WADC TECHNICAL REPORT 53-484
PART IV
ASTIA DOCUMENT No. AD 142233

THE PHYSIOLOGICAL BASIS FOR VARIOUS CONSTITUENTS IN SURVIVAL RATIONS

PART IV. AN INTEGRATIVE STUDY OF THE ALL-PURPOSE SURVIVAL RATION FOR TEMPERATE, COLD, AND HOT WEATHER

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UNIVERSITY OF ILLINOIS

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Statement A
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WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICES

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AERO MEDICAL LABORATORY
CONTRACT NO. AF 18(600)-80
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WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This final report summarizes the results and conclusions of five years' intensive investigation on the problem of survival rations for cold, temperate, and hot environments. Three major studies were conducted, the first for temperate conditions (University of Illinois, 1953), the second for cold environments (Camp McCoy, Wisconsin, Winter 1954), and the third for hot environments (Camp Atterbury, Indiana, Summer 1955). Details of planning, results and conclusions for each separate study are incorporated in complete phase reports: The Physiological Basis for Various Constituents in Survival Rations, WADC TR 53-484, Parts 1, 2, and 3. (For a detailed list of reports, publications, and theses based on these investigations, see Section V.)

The whole investigation was supported by Contract No. AF 18(600)-80 with the Aero Medical Laboratory, Directorate of Research, WADC, Project No. 7156, "Flight and Survival Foods, Feeding Methods, and Nutritional Requirements," Task No. 71805, "Nutritional Physiology of Men under Air Force Operating Conditions and Emergency Situations" (formerly RDO No. 698-81, "Survival Ration Requirements"). The Contract Monitor was Doctor H. C. Dyme, Chief, Nutrition Section, whose continuous enthusiasm, support and advice we acknowledge here. During the cold and hot weather phases, Lieutenant Colonel Roy W. Otto, Chanute AFB, served as Project Officer with outstanding ability. The various phases of the investigation, under the scientific supervision of the responsible investigators, R. E. Johnson and F. Sargent II, were conducted by several different large teams of civilian and military associates. To them should go much of the credit for the success of these studies. Individual team rosters and acknowledgments are recorded in the three detailed phase reports.

At the University of Illinois, the University Health Service kindly made space available in the Health Service Research Unit at McKinley Hospital. The University's Purchasing Department also has been of the utmost assistance.

Finally, we wish to record here the generous and efficient support provided by all echelons of the Air Research and Development Command, the Air Training Command, and the Fifth Army, whenever their cooperation was requested.

ABSTRACT

The problem of an all-purpose survival ration suitable for the healthy young castaway in any environment from cold to hot has been solved by five years' intensive investigation. One and the same nutrient combination can and should be used for all environments, for any daily work loads from light to hard, and for any water supply from limited to abundant. Three separate studies simulating survival were required: temperate conditions, moderate work; winter cold, light and hard work; summer heat, light and hard work. A total of 8698 subject-days yielded results of statistical reliability. The quantitative characteristics of the all-purpose survival regimen were established by physiological, biochemical, nutritional, and clinical observations on the relative effects of water intake, total calorie intake, osmotic intake, ketosis, and ratio of protein, carbohydrate, and fat, for 20 different experimental regimens. Numerous systematic observations were made on healthy young men during successive two-week periods of adequate, restricted, and recovery diets. Starvation and an adequate 3000-Calorie diet represented the worst and best regimens. Quantitative rank-ordering of regimens was made possible by as many as 27 discriminatory measurements of organ function and body efficiency, together with clinical findings, especially in cases requiring prompt medical attention to avoid serious eventualities.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

Jack Bollerud

JACK BOLLERUD
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

SUMMARY OF CONCLUSIONS

1. The all-purpose survival ration should be based on the several important nutritional and physiological relationships which we have detected and described quantitatively among: physiological function; environmental temperature; calorie balance; water balance; daily work load; balance of specific nutrients; osmotic balance; ratio of protein/carbohydrate/fat; and ketosis.

2. Regardless of temperature, work load, or water intake, one and the same regimen ranked next to the adequate 3000-Calorie diet in minimizing deterioration and protecting the castaway's survival potential as much as any survival ration can be expected to do.

3. It is this regimen which the all-purpose survival ration should approximate within practical limits: 2000 Calories per day; three quarts of water in hot environments, never less than one quart; caloric distribution of 15% from protein, 52% from carbohydrate, and 33% from fat; optimal osmotic intake of 0.7 osmols per day from protein plus minerals; no ketogenic effect.

4. Limitation of water; decrease of calories; marked deviation in protein/carbohydrate/fat ratios; marked deviation of osmotic intake either above or below optimal; marked ketosis -- all these will be associated with measurable, sometimes dangerous, clinical or functional deterioration, especially in hot weather.

Manuscript submitted in September 1957 for publication as a WADC Technical Report

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SECTION I

GENERAL CONSIDERATIONS

As a result of five years' intensive research on the survival ration problem, it is now possible to conclude that one and the same survival ration can and should be used for any environment, whether hot, temperate, or cold; for any daily work load, whether heavy or light; and for any water intake, whether adequate or inadequate. In brief, the all-purpose survival ration problem for healthy young men has been solved for practical purposes.

This final report will present our general conclusions and the general considerations upon which they are based. Details of all phases of the research are to be found in WADC TR 53-484 (Part 1. Temperate Conditions; Part 2. Conditions of Moderate Cold; Part 3. Conditions of Moist Heat).

The terms of reference within which the research was conducted were quite specific. The castaway may be exposed to any environment, cold, temperate, or hot. He may have unlimited water, or he may be severely limited in water. He may have to walk long distances to escape and evade, or he may have to sit by his plane awaiting rescue. He will have in his survival kit multiple vitamin pills which, if taken each day, will prevent vitamin deficiency. His survival ration will be strictly that: small in calorie content, not planned for indefinite survival. Finally, he will either be rescued or abandoned within two weeks. Our whole experimental design was based on these considerations.

A word of warning is required. These present conclusions are for the healthy, young, uninjured castaway. The ill or injured castaway is quite another problem. For him, practically nothing is known about survival requirements. A whole new research program would be required, under good conditions for clinical research in a hospital, in order to establish the physiological and clinical nutritional considerations which would be paramount in his survival.

SECTION II

GENERAL PLAN OF RESEARCH

The general question to be answered was, "Is there an all-purpose survival ration?" The answer to this one question requires answers to four others: (1) Is a survival ration required at all, or is starvation good enough? (2) Do different environments require different survival rations? (3) Do different daily work loads require different survival rations? (4) Do different intakes of water require different survival rations? To answer these questions required the systematic application of all possible techniques of modern clinical and human environmental investigation on a large scale. Statistically defensible answers had to be reached by the simultaneous study of the effects in man of many separate variables, any one of which could be altered independently of the others. These variables were: starvation, as compared with some food; different daily calorie intakes; different daily work loads (hard or light); different intakes of water (unlimited or restricted to one canteen per day); different percentages of protein, carbohydrate, and fat in the regimen; and different environments (hot, temperate, cold).

Three major studies were conducted. In 1953, 12 volunteer students lived under temperate conditions and performed moderate daily work. In 1954, 100 volunteer airmen simulated survival in the winter cold at Camp McCoy, Wisconsin. In 1955, 100 volunteer airmen simulated survival in the summer heat at Camp Atterbury, Indiana. Experimental design and experimental measurements were essentially the same in all three studies, so that statistically valid comparisons could be made between subjects in any one study, and between regimens in all three studies. Experimental contingencies required some differences in time of study and water intake in these three studies.

A pre-period of two weeks was followed by an experimental period of two weeks. There ensued a recovery period of two weeks. During pre-periods and recovery periods all subjects were subsisting on the same adequate regimen, with unlimited fluids, and identical daily work loads. During experimental weeks, one or the other of the experimental regimens of Table I were imposed on different groups of subjects, with insignificant variation from study to study. All possible combinations of the following variables were studied simultaneously: water (unlimited or 910 ml/day); total calories (starvation, 1000, 2000, 3000 Cal/day); proportion of calories from protein, carbohydrate, and fat (pure carbohydrate, low protein-low carbohydrate-high fat, moderate protein-moderate carbohydrate-moderate fat, high protein-low carbohydrate-high fat); daily work load (hard work, light work). In all periods, subjects were under constant control and medical observation. All food intake was controlled and measured. All excreta (urine, feces) were collected daily for subsequent analysis and calculation of nutrient balances. In all, a total of 8698 subject-days was the basis for our conclusions (Table II).

All feasible techniques of clinical, physiological, nutritional, and biochemical investigation were employed to answer quantitatively the major question -- What changes in organ and system function, and the efficiency of the body as a whole, were attributable to the combined effects of regimen, daily work, and temperature? Physicians obtained daily information on complaints related to regimen, work load, and environment. Complete physical examinations were performed periodically by these physicians to detect clinically significant signs. Laboratory measurements were made periodically on organ and system function, nutritional balance, and biochemical changes in blood and urine. These various aspects of the methods of study are listed in Table III for the summer study. Essentially the same observations were made in the other two investigations. Final evaluation of the results was based on statistical analysis of quantitative data, on clinical evaluation of the findings, and on the incidence of frank disorders which required the immediate attention of a physician to prevent serious, even fatal, disability. Two statistical controls were invaluable

TABLE I

EXPERIMENTAL NUTRIENT MIXTURES

(SUMMER 1955)

EXPERIMENTAL RATIONS AND OTHER FOODS USED	CALORIC INTAKE	% DISTRIBUTION OF CALORIES	SYMBOLS USED IN TABLES AND FIGURES
Pre-Period: 5-in-1	3450	15%P/51%CHO/34%F	PRE, Day 0
Recovery: 5-in-1	4950	16%P/52%CHO/32%F	REC
Negative Control: Starvation	0		ST 0
Spice Drops, Starch Jelly Bar, Hard Candy	1000 and 2000	0%P/100%CHO/0%F	0/100/0 1000 0/100/0 2000
Saltines, Oleomargarine	1000 and 2000	3%P/17%CHO/80%F	2/20/78 1000 2/20/78 2000
Meat Bar	1000 and 2000	30%P/0%CHO/70%F	30/0/70 1000 30/0/70 2000
Meat Bar, 5-in-1 Crackers, Raisins, Catsup, Jam *(Positive Control at 3000 Cal/day)*	1000, 2000 and 3000	14%P/52%CHO/34%F	15/52/33 1000 15/52/33 2000 N 3000
Ration Control: Field Ration A	3680	14%P/45%CHO/41%F	FRA, CONTROL
Water Limited: 910 ml/day			L
Water Unlimited: *ad libitum*			U

TABLE II

Man-days of subsistence on nutrient regimens studied

Nutritional regimen		Temperate		Cold		Hot	
		*Moderate**	*Hard*	*Moderate*	*Hard*	*Moderate*	*Hard*
PRE		336	---	1394	---	1367	---
ST 0	U	37	---	30	33	45	25
	L	40	---	31	48	30	36
0/100/0	U	26	---	28	28	18	17
1000	L	26	---	28	28	18	18
0/100/0	U	26	---	28	24	24	18
2000	L	28	---	28	28	12	18
2/20/78	U	14	---	28	28	9	16
1000	L	14	---	28	28	18	18
2/20/78	U	14	---	34	24	18	16
2000	L	9	---	28	28	18	18
15/52/33	U	24	---	28	28	18	18
1000	L	24	---	28	28	18	9
15/52/33	U	36	---	28	28	18	17
2000	L	15	---	28	28	18	11
15/52/33	U	65	---	28	28	18	18
3000	L	47	---	28	28	8	18
30/0/70	U	14	---	28	28	9	18
1000	L	7	---	28	28	18	14
30/0/70	U	14	---	28	28	18	18
2000	L	14	---	28	28	11	18
Control	U	-----	---	84	84	99	---
REC		340	---	1428	---	1201	---
Total		$\underbrace{1170}$		$\underbrace{4138}$		$\underbrace{3390}$	
				8698			

* "Moderate" and "Hard" designate degree of activity.

Table III

OBSERVATIONS - SURVIVAL RATION STUDY

(SUMMER 1955)

CLINICAL	METABOLIC BALANCE	BODY COMPOSITION	CLINICAL PATHOLOGY	LIVER FUNCTION
A. Physical Exam. B. Histories C. Cardiovascular *1. Lying and Standing B.P. and Pulse Rate* *2. E.K.G.* *3. Post-exercise Pulse Rate* D. Neurological Exams.	A. Intake *1. Gross* *2. Weighback* B. Balance *1. Energy* *2. Water* *3. Nitrogen* *4. Na, Ca, K* *5. Cl, P* *6. Acid-base* *7. Fat Absorption*	A. Weight B. Fat, LBM C. Water *1. D_2O Space* *2. Water Diuresis* D. Photographs E. Albright Calculations	A. Hematology B. Fecal Studies C. Blood Enzymes D. Blood Chemistry E. Urine Chemistry F. Urinalysis G. Sweat Chemistry *1. Qualitative* *2. Quantitative*	A. Serum Cholinesterase B. Serum Cholesterol C. Blood Sugar D. Clinical
ENDOCRINES	NERVOUS SYSTEM	KIDNEY FUNCTION	G.I. FUNCTION	HEAT TOLERANCE
A. Urinary 17-K.S. B. Eosinophils C. Resting M.R. D. Blood Sugar E. Serum Na, K, Ca, P F. Cholesterol G. Serum Amylase H. Urinary Creatine	A. Central *1. EEG* B. Psyche *1. Biological Time* *2. Diary* *3. Progress Notes* C. Clinical	A. Urinalysis B. Addis Count C. Creatinine Clearance D. Osmotic Clearance E. Urea Clearance	A. Fecal Weight B. Fecal Fat C. Occult Blood D. Formed Elements E. Clinical	A. Resting and Post-exercise Oral and Rectal Temperature B. Skin Temperature C. Sweat Rate D. Resting and Post-exercise Pulse Rate E. Kidney Function F. Clinical

in final ranking of regimens: the worst possible survival regimen, starvation with limited water; and the ideal ration, unlimited water and unlimited fresh and frozen foods. All experimental regimens fell between these two extremes, but some were almost as deleterious as starvation, others much better. It is on the basis of these final rankings that we have concluded that an all-purpose, all-environment survival ration is not only theoretically feasible but also practically desirable. We shall answer in Section III a series of questions which emphasize the fundamental scientific features of the composition of the all-purpose survival ration.

SECTION III

PHYSIOLOGICAL AND CLINICAL ASPECTS OF THE ALL-PURPOSE SURVIVAL RATION

A. Is a survival ration necessary at all? Is some food better than no food?

The answer is yes, decidedly. Even small amounts of food are beneficial in slowing down the deterioration and ultimate collapse which are characteristic of total starvation.

B. Is water supply an important problem?

The answer is yes, emphatically. Continued dehydration leads sooner or later to incapacity, and in the heat to heat stroke (a very serious disease). Abundant supplies of water prevent these characteristic effects of dehydration.

C. Granted that some food and water are necessary for the survival of the castaway, will the same survival ration suffice for all environments and all daily work loads? Or should there be specific survival rations for specific situations?

One and the same survival ration will suffice for all environments and all daily work loads. Indeed, a conclusion of major practical importance is involved in the answer to these questions. No low calorie survival ration can prevent deterioration entirely, but the best can minimize deterioration. In temperate, hot, and cold conditions, regardless of work load, regardless of water intake, the same particular combination of protein, carbohydrate, and fat has proved best in this respect. Wide deviations toward more protein, more carbohydrate, or more fat invariably have resulted in measurably enhanced deterioration of the subjects. Therefore, the all-purpose survival ration not only is theoretically feasible, but also is practically highly desirable in minimizing deterioration.

D. What are the physiological, nutritional, and clinical considerations in survival which establish the requirements of the all-purpose survival ration?

These considerations are best expressed in a form which brings out the mutual interrelationships among the important variables **of calorie** balance, water balance, osmotic balance, environmental temperature, and composition of the regimen in terms of protein, carbohydrate, and fat. We have chosen line charts (alignment charts, D'Ocagne nomograms) as best suited for the purpose (Figures I, II, and III). In each case, a straight line laid between the left line and the right line will intersect the middle line, thus illustrating the combined effects of the left and right variables on the variable under consideration. These alignment charts have been constructed from our own data, supplemented by data from the past scientific literature. Only one is calculated theoretically, that for metabolic water. The rest are all fitted empirically to actual data, and should be regarded as descriptions of events, not absolutely mathematical expressions.

1. Function depends on calorie balance and water balance (Figure I A). There comes a point in deterioration at which the castaway becomes ill, so ill that prompt medical attention is needed to prevent serious, even fatal, incapacity. Continued severe calorie depletion together with severe water depletion will result in deterioration and end in total incapacity.

2. Calorie requirements depend upon environmental temperature and daily work load (Figure I B). Energy requirements are the resultant of two main factors. Increased daily work load increases calorie expenditure to accomplish the muscular effort. Decreased average environmental temperature in which the castaway must live increases calorie requirements because of two main effects. First, body temperature must be maintained, and in the cold this requires combustion of fuel for its accomplishment. Second, in cold weather more clothes are worn than in hot weather. Extra weight requires increased energy for movement; "hobbling effect" of heavy clothes requires increased energy to accomplish any particular movement. The sum total of cold weather effects is to increase calorie requirements above those for warm environments. Basal metabolic rate does not enter the argument, for effects of cold on it are neither striking nor universally accepted by scientific observers.

3. Deviation from "normal" protein-carbohydrate-fat ratios predisposes to functional difficulties (Figure I C). In hot, temperate, or cold environments, functional deterioration is accentuated by wide deviation from "normal" protein-carbohydrate-fat ratios in the survival regimen. The actual sites of deterioration are different, sometimes kidney, sometimes liver, sometimes brain, sometimes heart. Especially in hot weather these different deteriorations may become dangerous to health or even life by resulting in heat exhaustion or heat stroke. The "normal mixture" seems to minimize tissue breakdown by the body when it does not have enough calories.

4. Calories usable for physical work depend upon total intake, specific dynamic action, and environmental temperature (Figure I D). Total calories are partly dissipated as heat, and partly used for muscular work. Specific dynamic action is that fraction of total calories dissipated as

heat. In cold environments, below the zone of thermal neutrality (75° - 85° F), this heat cannot be used at all and is wasted. In hot environments a regimen of high specific dynamic action (that is, high in protein such as meat bar) is wasteful of calories otherwise available for muscular work for escape and evasion.

5. Function depends on calorie balance and water balance (Figure II A). It needs to be emphasized that the ill effects of calorie depletion and water depletion can reinforce each other to the point of total deterioration and serious illness. Among subjects who were severely dehydrated, we had to treat several cases of total cessation of sweating, which could lead rapidly to heat stroke, a very dangerous condition.

6. Water requirement depends on environmental temperature and daily work load (Figure II B). Increased daily work load increases water requirement because of increased loss of water in sweat. Increased average environmental temperature increases water requirement by increasing rate of sweating for any given work rate. In hot environments with hard work, an intake of three quarts of water a day is needed to prevent cessation of sweating, and ultimate heat stroke. For light work, two quarts will be needed. For cold environments one to two quarts will suffice, although water requirements do increase as the temperature drops below freezing. The colder it becomes, the more water is lost through the lungs.

7. Water balance depends on intake of water and intake of osmotically active material (Figure II C). Water balance is not dependent just on total water intake alone, but is also affected critically by osmotic balance (i.e., excretion of urea and minerals). If too little osmotically active material is ingested, water cannot be retained because the kidney cannot function efficiently. If too large an amount of osmotically active material is ingested, excessive water must be excreted by the kidney to dispose of the excess osmols. Especially in limited water regimens, too little osmotic intake accentuates dehydration. High protein provides too much osmotic intake (meat bar); pure carbohydrate, too little (sugar or candy).

8. Water intake in part comes from metabolic water (Figure II D). Some of the water requirement is met by metabolic water, which is water produced by the body's burning protein, carbohydrate, or fat. Grams of water are calculated as follows: 0.41 x gm of protein + 0.6 x gm of carbohydrate + 1.07 x gm of fat. Stated in another way, grams of water may be calculated as follows: 103 per 1000 Cal of protein + 150 per 1000 Cal of carbohydrate + 119 per 1000 Cal of fat. The alignment chart permits rapid calculation of total metabolic water to be derived from any nutrient mixture. From this particular standpoint 1000 Cal of carbohydrate yields the most metabolic water, 1000 Cal of protein the least.

9. Balance of specific nutrients depends on actual intake of the particular nutrient and on total calorie balance (Figure III A, B). Line

charts are given for nitrogen and phosphorus. Similar results are found for sodium, potassium, calcium, chloride, and phosphorus. During continuous negative calorie balance, the body is forced to destroy its own tissues steadily. It cannot retain the nutrients in food unless there is at the same time a substantial intake of total calories. These findings are the basis of the universal "catabolic reaction" of the castaway. Also, they emphasize the fundamental point that no calorically inadequate regimen will support normal nutrition indefinitely. Therefore, no survival ration (which by definition is calorically inadequate for complete balance) can be expected to provide fully adequate nutrition.

10. Ketosis depends on calorie balance and on intake of carbohydrate (Figure III C). Ketosis should be prevented by the survival ration because a high concentration of ketone bodies (acetone, acetoacetate, beta hydroxybutyrate) is injurious to brain function and markedly impairs acid-base balance. Ketosis is prevented by adequate total calories in which is included a reasonable amount of carbohydrate. Ketosis is produced by inadequate calories (as in starvation or partial starvation) or a very low intake of carbohydrate (as with meat bar).

11. Ketogenicity depends on environmental temperature and calorie balance (Figure III D). Even for a non-ketogenic regimen, and especially for ketogenic regimens, temperature, total calorie balance, and carbohydrate intake control the potential ketogenicity. One and the same regimen (e.g., meat bar) may be highly ketogenic in cold weather and much less so in warm weather. Greatest ketogenicity is exhibited during large calorie deficits (as in starvation) in cold weather.

FIGURE I
FACTORS RELATED TO CALORIES

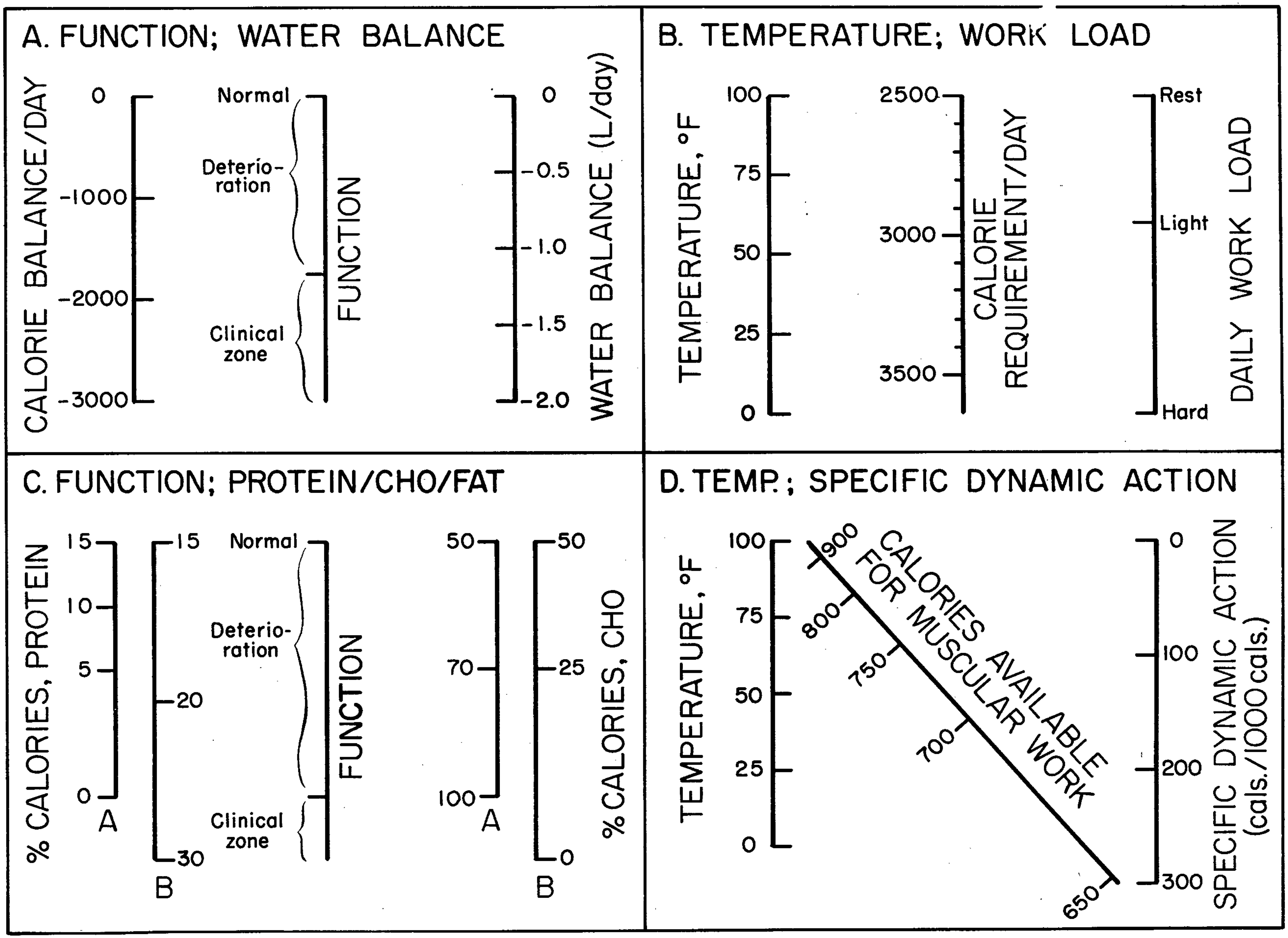


FIGURE II
FACTORS RELATED TO WATER BALANCE

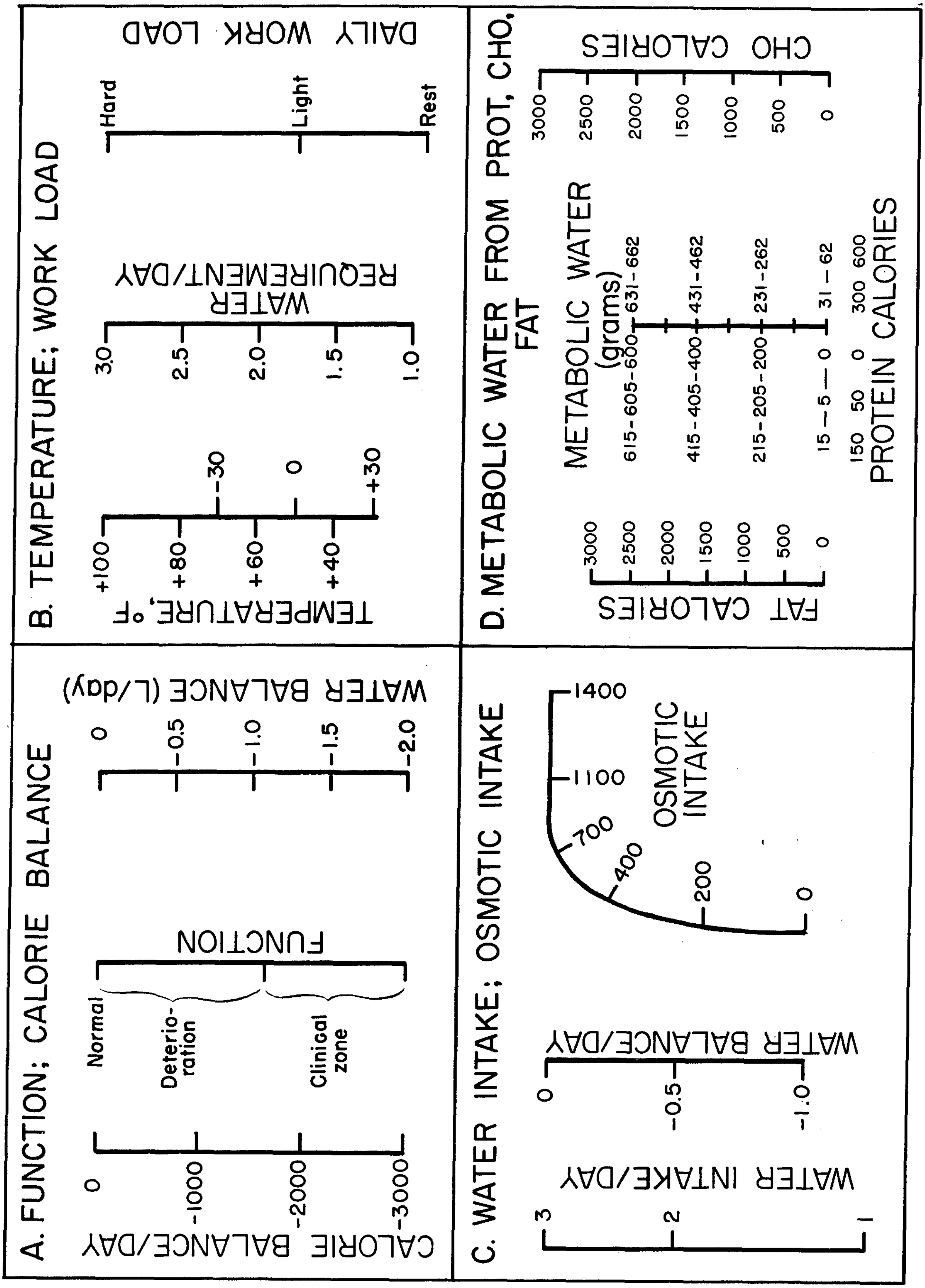
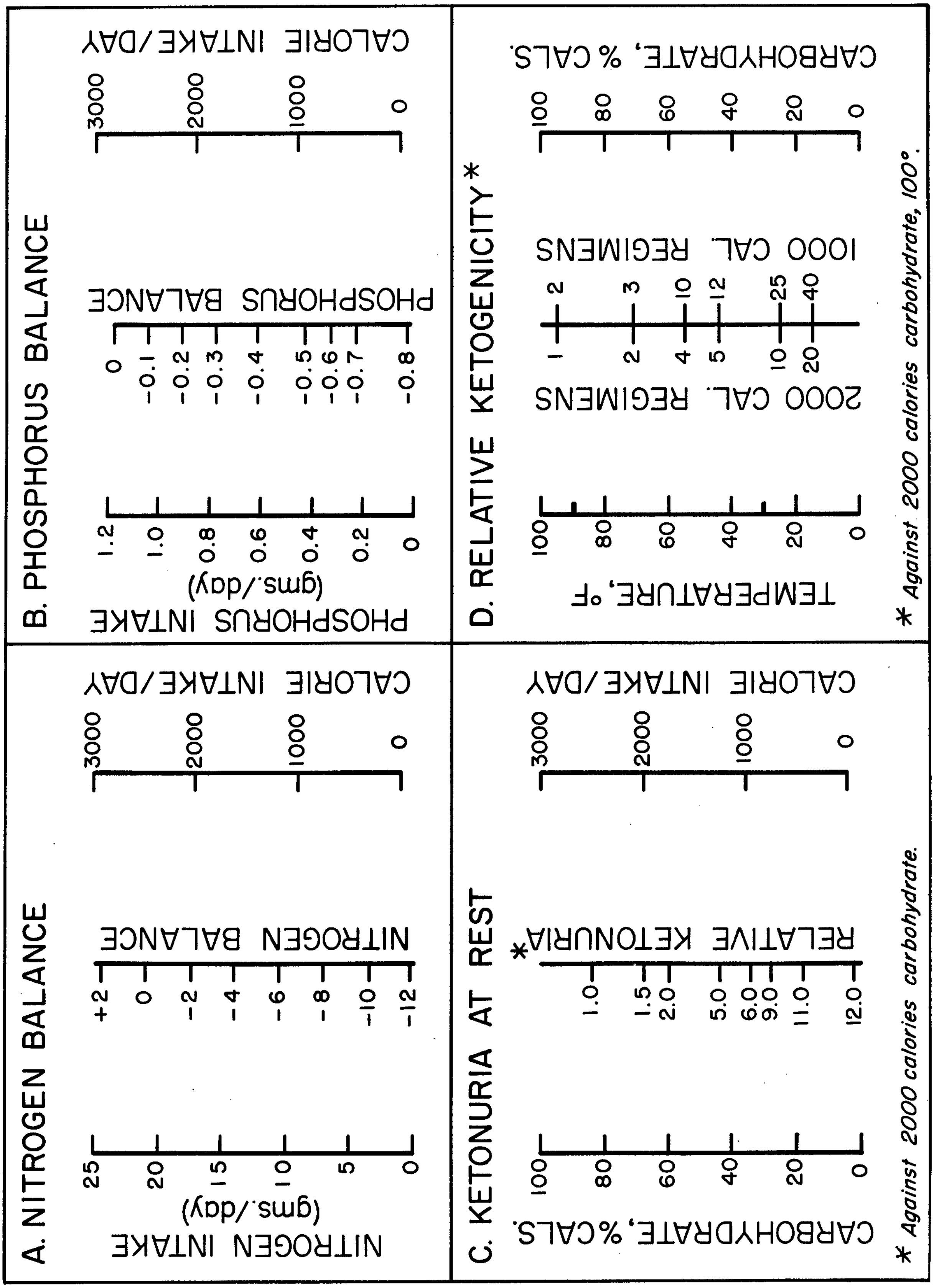


FIGURE III

FACTORS RELATED TO SPECIFIC NUTRIENT BALANCE & KETOSIS



SECTION IV

THE COMPOSITION OF THE ALL-PURPOSE SURVIVAL RATION

The purpose of the survival ration is to support the survival potential of the castaway long enough to permit him to escape or evade capture. However, no one should ask the impossible. Sooner or later, continued undernutrition and malnutrition will cause deterioration, illness, or even death, especially in extremes of heat or cold. The best that any survival ration can do is to minimize deterioration, thus protecting the castaway's survival potential.

We have established the fundamental physiological, nutritional, and clinical bases for the all-purpose, all-environment survival ration. It should possess the following characteristics, every one of which is important and established by convincing experimental evidence:

1. Maximum feasible calorie content provided by a balanced mixture of first-class protein, carbohydrate, and fat. The goal should be 2000 Calories per man per day, of which protein should provide 15 percent of calories, carbohydrate 52 percent of calories, and fat 33 percent of calories.

2. Water allowance as liberal as possible, with a goal of three quarts per man per day for hot weather, and no less than one quart per man per day under any circumstances.

3. An optimal osmotic intake, neither too large nor too small. The goal should be 700 milliosmols per day, provided by the sum of protein and minerals.

4. Within limits set by the recommended proportions of protein, carbohydrate, and fat, minimal ketogenicity, minimal specific dynamic action, and maximal water of oxidation.

Working within the framework of these physiological, nutritional, and clinical requirements, food technologists should be able to package in stable and usable form the all-purpose survival ration.

We end this report, summarizing five years of intensive study, on a note of warning. The castaway's survival potential can be protected by a survival ration, based on sound physiological and clinical principles. An ill-advised survival ration, not so founded, is going to be harmful to the castaway. Under some circumstances, an unsound survival ration may actually produce deterioration faster than will starvation, especially when water is limited. It is for this reason that we recommend strongly against the use of either meat bar or pure carbohydrate. Both of these regimens have intrinsically undesirable effects on the castaway's organic functioning and total efficiency, in contrast to the minimal effects associated with the "normal mixture." This regimen we do recommend as being best for a survival ration for all environments, for all work loads, and for all amounts of water, whether adequate or inadequate.

SECTION V

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