be tolerated, even with force feeding. It is understood that rectification of these problems is in progress for Skylab.

Impressions

There were no medical problems of consequence induced by the atmosphere, confinement, or other test conditions. The total absence of physical as well as psychological problems was unexpected and striking.

CDR

There was a recurrent beard folliculitis which responded to simple external measures. One had the feeling that a slight cardiovascular deconditioning trend may have been present but this is speculative. This subject was in excellent condition at the beginning of the test and large amounts of work are required to maintain such a state. The CDR limited himself to the exercise time available in S.L. A slight weight loss occurred.

¹ i.e., free of all food value except calories.

SPT

There was a superficial fungal and bacterial infection, both responding to simple treatment. A pulpitis resolved spontaneously. There was a major weight loss and some deconditioning, primarily somatic, apparently from the diet.

PLT

There were no changes of significance.