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EFFECTS OF MINIMAL PERSONAL HYGIENE AND RELATED PROCEDURES DURING PROLONGED CONFINEMENT

A. R. SLONIM, PhD

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Foreword

This investigation was accomplished at the Biomedical Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio 45433, under Project 7164, "Biomedical Criteria for Aerospace Flight," Task 716410, "Aerospace Sanitation and Personal Hygiene," with Dr. Arnold R. Slonim as principal investigator. The effort covered nine 6-week experiments from Jan. 1964 to Nov. 1965; data analysis was completed during the first quarter of 1966. The personal hygiene program was conducted in conjunction with the nutritional balance study that supported Task 716405, "Aerospace Nutrition." Major funding support of the nutrition research program, covering all 12 experiments from Oct. 1963 to June 1966, was provided by the National Aeronautics and Space Administration via NASA Defense Purchase Request R-85. The contractual efforts performed on-base in support of this investigation were provided via Contracts AF 33(657)-11716 with Miami Valley Hospital Research Dept., Dayton, Ohio, and AF 33(615)-1814 with Republic Aviation Div., Fairchild Hiller Corp., Farmingdale, New York.

Special acknowledgment and appreciation are due the following personnel for their important roles in the total program: Lt./Col. J. L. Hartley (Brooks AFB, Texas) – oral hygiene; 1/Lt. K. J. Smith and 1/Lt. E. W. Speckmann – nutrition; Dr. S. A. London – microbiology; and Mr. C. A. Metzger – AMRL Evaluator. In addition, the valuable discussions held with Drs. B. J. Katchman and G. M. Homer (Miami Valley Hospital) concerning the subjects, procedures, etc., and with Mrs. P. E. Riely (Republic Aviation) regarding the microbiological data are greatly appreciated. The contributions of many other persons to this effort are gratefully acknowledged. These include Lt./Col. B. G. Borden (WPAFB Dental Clinic), Dr. L. S. Gall (Republic), Drs. E. S. Harris and P. A. Lachance (NASA/MSC) as well as members of the Biospecialties Branch and Biotechnology Branch (AMRL), the Miami Valley Hospital and Republic Aviation on-base units, and, especially, the subjects involved in this program.

This technical report has been reviewed and is approved.

WAYNE H. McCANDLESS
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Abstract

Thirty-six healthy male subjects were studied under closely confined conditions in nine 6-week experiments over a 2-year period. The effects of minimal personal hygiene and related procedures were evaluated. No major problems resulted from the lack of bathing, sponging the body, changing clothes and bedding. Body odor, strongest in axilla, groin, and feet, heightened in 7-10 days inside the AMRL Evaluator, but subsided in the second week. The absence of shaving and hair and nail grooming resulted in 25% of the subjects having to trim their mustache, 50% having to trim their fingernails at or after the fourth week, and dandruff and scalp itchiness in almost all cases. Of all restricted hygenic procedures, the use of substandard oral hygiene produced the greatest clinical effect, with all 20 subjects tested developing varying degrees of gingivitis. Limited hygiene during exposure to two 32 C periods produced no major but a number of minor problems associated with much dryness of skin and scalp. The types of microorganisms recovered from subject and environment as well as their characteristic buildup and spread over certain body areas under these minimal hygiene conditions are reviewed. Prolonged wearing of full pressure suits was well tolerated in most cases. Constant wearing of bioinstrumentation electrodes attached to the skin irritated all subjects tested. Seven different oral hygiene procedures and the efficacy of various waste management items, including different chemically-saturated wipes and fecal collectors, were evaluated.

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SECTION I.
Introduction

A large program to investigate the nutritional requirements of subjects under strictly controlled environmental conditions was begun at these laboratories in 1963 in cooperation with the National Aeronautics and Space Administration (ref 1). Shortly afterwards, starting with the second in the series of twelve 6-week experiments, studies were initiated to determine criteria for personal hygiene and waste management for aerospace systems. Thorough microbiological analysis of man and his environment was included in this effort. The close interrelationship and interdependence of man's internal microbiological population and his nutritional state and of his surface microflora and hygenic state present a unique opportunity to study the interplay of nutrition, microbiology, and personal hygiene to better understand man's requirements for space travel.

The specific aims of the personal hygiene program are to determine what hygiene is necessary for various types of aerospace missions, which hygenic procedures are required in time or under certain environmental conditions, and which primarily influence or are affected by alterations in microbiological population dynamics. This investigation, including some of the early considerations and approaches to the over-all problem, has been documented recently (ref 2).

The development of the personal hygiene studies followed closely the needs of the time. Early in the program, information was urgently needed on the effects of continuously wearing pressure suits and of certain hygienic procedures and related items, particularly for Projects Mercury and Gemini, e.g., a space shaver, waste collector, special gum, and interdental stimulator, etc. Starting with the fifth experiment, studies were instituted to obtain base line information to establish personal hygiene criteria. This was accomplished by exposing the subjects to "minimal personal hygiene care" under strictly controlled environmental conditions. Minimal personal hygiene refers to the absence of all personal grooming, including changing clothes, bedding, etc. The study then progressed to include exposure to elevated temperatures and simulated Gemini profiles, as requested by NASA. This paper describes the results obtained in nine experiments of subjects exposed to minimal personal hygiene, wearing continuously pressure suits or biomedical electrodes attached to the skin, strict confinement, and heat stress. Some of the relevant microbiological data is briefly reviewed. In addition, the report presents the evaluation of various oral hygiene procedures and waste management items during periods of confinement for approximately 42 days.

SECTION II.
Methods

Thirty-six male subjects from 21 to 28 years of age were used in the nine experiments covered in this report. The selection of each subject was based on thorough medical, psychiatric, psychological, and dental examinations as well as various clinical tests. Each experiment used four subjects, had strictly controlled environmental conditions, including diet, and was about 42 days in duration. The subjects were at all times under surveillance of physiological and medical monitors; during chamber tests, an engineering monitor was added. Chemical and microbiological tests were conducted periodically on blood, urine, feces, and food; in later experiments, the sweat of the subjects was analyzed. In addition, both the subjects and confinement quarters were thoroughly analyzed microbiologically, and during chamber tests atmospheric samples were chemically monitored. The particular details of each experiment are described under the separate categories noted below.

EXPERIMENTAL DESIGN

All nine experiments, with minor variations, fit into four typical experimental designs, as illustrated in figure 1. The first design, involving Experiments II-IV, had a Latin Square arrangement in which diet and continuous wearing of the MA-10 pressure suit were evaluated. In each of these three experiments, the subjects were confined for 6 weeks in a metabolic-type ward,

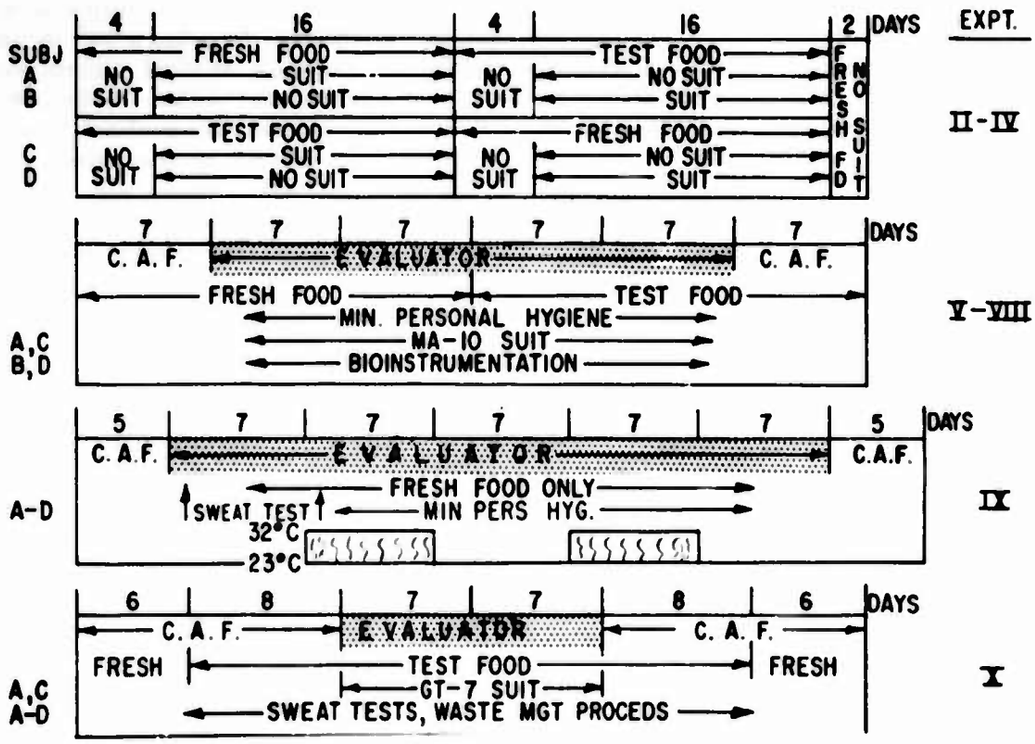

Figure 1. Types of Experimental Design.

referred to as the controlled activity facility (CAF), which is approximately 4300 cu ft (122m³) in size. Two 16-day test periods, evaluating suits and diet, were preceded by a 4-day adjustment period. Experiment II differed from Experiments III and IV by having only one type of metabolic diet and 14-day test periods; in the latter experiments, dehydrated food was compared to a control matching diet of fresh food.

The second type of experimental design contains Experiments V-VIII. The subjects spent 4 weeks of strict confinement in an 1130 cu ft (30m³) chamber facility, the AMRL Life Support Systems Evaluator; this was preceded and followed by 1-week control periods in the controlled activity facility. Starting with Experiment V, four subjects per experiment were divided into day and night work cycles (e.g., 1100-1900 and 2300-0700 hours, respectively), with one pair sleeping while the other was on duty. Of two subjects on the day shift (A and B, fig. 1) one wore the MA-10 full pressure suit, while the other was bioinstrumented for ECG, EEG, respiration, blood pressure, and oral temperature; the two subjects on the night shift (C and D, fig. 1) were treated in the same manner. The effects of "minimal personal hygiene care" under ambient environmental conditions were studied in these experiments (*V-VIII*). In the first two Evaluator experiments, only one type of metabolic diet was used. In Experiments VII and VIII, a 21-day period on liquid food was compared to a 21-day period on a control matching fresh food diet.

The third design, Experiment IX, was mainly a heat stress experiment. All four subjects were confined in the Evaluator for a period of 5 weeks, preceded and followed by 5-day control periods out of the Evaluator. The first, third, and fifth weeks in the Evaluator were at ambient temperature of 23 C (70-73 F); the second and fourth weeks were at 32 C (90-91 F). The mean relative humidity during heat stress was maintained at 40 ± 2%. The subjects subsisted on a fresh food diet throughout the 45-day experiment. Sweat tests of each subject occurred during the first 2 weeks of the Evaluator confinement period with limited personal hygiene being observed for the remaining 4 weeks of the experiment.

The last design, Experiment X, was a simulated Gemini-7 experiment, in which the subjects were in the Evaluator for 14 days with two of them (one on each shift) wearing the GT-7 pressure suit (A and C, fig. 1). The Evaluator test period was preceded and followed by 2-week control periods, respectively. All four subjects tested the Gemini proposed compressed food diet (30 days), waste management procedures, and techniques for measuring sweat and urine volume.

DIET

Four different types of diets were evaluated in these experiments. In chronological order, the first type, which is considered the control, was fresh, canned and heat-processed food that was served at room temperature. The second was a mixture of precooked freeze-dehydrated and compressed bite-sized food. The third was a nutrient defined liquid diet having four to six flavors, with each flavored drink representing a separate meal. The fourth was compressed bite-sized food with only the drinks being dehydrated and subsequently rehydrated prior to feeding. In the double diet experiments, the control diet was matched as closely as possible to the test diet. All the foods in these nine experiments averaged from 2500 to 2900 kilocalories per day. Details concerning the food and effects of diets on waste properties are presented elsewhere (ref 3).

CHEMICAL ANALYSES

The food, 3-6 day pooled fecal samples, blood, and urine of the subjects were analyzed to evaluate nutritional balance and to monitor the health of the subjects (refs 1, 4). Some of the analytical tests have been described previously (ref 4). The atmosphere within the Evaluator

during confinement was monitored constantly by gas chromatography and other instrumentation, which is described in detail in another but similar experiment (ref 5).

PERSONAL HYGIENE PROCEDURES

In the early phases of this program (*II-IV*), there was relatively little restriction on personal hygiene procedures. No change of clothes was permitted during each of the two test periods per experiment. In Experiment II, there was unlimited use of soap and water; shaving was not restricted; and oral hygiene consisted of brushing the teeth with toothpaste containing no hexachlorophene. In *III*, a prototype aerospace spring-driven shaver and lintless wipes (20.6 x 14.8 cm), both dry and saturated with the detergent sodium lauryl sulfate, were evaluated for NASA, along with NASA-furnished chewing gum and interdental simulator. In *IV*, shaving was still optional. Testing of the aerospace shaver and wipes was continued. Oral hygiene consisted of the use of an electric toothbrush, water, and interdental stimulator. In these three experiments, the MA-10 full pressure suit was worn unpressurized without helmet and gloves for 14-16 days; each day, however, the helmet and gloves were worn while the suit was pressurized for 3, 5, and 8 hours in Experiments II, III, and IV, respectively.

Starting with Experiment V and continuing for four experiments, the effects of "minimal personal hygiene care" were evaluated. This consisted of no bathing or sponging the body, no shaving, no hair and nail grooming (unless necessary), no changing clothes and bed linen, the use of substandard oral hygiene, and minimal use of wipes, which were permitted before each meal to avoid contaminating the food and after defecation. A protocol of a typical minimal personal hygiene experiment is presented in Appendix I. During these experiments (*V-VIII*), the clothing consisted of long underwear, AF pajamas, white lightweight to heavy cotton socks, low sneakers to moccasins; only the sneakers (or the like) were removed upon retiring to bed. The particular cleansing procedure used and clothing provision for each experiment is given as Appendix II. Different procedures and items were evaluated in these four experiments. In *V*, these consisted of a NASA-furnished fecal collector, minimal use of both detergent-containing and dry wipes, and oral hygiene using interdental stimulator only. In *VI*, change in clothes to looser fitting undergarments and heavy 100% cotton socks, minimal use of wet and dry wipes, and using regular toothbrush with water only were examined. The following were evaluated in *VII:* continuous wearing by two subjects of the MA-10 suit for 12 hrs/day for 19 of the 28 days in the Evaluator; wearing of bioinstrumentation electrodes by the other two subjects; comparing wipes saturated with a quaternary amine (10.1 x 9.4 cm) to the detergent-saturated wipes; and brushing teeth with water once per day. In *VIII*, the following were evaluated: wearing of the MA-10 suit for 24 hrs/day for 28 days by two subjects; wearing of bioinstrumentation electrodes by two other subjects (one for 28 days also); preliminary sweat tests (5-liter baths) of two subjects only in the pretest control and last day of the posttest control periods; determining the minimal number of wipes needed between fresh and liquid diets; and using toothbrush and USAFSAM edible dentifrice.

In the heat stress experiment (IX), all four subjects maintained minimal personal hygiene procedures following the sweat tests that occurred at the beginning of each of the first 2 weeks in the Evaluator (at 23 and 32 C, respectively). In addition to sweat tests, a parotid fluid assay (USAFSAM) was instituted for stress evaluation. Pressure suits and bioinstrumentation electrodes were not evaluated. Oral hygiene consisted of toothbrush, water, and dental floss.

In the Gemini-7 simulated experiment (*X*), various specialized life support items as well as techniques were evaluated. These included wearing the GT-7 full pressure suit without helmet

and gloves for 14 days in the Evaluator by two of the subjects; testing special fecal collectors; a short test of the urine transport system; and techniques using tritium for measuring urine volume and sweat tests for measuring water balance. All subjects underwent sweat tests as follows: one 24-hour period during each of the 4 weeks in the controlled activity facility and one 14-day period of the entire Evaluator confinement. Oral hygiene consisted of brushing the teeth with water only.

MICROBIOLOGICAL ANALYSES

An intense microbiological research program under the direction of AMRL microbioliogist, Dr. S. A. London, began with Experiment V to correlate the effects of minimal personal hygiene, confinement stress, continuous wearing of pressure suits and bioinstrumentation electrodes, and heat stress, alone and in combination, with any microbiological changes in subject and/or environment. The following body areas of the subjects were sampled periodically: scalp, eye, ear, nose, mouth, throat, axilla, forearm, umbilicus, groin, genitalia, anal area, and toes; the environmental areas sampled periodically included tables, toilet area, bed, handles on equipment, equipment surfaces, and various niches within the confinement quarters. A typical microbiological protocol including the frequency of sampling subject and environment, which differed slightly with each experiment, is presented as Appendix III. The complete microbiological analyses used and the results covering Experiments V-IX are reported by Reily and coworkers (ref 6).

SECTION III.
Results and Discussion

The results obtained with 36 subjects in nine experiments are grouped together generally into related topics. These include the evaluation of minimal personal hygiene under strict confinement at ambient environment and elevated temperature, microbiological observations, wearing continuously full pressure suits or electrodes attached to the skin, oral hygiene procedures, and evaluation of some waste management items.

TABLE I.

EFFECTS OF MINIMAL PERSONAL HYGIENE

Condition	*Expt*	*Subjects*	*Results*
Ambient Environment			
1. No bathing, 5 wks	V-VIII	16	No major problems; body odor strongest in axilla, groin, feet.
2. No shaving, 6 wks	V-X	24	6/24 needed to trim mustache.
3. No hair and nail grooming, 6 wks	V-X	24	12/20 needed to trim fingernails (4NB); varying degrees of dandruff.
4. No change of clothes, 5 wks	V-VIII	16	Socks—very soiled, damp, odorous. Underclothes—signs of decay.
5. No change of bed linen, 5 wks	V-VIII	16	No major problems.
6. Substandard oral hygiene			
—interdent. stimulator only, 5 wks	V	4	Decrease in dental status of all subjects—varying degrees of gingivitis.
—gum and interdent. stimulator, 6 wks	III	4	
—reg toothbrush and water, 6 wks	VI, VII, X	12	
32 C (90 F) Environment			
24 hrs/day for 7 days (twice)	IX	4	Tolerated by all subjects. Clothes very damp; body odor strong; skin and scalp dry and itchy; flaking off of skin; pimples; athlete's foot.

The results of exposure to "minimal personal hygiene care" for a period of 5 to 6 weeks under closely confined conditions are presented in table I. In an ambient environment (Experiments V-VIII), the lack of bathing or sponging the body presented no major problems. Body odor reached its maximum height within 7-10 days inside the AMRL Evaluator, with the source of the strongest odor varying in subjects between axilla, groin, and feet; the subjective response to the odors subsided after the second week. The lack of changing clothes was very troublesome in the beginning (Experiment V), because the underclothes were sticking to the subjects in the

groin and other body fold areas, and were very odorous and starting to decompose. In subsequent experiments, the use of looser fitting undergarments for all subjects improved the situation; however, after the fourth week, even the thick 100% cotton socks became very soiled, damp, and odorous, and underclothes started to show signs of decay. The problem with wet, dirty and odorous feet resulting from the rubber-like foot-covering (e.g., sneakers) that retained moisture throughout Experiment V improved somewhat as nonrubberized footwear was used subsequently. The lack of changing bed linen, along with sleeping in soiled socks and clothes, was unpleasant but well tolerated by all subjects. The absence of both shaving and hair and nail grooming in these experiments was observed in Experiments IX and X as well. (Although five subjects did not shave also in the earlier experiments (*II-IV*), the data are excluded since shaving and trimming the beard were not restricted in these instances.) Thus, without shaving, 25% of the 24 subjects (V-X) had to trim (or wax) their mustache because it was piercing and irritating the lips; this occurrence varied in the six subjects from 3 to 5 weeks. Without grooming the nails, a much higher percentage had fingernail growth problems; four of the subjects, however, were nail-biters (NB, table I). The nails grew too long for 12 subjects to either write or manipulate equipment, thus needed trimming; this usually occurred at or after the fourth week. Almost all subjects, who were required to have short haircuts before starting an experiment, complained of dandruff and itchiness on their scalp; this may have been due in part to some of the commercial detergents used in the thorough scalp and body cleansing prior to the start of the experiment and/or Evaluator period. (Of the two detergents used, Ivory® soap was reported to be less troublesome than pHisoHex.®) The greatest clinical change resulting from minimal hygiene was in dental health, the gums in particular, especially when the subjects were using a substandard oral hygiene procedure. In some subjects, bleeding gums developed in 3 weeks and persisted throughout the experiment. Oral hygiene is discussed separately later.

Exposure to a 32 C (90-93 F) environment continuously for 7 days (168 hours) twice during 5 weeks of confinement in the Evaluator (Experiment IX) produced no major effects but a number of minor skin problems. The lack of skin cleansing during the hot periods produced much dryness of skin and scalp as well as itchiness over various parts of the body such as the groin, back, neck and feet. The scalp itched constantly, with 3 out of 4 subjects developing varying degrees of dandruff. The skin of some subjects peeled off the hands, elbows and knees, mostly in the second heat stress period. In addition, pimples developed, lips became chapped, and athlete's foot recurred. Body odor was very strong in three of the four subjects and appeared to accompany the irritation in the axilla, groin or feet. The eyes, nose and throat were not troubled during the hot spells except for an occasional dryness of eyes and plugged-up nose. Lack of changing clothes was bothersome only during brief periods when the relative humidity increased much beyond the 40% range. The dampness of the clothes, which were also starting to decompose, made it difficult for one subject to keep dry his chafed anal area and irritated the axillary area of another subject. Generally, however, all four subjects felt that the heat stress exposure was tolerable and presented no serious problem.

Minimal personal hygiene at either ambient or elevated temperature environments did not bring about changes in the microbiological population of the subjects that resulted in any clinical manifestations (ref 6). However, several interesting observations were noted as a result of exposure to minimal hygiene during prolonged confinement. Some of the results reported by Riely and her coworkers (ref 6) are synopsized here in tabular form. For example, the occurrence and distribution of certain predominant microorganisms in seven random body areas in a total of 13 sampled from all the subjects under minimal hygiene is shown in table II. Corynebacteria were second only to the staphylococci in the frequency of occurrence among the subjects; this was un-

TABLE II.

MICROORGANISMS PREDOMINANT IN CERTAIN BODY AREAS OF SUBJECTS DURING MINIMAL PERSONAL HYGIENE*

Body Area	*Microorganisms*†	*No. of Subjects*
Axilla	Staphylococci	20
	Corynebacteria	17
	Proactinomyces	9
	Bacillaceae	6
	Neisseria	5
Anal Area	Staphylococci	20
	Corynebacteria	19
	Streptococci	10
	PPLO	8
	E. coli	7
Umbilicus	Staphylococci	20
	Corynebacteria	8
Eye	Staphlyococci	20
	Corynebacteria	5
Scalp	Staphlyococci	20
	Corynebacteria	10
Ear	Staphylococci	19
	Corynebacteria	14
	Proactinomyces	9
	Bacillaceae	7
Toes	Staphylococci	20
	Corynebacteria	9
	Proactinomyces	6
	E. Coli	5

* Experiments V-IX.
† Microorganisms listed are those recovered in 5 or more subjects.
(Modified after AMRL-TR-66-33)

expected in view of the minor role ascribed to this group of skin organisms. Of more importance is the demonstration of the spread of the enterobacteria under these conditions to various areas of the body, which reflects the inadequate personal hygiene. The occurrence of these enteric organisms, referred to as "indicator" organisms, in each of the five experiments is presented in table III. In almost every experiment, the groin and glans penis contained enterobacteria; in one experiment (e.g., *VI*) five species of organisms were recovered. Some body areas observed to be contaminated occasionally were the throat, eye, axilla, nose, and toe (table III). Thus, these workers feel that the groin and glans penis serve as the best "indicator" areas of a deterioration in hygenic conditions.

TABLE III.

OCCURRENCE OF ENTEROBACTERIACEAE IN CERTAIN BODY AREAS OF SUBJECTS DURING MINIMAL PERSONAL HYGIENE – INDICATION OF INADEQUATE PERSONAL HYGIENE*

Experiment	*Microorganism*	*Body Areas*
V	*E. coli*	anal area, eye
	Aerobacter	axilla, groin, glans penis, throat
	Citrobacter	throat
VI	*E. coli*	anal area, glans penis
	Aerobacter	groin
	Klebsiella	groin
	Alk. dispar	anal area, glans penis
	Alcaligenes	groin
VII	*E. coli*	anal area, nose, eye
	non-nitrate users	axilla, mouth, throat, glans penis
	Alk. dispar	nose
	Aerobacter	groin
VIII	*E. coli*	anal area, eye, toe
	Pseudomonas	glans penis, toe
	Alk. dispar	anal area
IX	*E. coli*	anal area, groin, toe
	Alcaligenes	glans penis, groin, anal area, toe nose, throat, gingiva, axilla
	Aerobacter	anal area, throat
	Proteus sp.	groin, glans penis, toe, axilla

*Occurrence is noted if organism is present in one subject per experiment without regard to frequency. (Modified after AMRL-TR-66-33)

It was interesting to observe the pattern of buildup of the microorganisms, particularly the various micrococci and corynebacteria, on the subjects under prolonged confinement and minimal hygiene. According to Riely*, the buildup of the numbers of microflora was significant after the third week ("about the 25th day") on minimal hygiene; there was no significance in the microbial levels between the first and 15th day. On the other hand, the number of organisms in the posttest control period was significant from that in the pretest control, indicating a slow rate of return to normal microbiological levels. A list of about 11 groups of aerobic microorganisms recovered from various body areas of all of the subjects during minimal personal hygiene is presented as Appendix IV. The anaerobic organisms recovered from these subjects were chiefly streptococci, peptococci, veillonellas, lactobacilli, and fusobacteria (ref 6). The transference of microorganisms within closely confined conditions was clearly demonstrated in one instance when a phage type of *Staphylococcus aureus* was observed to pass between subjects as well as between

*Riely, P. E. (Republic Aviation Div., Farmingdale, N. Y.) Personal communication (May 1966).

subject and environment in the Evaluator. Fortunately, no illness resulted from this pathogenic organism.* In regard to the microbiological population in the three major odoriferous areas of the body (i.e., axilla, groin, and feet) during minimal hygiene, no definite correlation can be made at this time. The organisms sampled from the toes did not appear to be of the magnitude found in the groin and axillary areas. However, it has been pointed out (ref 6) that various fungi recovered on the feet as well as in the groin area could serve as hygenic indicator organisms. Relevant also is that subjective response to body odor heightened up to 2 weeks, whereas a significant buildup of organisms occurred after 3 weeks. Assuming that adaptation to odor is very limited or that odor does diminish after 2 weeks of confinement, then the types of organisms present would be more important than the numbers. However, additional microbiological data analysis may shed more light on this and related topics, including consideration of preventive hygenic measures for prolonged space travel.

TABLE IV.

EFFECTS OF CONTINUOUS WEARING OF SUIT AND ELECTRODES

Condition	*Expt*	*Subjects*	*Results*
Wearing MA-10 full pressure suit			
—12 hrs/day for 19 days	VII	2	
—24 hrs/day for 14-16 days	II-IV	12	Tolerated well by all subjects
—24 hrs/day for 28 days	VIII	2	except in cases of poor ventila-
Wearing GT-7 full pressure suit			tion in the leg areas.
—24 hrs/day for 14 days	X	2	
Wearing of bioinstrumentation electrodes, 16-28 days	IV-VIII	10	All subjects developed varying degrees of skin irritation due to electrode paste or tape.

The results of the effects of wearing continuously a full pressure suit and bioinstrumentation electrodes, or telemetry units, are briefly presented in taxle IV. In the early part of the program (Experiment III), the only problem of consequence was the irritation to the eyes of the subjects during the pressurization period when helmet and gloves were worn with the MA-10 suit; this was corrected by filtering the air going into the helmet. In addition, during the early experiments (*II-IV*), the subjects reported much more scalp itchiness (while wearing helmets) than at any time during the nonsuited periods. In the longest test of continuous wearing of full pressure suits (28 days, *VIII*), the two subjects tolerated it satisfactorily. One MA-10 suit was better ventilated below the waist than the other, so that the subject (No. 31) in the former case was more comfortable and had less odor problems than the subject (No. 29) in the latter situation. Much flaking off of skin occurred around the bottoms of the feet of both subjects after the suits were removed. In addition, after 4 weeks in the suit, the underclothes and socks deteriorated and required replacement, in contrast to the nonsuited subjects. The two subjects who wore the Gemini suits (*X*) both developed maceration of the skin on the bottoms of the feet, which, because of no infection, healed shortly after the end of the suiting period. In the case of all 18 subjects tested

*Loter, L. (Miami Valley Hospital, Dayton, Ohio): Unpublished data.

with pressure suits, sleeping in the suit was generally uncomfortable but not unbearable. Only suits that did not fit the subjects properly or had poor ventilation, especially in the lower extremities, presented a problem with time. Continuous wearing of various types of bioinstrumentation electrodes on scalp and chest areas caused varying degrees of skin irritation in all 10 test subjects in Experiments IV-VIII. The bioinstrumentation system varied somewhat starting with the Gemini bioinstrumentation pack in *IV* to utilizing the AMRL 7-channel pulse modulated telemetry unit in *VIII*. The types of electrodes used varied also. In a typical experiment (e.g., *IV*), each of two subjects would wear three electrodes attached to the chest, one microphone to the arm, and four electrodes on the scalp to monitor ECG, respiration, B.P., and EEG, respectively. Details of the bioinstrumentation system for Experiments V-VII are presented elsewhere (ref 7). The electrodes, themselves, were not stable and usually required constant replacement, e.g., every 5 and 7 days for EEG and ECG, respectively.* Much of the skin irritation was due to the tape or paste used for skin attachments; however, constant wear on the skin, itself, must also be suspect as contributing some if not a major part of the irritation. In regard to any microbiological problems associated with wearing pressure suits or electrodes for prolonged periods, the results were negative. No significant increase in either numbers or kinds of microorganisms were noted in the suited subjects (ref 6); nor was there any buildup of microbes evident in the areas of the skin to which electrodes were attached.

Early in the program the dental health of the subjects appeared to be very vulnerable to inadequate oral hygiene, as it is to stress in general. An intensive AMRL-SAM coordinated program in conjunction with the nutritional balance and personal hygiene study was undertaken under the direction of Lt. Col. J. L. Hartley (USAFSAM). All dental hygiene procedures had to conform to onboard programs, e.g., any dentifrice had to be free of calcium and low in other electrolytes for the nutritional balance study; moreover, no bacteriostatic material could be used to interfere with the oral and fecal microbiological analyses. The results of evaluating these dental procedures in somewhat chronological order are presented in table V. In view of the good results obtained with the electric toothbrush plus interdental stimulator (*IV*), this procedure was used as a reference standard. In two experiments (*V* and *VI*), the electric toothbrush was used only during the first week, just before confinement in the AMRL Evaluator, in an attempt to equate the dental status of all subjects to better assess the effects of confinement stress with limited oral hygiene. Interdental stimulator alone or with chewing gum as well as regular toothbrush with water only (*III*, *V-VII*, *X*) gave poor results and were considered substandard procedures. On the other hand, the addition of dental floss greatly improved the dental health of all four subjects (*IX*). As a result of subsistence on a liquid diet (*VII* and *VIII*), the teeth and even the tongue of the subjects were heavily coated, a condition not completely corrected even by using an edibile dentifrice of low abrasive content. Varying degrees of halitosis were present in all experiments in which a dentifrice was absent. Generally, the soft tissues of the subjects on substandard oral hygiene suffered the most, resulting in moderate to severe gingivitis (ref 8). Some subjects reported that the gums bled persistently from the third week until the end of the experiment. Of 36 subjects, only one (No. 27) was admitted for study with a dental partial plus massive fillings in his own teeth; he felt very uncomfortable throughout the experiment (*VII*) because of limited dental hygiene. Generally, in the nine experiments, only two subjects developed serious dental problems that required on-the-spot emergency care involving temporary restorations. One subject (No. 11, *III*) developed a toothache after a portion of restoration, undermined by caries,

*Speckmann, E. W. Aerospace Medical Research Laboratories: Personal communication (June 1965).

TABLE V.

EVALUATION OF ORAL HYGIENE PROCEDURES

Procedure	*Expt*	*Results*
Toothbrush and toothpaste (no hexachlorophene)	II	Adequate oral hygiene.
Gum and interdental stimulator	III	Ineffective – gingivitis in all subjects, stained teeth, halitosis.
Electric brush and interdental stimulator	IV	Improvement in dental status of all subjects.
Interdental stimulator only	V*	Ineffective – gingivitis, stained teeth, halitosis.
Toothbrush and water only	VI*, VII, X	Varying degrees of gingivitis, stained teeth, mild halitosis.
Toothbrush and (USAFSAM) edible dentifrice	VIII	Adequate oral hygiene.
Toothbrush and water and dental floss	IX	Improvement in dental health of all subjects.

*Electric toothbrush used first week only; all other procedures were tested for 6 weeks.

was dislodged; treatment by the "buddy care" system, consisting mainly of a temporary sedative dressing, worked satisfactorily. In the case of the other subject (No. 35, *IX*), a cusp broke off of one tooth along with the filling. A temporary filling was put in by an Air Force dentist during the sweat test period; this had to be repeated again during sweat testing the next day because the filling broke loose. Thus, selection of spacecrews based on strict dental standards is very important for extended space missions or simulated flights especially under altered environmental conditions. The dental hygiene research program was reviewed in detail recently (ref 8).

The results of the evaluation of various waste management items and systems during the course of these studies are presented in table VI. The first item under investigation was a spring-driven shaver. This required too many windings, took very long to shave and did not adequately collect shaving debris. In almost all the experiments, small lintless cloth wipes were used, some saturated with a chemical or plain water ("wet" wipes) and some without either ("dry" wipes). In one experiment (*VII*), two different chemical wipes were evaluated, each for 21 days. The wipes saturated with the detergent sodium lauryl sulfate were not able to cleanse skin surfaces of organic debris as well as those containing the quaternary amine, benzethonium chloride. The packaging of the latter, however, made it difficult to open readily. In the subsequent experiment (*VIII*), which was divided also into 21-day fresh and liquid diet periods, the average minimal number of wet wipes (water only) needed to clean the hands and face was four per day while on fresh foods and only two on liquid meals. One of the least developed areas in life support, perhaps the most difficult, is waste collection, particularly fecal collection. One type of fecal collector was evaluated for 2 weeks in the AMRL Evaluator by the four subjects in Experiment V as well as by three flight (weightlessness)-oriented airmen for a 3-5 day period. All seven testers were critical of the plastic fecal collector with supportive harness, stating that it took too long to defecate, was very uncomfortable, poor weightless operational capability, etc. However, many suggestions

TABLE VI.

EVALUATION OF SOME WASTE MANAGEMENT ITEMS

Item	*Expt*	*Results*
Self-winding, spring-driven shaver	III	Unsatisfactory; needs improvement.
Wipes saturated with sodium lauryl sulfate	III-VII	Unsatisfactory for cleansing skin surfaces of organic debris.
Wipes saturated with a quaternary amine (benzethonium chloride)	VII	Satisfactory.
MA-10 type fecal collector	V	Slightly acceptable; needs improvement.
GT-7 type fecal collector	X	Moderately acceptable.
Urine transport system (GT-7)	X	Needs improvement to correct valve and bag leakage.

for improving the design of this system resulted. A Gemini-type of fecal collector was tested in Experiment X and was rated as moderately acceptable by the majority of subjects. The urine transport system (UTS) did not undergo as long an examination as the waste collector due to persistent valve and collector bag leakages. Both the urine transport system and a similar waste collector unit were evaluated subsequently by an Air Force physician and two airmen during a 14-day test in the AMRL Evaluator at a reduced atmosphere containing an equal mixture of helium and oxygen. The acceptability of the UTS did not rate as highly as that of the waste collector, and constructive criticisms of both items were made for future design and development.

Some of the results reported in this paper involved only one experiment of four subjects, such as the evaluation of some of the oral hygiene and waste management procedures; wearing a pressure suit full-time for 28 days involved only two subjects. If the same individual were tested a second time and showed no large variability of response to the same condition or reacted to two different conditions in a manner similar to the group as a whole, these results then would be useful for predicting the response of a much larger group of subjects in evaluating any one system or item. Of 36 subjects, three were used twice over the nine experiments. Some of their reactions in two different 6-week experiments are tabulated as Appendix V. Subject R. M. wore two different pressure suits, each for 14 days. The one that was the better fit was tolerated very well, whereas foot problems developed with the poorer fitting suit. Brushing his teeth with toothpaste provided adequate oral hygiene, but without it he developed gingivitis. Similarly, Subject G. M. showed a marked dental improvement with dental floss, and using the same procedure without it he developed gingivitis. On the other hand, Subject R. R. had the benefit of two acceptable oral hygiene procedures and his dental status was adequate or improved in both cases. This subject wore a pressure suit in one experiment and was bioinstrumented in another; the only effect on him was the skin irritation in the area of the body where the electrodes were attached. Lastly, in the case of Subject G. M., personal grooming was limited in both of his experiments. His most sensitive area appeared to be the groin, for in both experiments he developed a chronic groin irritation. Also, the necessity to trim his fingernails in both experiments occurred at the same time. Thus, from a hygenic point of view, very little intraindividual variation exists and the data appear to be somewhat reproducible, in contrast to other physiological measurements observed in these

same subjects (ref 3*). Unfortunately, it was not possible to compare the microbiological profiles of the same subject over two different experiments, since microbiological-hygiene data from Experiments V-IX only were available (refs 6, 9).

In the light of these minimal hygiene and extensive microbiological studies, 5-6 weeks without body cleanliness has been shown to be generally tolerable and without serious consequences. An important question that remains to be answered, however, is how much body cleanliness is necessary for extended space missions. For example, a danger to personnel of being "over cleaned" in a space environment may result from a reduction of important skin chemicals as well as microbiological defensive mechanisms, all of which could increase susceptibility to infection. This area needs further study to establish a definite surface hygiene requirement for prolonged space travel.

*Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, Quarterly Informal Progress Report No. 7 to NASA/MSC, NASA Defense Purchase Request R-85, 11 Aug.-11 Nov. 1964.

SECTION IV.
Summary of Results

Thirty-six healthy male subjects were confined for a period of six weeks under closely confined conditions. The effects of minimal personal hygiene and related procedures were evaluated in nine experiments over a two-year period.

1. No major problems resulted from the lack of bathing, sponging the body, changing clothes and bed linen. Body odor was strongest in axilla, groin and feet, reaching a maximum in 7-10 days inside the AMRL Evaluator; the subjective response to odor subsided in the second week. The lack of changing clothes was tolerated better by wearing very loose-fitting underwear and thick cotton socks; foot-covering was changed to non-rubberized material to reduce moisture retention.

2. As a result of no shaving, 25% of the subjects had to trim (or wax) their mustache because it was piercing and irritating the lips; this took place from three to five weeks. A growth of beard of this same duration did not interfere with wearing a pressure suit helmet up to 10 hours per day.

3. Lack of hair and nail grooming resulted in dandruff and scalp itchiness in the majority of subjects. One-half of the subjects needed to trim their fingernails, the growth of which was a handicap to writing or working with equipment; this usually occurred at or after the fourth week of confinement.

4. Of all the restricted procedures, the use of substandard oral hygiene produced the greatest clinical effect on the subjects. All 20 subjects exposed to inadequate oral hygiene procedures developed varying degrees of gingivitis. Some subjects had persistent bleeding gums from the third week until the end of the experiment.

5. Limited hygiene in conjunction with exposure to a 32°C environment for two separate weeks (168 hours each) during five weeks of confinement in the Evaluator produced no major but a number of minor problems associated with much dryness of skin and scalp, such as itchiness, pimples, peeling off of skin, chapped lips, and recurrence of athlete's foot. In addition, body odor was strong, irritation in some skin areas was bothersome, and undergarments started to decompose at the end of the second heat stress period.

6. Limited personal hygiene did not cause changes in the microbiological population that resulted in any demonstrable clinical symptoms. Several interesting observations were noted, however. The corynebacteria were found to be second only to the staphylococci as predominant microorganisms in the 13 body areas sampled in the 20 subjects examined. The spread of enterobacteria to various parts of the body served as a good index of inadequate personal hygiene. The body areas that were observed to contain these enteric or "indicator" organisms in almost every limited hygiene experiment were the groin and penis, which the microbiologists now consider as "indicator" areas of personal hygiene breakdown. Some of the other contaminated areas of lower frequency of enteric organisms include the throat, eye, axilla, nose and toes.

7. The buildup of the numbers of microorganisms on the subjects and in various areas within the environment became significant after the third week. The rate of return of these organisms to normal levels in the posttest control period was slow but gradual. Transference of microbes between

subjects and between subject and environment was demonstrated. The nature of the microbiological population in the major odoriferous areas of the body was discussed.

8. Wearing full pressure suits continuously for various periods up to 28 consecutive days was generally tolerated satisfactorily by 18 subjects. Only in the cases where the fit of the suit or ventilation to the lower extremities was poor was there a problem with time. The problems that developed were minor in nature and involved mainly the feet, e.g., flaking off of skin, and the scalp, where considerable itchiness developed especially during the periods when the helmets were worn; also undergarments deteriorated during the longest trial (28 days).

9. Wearing various types of bioinstrumentation electrodes attached to the chest and scalp produced varying degrees of skin irritation at the attachment sites in all 10 subjects tested. This was attributed in part to the paste or tape used as well as to constant wear on the skin.

10. Of seven different oral hygiene procedures evaluated, the use of interdental stimulator alone or with chewing gum as well as brushing the teeth with water only were inadequate; all subjects developed gingivitis. The dental status of the subjects improved markedly when an electric toothbrush was used in conjunction with interdental stimulator in one experiment and dental floss was added to brushing the teeth with water in another experiment. An edible dentifrice was tested also in an experiment. The lack of a dentifrice in seven experiments caused varying degrees of halitosis in all subjects. Two subjects required emergency, on-the-spot temporary dental restorations; this emphasizes the importance of strict dental screening standards for spacecrews.

11. During the course of these experiments, a spring-driven shaver, two different chemically-saturated lintless cloth wipes, two types of fecal collection units, and a Gemini urine transport system were evaluated by the subjects; the latter two systems were evaluated also by flight-oriented airmen.

12. The response of the same subject in two different six-week experiments in the case of three of the 36 subjects was discussed on a comparative basis, e.g., comparing two different pressure suits, wearing pressure suit versus electrodes attached to the skin, and evaluating different oral hygiene procedures. The question was raised also as to how much skin hygiene would be necessary for prolonged space travel.

SECTION V.
Conclusions

Men are able to forego body cleanliness, changing clothes and personal grooming under closely confined conditions for 5 to 6 weeks without serious consequences. Adequate oral hygiene must be considered, however, for space flights exceeding 3 weeks, since the soft dental tissues were found to be the most vulnerable areas of the subjects effected by minimal hygiene care. A certain percentage of the male population needs to trim his mustache and a larger percentage his fingernails about every 4 weeks, so that provisions to do so should be considered for space missions beyond this period. The presence of enteric microorganisms in certain body areas would tend to signal or confirm a breakdown in personal hygiene or environmental control conditions. In the case of a breakdown in the environmental control system resulting in sustained elevated temperatures within human tolerance, adequate provision for keeping skin, including scalp, surfaces moist would enhance tolerance to the heat stress. Constant wearing of well-fitted full pressure suits is tolerable if ventilation to all extremities is adequate. Wearing bioinstrumentation electrodes attached to the skin for prolonged periods, however, is still a problem. Whether or not thorough skin cleansing is necessary for prolonged space travel needs to be investigated.

APPENDIX I.

TYPICAL PROTOCOL FOR MINIMAL PERSONAL HYGIENE STUDIES

1. All subjects will obtain a close haircut, trim fingernails and have all corrective dentistry completed prior to start of experiment.

2. The subjects will thoroughly cleanse themselves by scrubbing with soap (e.g., Ivory) and water from scalp to toes during shower before start of the experiment and before entry into the AMRL Evaluator (start of second week). Sterile wash cloths and towels will be provided as needed. The ears and nose will be cleaned with sterile Que-tips. The subjects will step out of the shower onto a sterile towel and don sterile garments after each bath, followed by a sterile cap, gown, mask and shoe-covering for transfer to the confinement quarters; the transfer garments will be removed upon entering confined area.

3. The subjects will NOT be allowed to bathe, sponge the body, comb, brush or cut the hair, clean or cut the nails, shave, change or remove clothes, and use wet wipes in any area of the body or at any time not specifically authorized. The wet wipes will be used on face and hands before each meal to reduce the number of contaminants entering the mouth via the food and on hands after defecation. A change of clothes will be permitted only after the second bathing period, which is just prior to entering the AMRL Evaluator (see Outline, page 18).

4. Two of the four subjects will be in a MA-10 full pressure suit with boots and, during brief pressurization periods, with helmet and gloves in the AMRL Evaluator. After removing the suit, helmet, gloves and boots, each subject will don his pajamas and slippers, with no other change permitted. The unsuited subjects will be bioinstrumented. Upon retiring to sleep, all four subjects will remove the slippers only.

5. There will be a minimum of contact between subject and monitor. Any person authorized to examine the subject during confinement in the controlled activity facility will be required to ob-

serve surgical-type sterile procedures, including scrubbing and donning of gloves, gown, mask and shoe-covering.

6. The following is an outline of the personal hygiene protocol:

PERIODS (in weeks)

Procedure	*1* *Pretest*	*2*	*3*	*4*	*5*	*6* *Posttest*
		Test (Evaluator)				
Shaving	none		none			none
Bathing	A none	A	none			none
Hair and nail grooming	none		none	B		none
Oral hygiene	C electric toothbrush	D	← regular toothbrush and water only →		D	C
Fecal collection	←		Plastic bags as directed			→
Urine collection	←		Plastic gallon-size bottles as directed			→
Clothing	A	A				
underwear	←		Loose-fitting long underwear			→
outerwear	←		Air Force pajamas			→
feet	←		Heavy white cotton socks + light leather slippers			→
MA-10 Suit	none		← (2 subjs: 12 hrs/day for 28 days) →			none

A: Thorough bathing with soap and water; sterile garments (as well as cover garments for transfer) will be donned on a sterile towel provided near the shower stall.

B: If nails get too long to work controls or write, subject will inform monitor to note the exact date prior to clipping them. (Note: Not all subjects may need to trim fingernails or mustache the entire experiment.)

C , D: Dental examinations (exclusive of selection examination that included full mouth Xrays) will be as follows: C – At the start and end of the experiment, the teeth of the subjects will be charted at the W-PAFB Hospital Dental Clinic. D – Before and after confinement in the Evaluator, dental examinations, including colored photography, will be performed in the controlled activity facility by Lt/Col. J. L. Hartley (USAFSAM).

APPENDIX II.

SPECIAL PREPARATIONS AND CLOTHING PROVISIONS FOR EACH EXPERIMENT

Expt	*Cleansing or Pre-test Bathing* Preparations*	*Types of Wipes Used†*	*Clothing Provisions‡*
II	Unlimited use of soap and water	None	Long underwear, pajamas, black AF socks, hospital-type sandals
III	Use of soap and water banned in two 16-day test periods	Wet wipe #1 and Dry wipe	Same as Expt II
IV	Same as Expt III	Same as Expt III	Same as Expt II
V	Thorough scalp to toe scrubbing with Ivory soap (Bathing)	Same as Expt III	Long underwear, AF pajamas, white lightweight socks, tennis-type sneakers
VI	Thorough scalp to toe scrubbing with pHiso-Hex (Bathing)	Same as Expt III	Loose-fitting underwear, oversize AF pajamas, heavy white 100% cotton socks, moccasins
VII	Same as Expt VI	Wet wipe #1, Wet wipe #2, and Dry wipe	Same as Expt VI
VIII	Same as Expt V except trial sweat test during 1st wk	Dry wipe and water	Same as Expt VI
IX	Same as Expt V except for Sweat Test 1 and 2 (see Fig 1)	Same as Expt VIII	Same as Expt VI; change of clothing required before end of heat stress experiment
X	Sweat tests throughout experiment	Same as Expt VIII	Special GT-7 clothing provided suited and instrumented subjects

* Thorough body cleansing in the minimal personal hygiene experiments (V - IX) limited only to start of the experiment and before entry into the Evaluator.

† Wipe No. 1 was saturated with sodium lauryl sulfate; Wipe No. 2 contained benzethonium chloride (p-diisobutyl-phenoxy-ethoxy ethyldimethyl benzyl ammonium chloride). Use of wet wipes was limited to cleansing hands and face before meals and the hands after defecation. The dry wipes were used to remove any excess dirt on skin surfaces.

‡ Only the sneaker or moccasin was removed upon retiring to bed (Expts V - IX).

APPENDIX III.

TYPICAL MICROBIOLOGICAL PROTOCOL: SAMPLING SITES AND FREQUENCY PER SUBJECT AND ENVIRONMENT*

Sample Sites	*CAF (1 week)*	*Evaluator (4 weeks)*	*CAF (1 week)*
Body Areas "A"			
Ear, nose, throat, mouth, axilla, groin and glans penis	two times	12 times	two times
Body Areas "B"			
Scalp, eye, forearm, umbilicus, anal fold and toes	one time	two times	one time
Environment			
Tables (fore and aft), bed, floor of hygiene area, equipment, knobs, etc.	two times	12 times	two times

* Exclusive of analyses of feces, which was sampled 10-14 times per subject per experiment, of skin electrode areas of subjects wearing bioinstrumentation electrodes, and of gingival scrapings, which was obtained only in Experiment IX.

(Modified after ref 6, AMRL-TR-66-33)

APPENDIX IV.

SOME AEROBIC MICROORGANISMS RECOVERED FROM VARIOUS BODY AREAS OF ALL SUBJECTS DURING MINIMAL PERSONAL HYGIENE

Groups of Microorganisms	*Experiment*	*V*	*VI*	*VII*	*VIII*	*IX**
Streptococci		X	X	X	X	X
Micrococcaceae		X	X	X	X	X
Neisseria		X	X[a]	X	X	X
Enterobacteriaceae		X	X	X[b]	X	X
Gram positive bacilli†		X	X	X	X	X
Corynebacteria		X	X	X	X	X
Staphylococci		X	X	X	X	X
Other aerobes‡		X	X	X	X[c]	X
Actinomycetales		NS	X	X	X	X
Fungi		X[d]	X	X	X	X
PPLO		X	X	X[e]	X[f]	X[g]

* Exclusive of and following two sweat tests early in Evaluator period.
† Mainly Lactobacilleae and occasionally Bacillaceae.
‡ Haemophilus, Sarcina, Gaffkya, Moraxella and/or Mima.
X = Present in all four subjects, except as noted.
NS = Not sampled or reported.
[a] None found in Subj. 23.
[b] None reported for Subj. 28.
[c] Only Neisseria identified on Subj. 29; other aerobes‡ also on Subjs. 30, 31, and 32.
[d] None recovered in body areas of Subj. 18.
[e] None reported for Subjs. 27 and 28.
[f] None reported for Subj. 31.
[g] None reported for Subjs. 34 and 35.

(Modified after ref 6, AMRL-TR-66-33)

APPENDIX V.

RESPONSE OF THE SAME SUBJECT TO TWO DIFFERENT SIX-WEEK EXPERIMENTS

Subject	*Expt*	*Number*	*Conditions*	*Results*
R. M.	II	7	Unlimited use of soap and water	– adequate hygiene
			Wore MA-10 suit for 14 days	– no major problems
			Used toothbrush and toothpaste	– adequate oral hygiene
	X	39	(Sweat test throughout experiment)	
			Wore GT-7 suit for 14 days (with two pairs of socks)	– slight maceration of skin of both feet (with no infection)
			Tested GT-7 waste mgt. items	– both items need improvement
			Used toothbrush with water only	– developed gingivitis and halitosis
R. R.	IV	15	Tested aerospace shaver	– relatively ineffective
			Used wipes saturated with detergent	– inadequate skin cleanser
			Wore MA-10 suit for 16 days	– no major problems
			Used electric brush & gum stimulator	– improved dental status
	VIII	30	Minimal personal grooming	– had to trim fingernails after 3rd week; developed facial pimples
			Wore bioinstrumentation skin electrodes	– irritation in electrode skin areas; mechanical problem of disengaging electrodes
			Used dry wipes and water	– inadequate personal hygiene
			Used toothbrush & edible dentifrice	– adequate oral hygiene
G. M.	IX	34	(Sweat test used only twice)	
			Minimal hygiene at ambient and elevated temperatures	– chafing and much irritation in groin; had to trim nails after 3rd week
			Used toothbrush, water & dental floss	– improved dental status
	X	38	(Sweat test throughout experiment)	
			Limited personal hygiene	– persistent groin irritation; had to trim nails; developed several lip ulcers
			Tested GT-7 waste mgt. items	– both items need improvement
			Toothbrush and water only	– developed gingivitis and halitosis

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13. ABSTRACT

Thirty-six healthy male subjects were studied under closely confined conditions in nine 6-week experiments over a 2-year period. The effects of minimal personal hygiene and related procedures were evaluated. No major problems resulted from the lack of bathing, sponging the body, changing clothes and bedding. Body odor, strongest in axilla, groin, and feet, heightened in 7-10 days inside the AMRL Evaluator, but subsided in the second week. The absence of shaving and hair and nail grooming resulted in 25% of the subjects having to trim their mustache, 50% having to trim their fingernails at or after the fourth week, and dandruff and scalp itchiness in almost all cases. Of all restricted hygenic procedures, the use of substandard oral hygiene produced the greatest clinical effect, with all 20 subjects tested developing varying degrees of gingivitis. Limited hygiene during exposure to two 32 C periods produced no major but a number of minor problems associated with much dryness of skin and scalp. The types of microorganisms recovered from subject and environment as well as their characteristic buildup and spread over certain body areas under these minimal hygiene conditions are reviewed. Prolonged wearing of full pressure suits was well tolerated in most cases. Constant wearing of bioinstrumentation electrodes attached to the skin irritated all subjects tested. Seven different oral hygiene procedures and the efficacy of various waste management items, including different chemically-saturated wipes and fecal collectors, were evaluated.

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Security Classification

Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Minimal Personal Hygiene						
Personal Grooming						
Clothing Provisions						
Oral Hygiene						
Gingivitis						
Strict Confinement						
Full Pressure Suits						
Heat Stress						
Bioinstrumentation Electrodes						
Surface Microorganisms						
Enterobacteria						
Indicator Organisms						
Buildup of Microflora						
Body Odor						
Skin Problems						
Dental Hygiene Procedures						
Waste Management Items						
Lintless Wipes						
Fecal Collection						
Urine Transport						

Security Classification