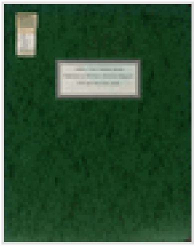

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COMBAT FIELD FEEDING SYSTEM

Committee on Military Nutrition Research

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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CONTENTS

INTRODUCTION AND BACKGROUND

The Committee on Military Nutrition Research of the National Research Council's Food and Nutrition Board reviewed and evaluated the data and resulting conclusions and recommendations pertaining to specific nutritional and medical questions addressed by the Combat Field Feeding System-Force Development Testing and Experimentation (CFFS-FDTE) conducted by the U.S. Army at Pohakuloa Training Area, Hawaii, in July and August 1985.

Two members of the committee and the FNB staff officer visited the site while the CFFS test was being conducted, to observe field conditions and activities, data collection, and laboratory facilities and to meet with the test subjects and staff. The entire committee then reviewed and discussed the test methods, data, and results with the Nutrition Research Task Force of USARIEM during a 3-day meeting held November 19-21, 1985, at Natick, Massachusetts. After extensive discussion and review of all available data, the committee reached the conclusions presented in this report.

It is the understanding of the committee that the U.S. Army Natick Research and Development Command was charged to design and develop a suitable feeding system to meet the demands of future combat situations more adequately than the current system. The new system, based primarily on Meals-Ready-to-Eat (MREs) and tray-pack (T) rations, is intended to incorporate modern technologic advances in food processing, packaging, and equipment; provide nutritionally adequate rations; and reduce combat food-service requirements for labor, fuel, and food preparation time. The CFFS-FDTE was thus designed to evaluate the ability of the Combat Field Feeding System (CFFS) to provide subsistence support to and maintain the health and nutritional well-being of troops engaged in moderate activity for a specified period (Appendix A). The actual field testing was undertaken by the U.S. Army Research Institute of Environmental Medicine (USARIEM).

The field test was conducted over a 44-day period at Pohakuloa Training Area (PTA), Hawaii. The site has an elevation of approximately 6,000 feet; is dry, dusty, and rugged; and has an average ambient temperature of 72°F. Two hundred forty persons from six units volunteered to serve as test subjects: 40 men each from three artillery battalions, one combat support company, and one combat service support company and 40 women from a combat service support company. Volunteers from all units were maintained on three MREs per day for the first 3 days of the study. Each group was then changed to one of five ration regimens, as follows:

- Group 2A: one MRE and two A rations (meals prepared with shelf-stable and fresh ingredients; refrigeration or ice required).

- Group 2B: one MRE and two B rations (meals prepared by cooks with shelf-stable ingredients, primarily dehydrated; no refrigeration needed).

- Group 1T: two MREs and one T ration (heat-sterilized tray packs warmed by cooks; no refrigeration needed.)

- Group 1TF (the female group): two MREs and one T ration (comparable with regimen of Group 1T).

- Group 2T: one MRE and two T rations.

- Group 2TE: one MRE and two T rations augmented with enhancements from A rations and B rations during the latter phase of the study.

Members of all groups participated in their normal training exercises throughout the study. (For further details of schedules for feeding, fluid intake, and activity, see Appendix B.)

To evaluate the adequacy of the proposed rations to support the nutritional health and well-being of the troops, the investigators identified six issues that needed to be addressed. These issues, the criteria and methods used to examine them, and the resulting analysis and recommendations of the Nutrition Research Task Force of USARIEM are described in detail in Appendix C. The supporting data can be found in Appendixes D, G, H, I, J, K, and L. The Committee on Military Nutrition Research examined each issue by reviewing the associated criteria and methods and assessing how well the data supported the USARIEM investigators' conclusions and proposed recommendations.

In the following discussion, the committee responds first to Issues 2.1 and 2.4, because they are directly related, and then to Issues 2.2, 2.3, 2.5, and 2.6.

COMMITTEE FINDINGS AND CONCLUSIONS

Issue 2.1: Will troops eat a sufficient quantity of CFFS rations (T, B, and A rations and MREs) over an extended period (42-49 days) to meet the Surgeon General's Military Recommended Dietary Allowances (MRDAs) for protein, vitamins, minerals, fat, and energy?

The committee concludes that the calculated nutrient consumption by each of the six test groups probably met the MRDAs proposed in the test standard for almost all nutrients measured. (See Appendix D for nutrient intake data; see Appendix E for MRDAs.) The validity of nutrient intake data depends directly on the accuracy of the estimates of food intake and of the nutrient content of the various rations. Accurate measurement of food intake under field conditions is exceedingly difficult. The investigators designed an innovative system both to measure food consumption and to validate their measurements. (See Appendix M.)

Confidence in the data concerning nutrient content of the MRE and the T-ration components as consumed would be substantially increased if these food items had been chemically analyzed closer to the time of their consumption. The MREs were in storage for approximately 3 years before the study, and nutrient composition data were obtained at the time of their formulation. The results of current analyses would be especially useful for evaluating the nutritional adequacy of the rations, in light of the failure to obtain some nutritional status indicators, including serum concentrations of vitamin C, thiamin, riboflavin, niacin, and vitamin B_6 (see the discussion of Issue 2.4). The rations were probably adequate in these nutrients, but analytic data on the composition of the MREs and T rations are necessary to confirm the calculated nutrient consumption data. Without these analytic data, valid conclusions cannot be made concerning nutrient intake. Representative samples of the MREs fed during the study are available at USARIEM, and the committee strongly recommends that these rations be analyzed and compared with the calculated estimates of intake. It is the committee's understanding that the MREs have not been analyzed for many nutrients known to be essential--such as zinc, magnesium, folacin, vitamin B_{12}, selenium, copper, and chromium--and the committee suggests that these nutrients be included in the analysis.

Average daily calcium intakes met the MRDA only in groups that received milk (Groups 2A, 2B, and 2TE). The deficit in intake was particularly large for women (Group 1TF). It should be noted, however, that these intakes do not differ significantly from those found in studies on the U.S. civilian population, as reported by the second National Health and Nutrition Examination Survey (DHHS, 1983). Because women have a lower energy intake, it is more difficult for them to meet their calcium requirement. Given the current MRDA for calcium, the committee recommends that methods for increasing the calcium content of the MRE and T rations be investigated.

The MRDA suggests a maximal sodium intake of 1,700 mg/1,000 kcal. This intake was attained or moderately exceeded in all test groups. In keeping with the desirability of lowering sodium intakes in the population, efforts should be made to reduce sodium intake while providing safe and acceptable foods.

<u>Issue 2.4</u>: Will troops subsisting on CFFS rations over an extended period (42-49 days) maintain their nutritional status?

The committee concludes that protein, vitamin A, vitamin C, thiamin, riboflavin, niacin, and vitamin B_6 nutriture was probably maintained throughout the study. (See Appendix G for data on nutritional status.) Definitive conclusions cannot be made for vitamin C, thiamin, and riboflavin, owing to the lack of valid analytic measurements due to improper handling of samples and contractor error. Vitamin C status could not be evaluated, because samples were not acidified in the field and ascorbate was thus destroyed before analysis. The analytic methods requested by the nutrition staff for thiamin and riboflavin determination were not used by the contracting laboratory, so serum concentrations of these nutrients are not available. However, intake of these three nutrients appeared adequate, as judged by food consumption data that indicate that intake exceeded the MRDAs. Nutrient analysis of the food consumed that supported the calculated data (as recommended in the discussion of Issue 2.1) would increase the confidence in this conclusion.

Serum calcium concentrations were not measured in this study, because the concentration of calcium in plasma is stable and therefore is not an indicator of calcium nutriture. It has been suggested that bone-density measurements might be a more reliable indicator of calcium status, but such a measurement was not feasible in this field situation.

The committee concludes that all groups maintained adequate folacin status, although, according to the biochemical criteria established for this study, serum folate concentrations were to be considered unacceptable if below 6 ng/ml. In a recent report of the Life Science Research Office (LSRO, 1984a), the criteria for adequate serum folacin were re-examined. It was suggested that a serum concentration of 3 ng/ml or greater indicated acceptable folate status. All groups in this study met this criterion; none showed deterioration in serum folate values during the period of the study.

The committee concludes that iron nutrition was adequate. Hematocrit, hemoglobin, and serum ferritin concentrations (see Appendixes G and H) were within the normal ranges for all test groups throughout the study. Although a few low values of several hematologic variables were observed in Group 1TF (women), they were less frequent than commonly observed in the civilian population (DHHS, 1983; LSRO, 1984b). Iron intake was below the MRDA in Group 1TF, but the high ascorbic acid content and heme content of the diet appear adequate to compensate for the moderately low iron intake (Hallberg, 1981; NRC, 1980).

The committee notes that Group 2A (fresh foods) had higher fat and cholesterol intake and suggestions of higher total serum cholesterol and LDL concentrations (and decreased HDL concentrations) over time, as might be expected from the dietary intake (see Appendix G). Serum triglyceride concentrations did not fluctuate over time and were similar among test groups. The entire set of lipid data suggests that intakes and serum concentrations in all groups were comparable with those of the civilian population (DHHS, 1983) and were higher than desirable if sustained over long periods. Accordingly, the committee suggests that consideration be given to total fat, type of fat, and cholesterol content in the formulation of diets for military personnel.

Concentrations of serum proteins were well within normal limits in all groups throughout the study. Plasma osmolality and inorganic ion content (electrolyte) were normal and were not significantly different among test groups (see Appendix H). Blood urea nitrogen and creatinine concentrations were increased in Group 2A (the ration most similar in composition to the typical American diet) at days 20 and 44 of the study, but were steady over time in all other test groups. An explanation for the increase in Group 2A is not evident in the data available. However, the increased values were not high enough to be considered abnormal, and the committee sees no reason for concern over this observation.

The data support the conclusion that fat-free body mass remained constant throughout the study in all test groups. (Body composition is discussed further in Issue 2.2.)

Issue 2.2: Will troops subsisting on CFFS rations over an extended period (42-49 days) consume sufficient calories to meet energy demands associated with extended field operations?

The committee concludes that on the average the members of each test group maintained their body weight within the established criteria. No significant differences among test groups in changes in mean body weight were observed over the course of the study (Appendix I). However, the number of subjects whose body-weight loss exceeded 5% or 7.5% of initial body weight varied among the groups. None of the soldiers in Group 2A lost 7.5% of initial weight, and only a few lost even 5%. The mean body weight of soldiers in each group except Groups 1T and 2B tended to decrease slightly during the first half of the study, then to increase progressively between day 20 and day 44. The soldiers in Group 2B showed the greatest tendency to continue to lose body weight, as measured by mean values and the number of soldiers who lost more than 7.5% of initial body weight. Group 2B was composed of engineers who were most consistently engaged in continuous moderate activity throughout the study; this might account for the observed changes in their body weight. However, although the average caloric intake among the five groups of male soldiers was similar (see Appendix D, p. D-3), as was the trend in their mean body-weight changes (see Appendix I, p. I-1), this explanation is speculative, because of the confounding effects of the different dietary regimens on fluctuations in individual body weights.

The soldiers in Group 1T consumed two MREs per day. The high incidence of weight loss among members of this group (see Appendix I) is similar to the findings of an earlier study of this ration system. Results of the 1983 MRE study, conducted under similar conditions for 30 days, suggested that scout troops consuming three MREs per day were not able to maintain pretest body weight (Hirsch *et al*., 1984). It is not certain whether these findings are related to the dehydrated nature of the food items or other possible confounding factors. The energy intake data do not explain the findings.

The soldiers in the present study were engaged in light to moderate activity with periodic increases in energy expenditure. These troops maintained their weight adequately (as established by test criteria) during the study period, but it is not known whether troops engaged in heavier physical activity or consuming the rations for longer periods would increase their food intake sufficiently to maintain their weight within the range observed in this study. Furthermore, the committee notes that the criterion for average weight change of a platoon or larger unit was at 3% of initial weight. The data suggest that individual body-weight changes of 3%, 5%, or 7.5% of initial weight might reflect the effect of diet on body weight more accurately. The committee encourages USARIEM to explore these issues further.

Issue 2.3: Will troops subsisting on CFFS rations drink sufficient fluids and water to maintain hydration status?

The committee notes that clinically significant dehydration was not observed in this study. No days were lost from work because of hypohydration. The average urine specific gravity (SG) never reached 1.030 in any group, but the incidence of SG greater than 1.030 in individual soldiers did reach about 60% in Groups 1T and 2A on two occasions (see Appendix J). The USARIEM investigators are correct in focusing on the latter criterion (incidence versus average) as evidence of suboptimal hydration.

The committee is concerned that the three-MRE ration might increase the risk of dehydration because of its low water content, and the troops might not have compensated by increasing their water intake. This concern is supported by the higher incidence of urine SG greater than 1.030 in subjects on two-MRE feeding regimens than in subjects on one-MRE regimens. Nevertheless, the lower total water intake during the three-MRE days could depend in part on the fact that these rations were mostly dehydrated. Furthermore, the MRE rations were eaten during the initial acclimatization period in the field. The loss of body water by extrarenal routes could have been accentuated during the acclimatization period. In addition, if MREs tended to predispose soldiers to dehydration, body-weight loss would be expected to be correlated with the number of MRE meals, especially at the three-MRE level. No such correlation for the entire group was found; that is, there was little or no average weight loss while the incidence of urine SG greater than 1.030 was highest. However, this preservation of body weight could indicate the effectiveness of renal conservation of water; that is, the kidneys might not have allowed the tendency toward marginal dehydration during the initial three-MRE period and later two-MRE periods to reach the point of detectable weight loss, hyperosmolality, or hemoconcentration.

Another possible index of hydration is provided by the blood chemistry and hematocrit (see Appendix H). However, the effect of altitude acclimatization in raising the hematocrit makes this type of evaluation of hydration status unreliable. The following factors might have influenced hydration status of the soldiers when they were on the two- or three-MRE regimen:

- The three-MRE regimen was used only during the initial acclimatization period.

- Urine SG was determined in a single early-morning sample, rather than based on 24-hour urine collection. The kidney concentrates urine during sleep; therefore, the analysis was performed on the most concentrated sample of the day. (The committee recognizes the impossibility of obtaining a 24-hour urine collection under field conditions.)

- The statistical confidence limits around average values based on 40 subjects are relatively large, and information is not available on the statistical power of the study for evaluating hydration status. Data are available from the study for calculation of correlation coefficients within each group and diet period for morning urine SG versus body-weight change, hematocrit change, plasma osmolality, and plasma total protein. These calculations will be valuable to the investigators in drawing final conclusions.

Any conclusion about the positive effect on hydration of adding ice is complicated by the general adaptation in hydration that appears to have taken place in response to the move to the field environment and exposure to moderate hypoxia (elevation, 6,000 feet). Other factors might have played a role as well, such as a reduction in osmolar load, a decrease in physical activity, and adaptations in endocrine or other fluid-balance control mechanisms. The committee cautions against drawing definitive conclusions concerning the value of adding ice to increase water consumption, at least under the temperate conditions of the field test. Furthermore, providing ice for direct introduction into beverages or foods should be viewed with caution, because this can be a route for contamination with bacteria and other agents. If cooling of food and beverages is deemed necessary, perhaps means other than the use of ice can be provided.

The introduction of flavorings for canteen water on day 30 for the groups fed T rations was associated with the lowest incidence of urine specific gravities over 1.030. However, the committee suggests caution in interpreting the value of added flavorings to increase water consumption. The general adaptation in hydration toward water balance indicated that body-water balance was essentially achieved by this time (i.e., by 30 days) in all test groups. The favorable influence of flavoring was small, if it occurred at all. The water intake data, although prone to relatively large variance, do not support a conclusion that the addition of flavorings increased water intake. Consideration of the use of flavorings should be tempered by the possibility that flavoring can inhibit the action of chlorine or other antibacterial agents and thereby facilitate contamination of the drinking water (Rogers *et al*., 1982).

Women had a high individual incidence (25-30%) of urine SG greater than 1.030 in the early phase of the study. However, they showed the same trends of general adaptation in water balance as shown by the men. Inspection of the urine SG by test day shows no discernible sex-related pattern of adaptation.

Issue 2.5: What is the incidence of food-related health disorders in troops subsisting on CFFS rations over an extended period (42-49 days)?

The committee concludes that the incidence of food-related disorders requiring medical attention was very low in all test groups. The overall incidence of days lost to sick call for gastrointestinal disorders was very low: 1.6 per 1,000 person-days for all subjects, 3.8 per 1,000 person-days for females, and 1.2 per 1,000 person-days for males. Reports of food-related symptoms were higher in the female group than in the male groups. That finding and the higher rates of sick-call visits among females are consistent with findings of other studies of sex differences in reporting on food-related and non-food-related symptoms, such as a recent report concerning the complaints registered by aspartame users (MMWR, 1984). Additional factors might have been the relative inexperience of the women in a field environment and their greater difficulty in meeting personal hygiene requirements. Male subjects had more minor complaints of gastrointestinal symptoms (e.g., gas pressure and stomachache) in the groups fed T rations, but complaints and days lost to sick call due to gastrointestinal problems were within normal limits set by the military in both male and female groups. The consistency of objective and subjective measures of food-related health problems supports the validity of the measures used and the proposed conclusions.

Full interpretation of these data would benefit from two additional types of analysis: the groups should be compared statistically, to determine the reliability of the observed small differences; and data should be compared with incidence rates of gastrointestinal and other symptoms in other field exercises, inasmuch as no numerical values were included in the criteria.

Issue 2.6: Will troops subsisting on CFFS rations over an extended period (42-49 days) maintain muscle strength and muscular endurance?

The committee concludes that the muscle strength and muscular endurance of the soldiers--as measured in this study by handgrip strength and endurance, upright pull, and incremental dynamic lift--were maintained throughout and that there was no effect of rations (see Appendix N). Indeed, the body-composition data suggest that there was a slight increase in fat-free body mass among the women in the study (see Appendix K).

Performance tended to increase over time in all test groups. This increase was probably due to a training effect that resulted in a small increase in actual strength.

The committee recognizes that the selection of the criterion--a decrease of 10% from initial pretest values--was arbitrary. However, inasmuch as there appeared to be no decrease in muscular strength or performance, this criterion did not influence the interpretation of the data. The committee also concludes that hand-eye coordination did not deteriorate among the troops in this study (Appendix L).

SUMMARY AND RECOMMENDATIONS

The committee believes that, under the extenuating and limiting field conditions of the CFFS test, the study was well planned and executed. Furthermore, the nutritional issues were only one of three major considerations of the overall test design plan. The other issues addressed were the capability of the CFFS to operate according to the established operational and organizational plan and the acceptability of the proposed rations and their effect on morale and unit cohesion. The planning of the collection of the nutritional data was hampered by the constraints imposed by the contingencies of the multiple study objectives. Team leaders developed innovative, effective methods to gather data under less than optimal field conditions. The excellent quality of personnel management, staffing, and commitment of volunteer subjects clearly contributed to the successful execution of this study. The committee concludes that the various ration systems evaluated adequately met the criteria defined in the test protocol under the conditions of this study. Several important factors, however, must be considered before the results of this study can be applied more broadly.

As a ration system changes from one composed of a wide variety of fresh, common foods, such as the A ration, to one composed primarily of less customary, fabricated foods, such as the MRE, accurate information on nutrient content becomes more critical in evaluating the adequacy of a diet. The available analytic information on the nutrient content of the MRE is inadequate with respect to many nutrients, including zinc, magnesium, folacin, vitamin B_{12}, selenium, copper, and chromium. Similar information on the T ration is also lacking. Deficiencies of many of these micronutrients usually can be detected only after feeding of a deficient diet for more than 49 days.

Information is not available on the stability of nutrients in the MRE under the usual conditions of storage for extended periods. Although it is important to know the nutrient content of the MRE when manufactured, it is even more important to know whether the nutrients are present in adequate amounts when the ration is consumed 3 or 4 years later. Vitamin C and thiamin, for example, are unstable under particular conditions.

The troops in this study were generally involved in light to moderate activity. Body weight was maintained by most subjects, but the engineers, who were engaged in continuing moderate activity, had the greatest tendency to continue to lose weight throughout the study. The extent to which voluntary food restriction, lack of acceptability of rations, and increased energy expenditure contributed to weight loss is not clear. It is also not known whether troops involved in heavy activity, such as foot soldiers carrying heavy packs for extended periods, would increase their consumption of these rations sufficiently to maintain body weight and performance, as found in this study.

The environmental conditions in this study were moderate. Whether troops exposed to extremes of heat or cold or higher elevations would consume enough food and water to maintain adequate hydration status and performance has not been determined in this study. Because the incidence of urine specific gravity greater than 1.030 was sometimes as high as 60% in some groups, it is important to consider the potential impact of environmental extremes on hydration status, particularly in troops consuming the MRE.

Muscular strength and endurance and hand-eye coordination were maintained in this study, but it would be important to evaluate the effects of the different rations on the endurance of troops tested under more stringent conditions, as might be expected in military field combat.

In view of the concerns discussed above, which limit the broader application of the test results, the committee offers the following recommendations:

o The MRE rations should undergo a complete nutrient analysis to determine the concentrations of all the essential micronutrients supplied by the various MRE components. Similarly, the T-ration components should be analyzed further for all essential micronutrients.

o The nutrient content of the MRE should be analyzed after usual conditions and periods of storage. This would determine whether the ration delivers at the point of consumption the nutrients required to meet the MRDAs, as well as other micronutrients for which there are no MRDAs. A permanent monitoring system to ensure nutritional quality should emerge from this initial effort.

o The adequacy of the proposed rations constituting the CFFS to maintain the nutritional health and well-being of soldiers should be tested further under the conditions of heavy activity, longer periods, and extremes of temperature, relative humidity, and elevation likely to be encountered in military field combat. Initially, at least, these tests can be done in a laboratory setting with small groups of soldiers and controlled simulated field conditions.

REFERENCES

DHHS (U.S. Department of Health and Human Services). 1983. Dietary Intake Source Data: 1976-1980. Data from the National Health Survey Series II, No. 231. DHHS Publ. (PHS) 83-1681. National Center for Health Statistics, Public Health Service, U.S. Department of Health and Human Services, Hyattsville, Md.

Hallberg, L. 1981. Bioavailability of Dietary Iron in Man. Annu. Rev. Nutr. 1:123-147.

Hirsch, E., H. L. Meiselman, R. D. Popper, G. Smits, B. Jezior, I. Lichton, N. Wenkam, J. Burt, M. Fox, S. McNutt, M. N. Thiele, and O. Dirige. 1984. The Effects of Prolonged Feeding Meal, Ready-to-eat (MRE) Operational Rations. Technical Report Number NATICK/TR-85/035. United States Army Natick Research and Development Center. Natick, Mass.

LSRO (Life Science Research Office). 1984a. Assessment of the Folate Nutritional Status of the U.S. Population Based on Data Collected in the Second National Health and Nutrition Examination Survey, 1976-1980. Life Science Research Office, Federation of American Societies for Experimental Biology, Washington, D.C.

LSRO (Life Science Research Office). 1984b. Assessment of the Iron Nutritional Status of the U.S. Population Based on Data Collected in the Second National Health and Nutrition Examination Survey, 1976-1980. Life Science Research Office, Federation of American Societies for Experimental Biology, Washington, D.C.

MMWR (Morbidity and Mortality Weekly Report). 1984. Aspartame. Data from the Morbidity and Mortality Weekly Report (33)43:605-607. November 21, 1984. DHHS Publ. No. (CDC)84-8017. Washington, D.C.

NRC (National Research Council). 1980. Recommended Dietary Allowances, Ninth Revised Edition. A report of the Committee on Dietary Allowances, Food and Nutrition Board, Division of Biological Sciences, Assembly of Life Sciences. National Academy Press, Washington, D.C.

Rogers, M. R., J. Kutzko, and A. M. Kaplan. The halogen demand of commercial beverage powders, drinks and their constituents. Natick Tech. Report 82/018, pp. 1-46, February 1982.

APPENDIX A

SUMMARY OF COMBAT FIELD FEEDING SYSTEM TEST BACKGROUND AND OBJECTIVES*

*Excerpted from Combat Field Feeding System--Force Development Testing and Experimentation, Test Design Plan, June 1985, U.S. Army Combat Developments Experimentation Center, Fort Ord, California.

1.1 **PURPOSE.** The purpose of the Combat Field Feeding System - Force Development Test and Evaluation (CFFS-FDTE) is to evaluate the Combat Field Feeding System's capability to provide subsistence support and also the nutritional value of the rations consumed by troops in a field environment. The data will be used to answer the Vice Chief of Staff of the Army's tasking on field feeding.

1.2 BACKGROUND.

1.2.1 **History.** The future combat scenario will be characterized by highly mobile operations on an integrated battlefield. The current field feeding system and feeding techniques, using B Rations and combat rations, cannot effectively perform the food-service mission in such an environment. Recent technological advances in food processing, packaging, and equipment offer considerable opportunity to reduce combat food-service requirement for labor, water, fuel and food preparation time and to increase the mobility, flexibility, and responsiveness of combat field feeding operations. Department of the Army Deputy Chief of Staff for Logistics has stated that the concept and the equipment for the field feeding system needs modifications. The USAQMS was designated as the proponent of the CFFS test, and United States Army Natick Laboratories was designated as the developer of the CFFS. The United States Army Training and Doctrine Command (TRADOC) was charged with testing the system.

1.2.2 Previous Testing.

a. The CFFS underwent a FDTE at Fort Hood, Texas, from 13 October throught 10 November 1982. The results indicated that the CFFS concept, as proposed in the original CFFS study dated 6 August 1980, required modification in the equipment used and in the operational concept of the system.

b. The CFFS underwent an Operational Test I (OT I) of selected elements at Fort Hood, Texas, from 9 October through 3 November 1984. The selected elements involved in the OT I were the Modular Field Kitchen (MFK), the Consolidated Field Kitchen (CFK) and the Hospital Ward Food Service Transport System (HWFSTS). The purpose of the test was to examine the capability of the CFFS to support units during sustained operations. The test agency was the TRADOC Combined Arms Test Activity (TCATA) and the USAQMS was the Independent Evaluator. The overall test result was that no assessment could be made on the mission capability of the MFK due to new equipment availability for testing, and the test unit being a hospital which is not representative of CSS units.

c. The Kitchen, Company-Level Field Feeding (KCLFF) component of the CFFS also underwent an Operational Test II (OT II) at Fort Hunter Liggett, California, from 23 July through 24 August 1984. At the time of the test, the component was known as the Company Level Field Feeding Kit (CLFFK). The Dismounted Rations Heating Device (DRHD), currently known as the Canteen Cup Stove, and the Remote Food Carrier (RFC) were included in the test. The purpose of the test was to provide data and observations on the operational effectiveness and suitability of the KCLFF to the combat developer's independent evaluator. The test agency was the Combat Developments Experimentation Center (CDEC). There was no overall assessment provided, instead, major findings and assessments were stated.

1.2.3 **General**. As a result of the Quartermaster Corps Functional Area Assessment (FAA) briefing to the Vice Chief of Staff of the Army (VCSA) on 2 Jul 84, TRADOC, in conjunction with FORSCOM, was tasked to conduct a test of the Combat Field Feeding System (CFFS), to include augmentation for fielding A Rations. The initial interpretation of the tasking was to test the Kitchen Company Level Field Feeding (KCLFF) using the new field feeding standard of two Meals-Ready-to-Eat (MREs)/one hot T Rations during the Nov-Dec 84 time frame. Upon receipt of the official FAA Tasker (10-53) and viewing of the TV tape of the QM FAA briefing that resulted in the VCSA directions, it became clear that the test scope was broader than the KCLFF. Therefore, plans to expand the test scope were initiated and a TRADOC message was dispatched advising the major participants of the expanded test scope and to advise on the CFFS equipment by component and capability. During a later briefing to the Chief of Staff of the Army (CSA), the test scope was increased to include females and a rations mix of T Rations, B Rations, A Rations, and MREs. On 4 Sep 84, the Combat Developments Experimentation Center (CDEC) was tasked by message to be the operational tester, to develop the Outline Test Plan (OTP), and to execute the test.

1.3 **SYSTEM DESCRIPTION.** The CFFS is configured to support the Army in the field and is designed to be highly mobile; to possess inherent flexibility; to reduce food preparation time, labor, and water requirements; and to provide two hot meals per day to the combat soldier in the field. The system is designed to operate in all climatic conditions and levels of visibility.

1.3.1 **Equipment.** The CFFS consists of the Mobile Kitchen Trailer (Models MKT-75, 75A, or 82), Figure 1-1; KCLFF, Figure 1-2; Sanitation Center, Figure 1-3; and Remote Food Carrier (RFC), Figure 1-4. The following components of the CFFS will not be tested; the Modular Field Kitchen (MFK), Hospital Ward Food Service Transport System (HWFSTS), Mounted Individual Rations-Heating Device (MRHD), and Canteen Cup Stove (Figure 1-5). The MKT is designed to prepare and serve the full range of field rations in the Army inventory, to include A Rations, if refrigeration storage capability is available. A single MKT should be able to prepare the standard B Ration for 250 soldiers per meal on a sustained basis and when two MKTs are consolidated, their support capability should increase to 700 personnel per meal on a sustained basis. The MKT will be issued to units requiring high mobility. The CFFS is designed to use disposable eating ware with permanent ware being used as a backup. The Sanitation Center consists of one Tent Modular Personnel (TEMPER), three field sinks, one drain table, and two work tables. Remote Food Carriers will be used to provide meals to dispersed or small squad-sized elements and used as holding devices for the KCLFF. The KCLFF is capable of heating tray packs for companies of the Light Infantry Division that cannot receive food service support from established field kitchens. The KCLFF will enable a company to receive a hot T Rations meal when authorized by the battalion commander or the level of commitment permits. The KCLFF is provided to company-sized units unable to receive centralized kitchen support. One KCLFF will support up to 200 soldiers. A unit's mission profile will dictate the type of food service equipment issued.

1.3.2 Concept of Employment.

1.3.2.1 General. Various field feeding techniques are available to the commander to meet operational requirements. Factors to be considered in determining which field feeding technique is to be used are: available food service equipment and personnel, system capability, level of commitment, and availability of rations. Other considerations for selecting a feeding technique are number of troops to be fed, feeding times, mission of unit, and unit location. The CFFS is able to be tailored to meet the food service requirements of divisional and nondivisional units. For example, units located in the Corps or COMMZ may not require rapid mobility; therefore, the commander may decide to consolidate the Modular Field Kitchens (MFK) near troop concentrations. Conversely, combat units which require a high degree of mobility and which move often on short notice will utilize primarily the Mobile Kitchen Trailer (MKT). Figure 1-6 presents the Light Infantry Division Combat Field Feeding Concept. The KCLFF will be used by Light Infantry Division company-sized units which cannot receive food service support from a field kitchen. Figure 1-7 shows the use of the KCLFF in the Light Infantry Division. The proposed food service system provides commanders with the necessary flexibility to establish field food service operations to meet a variety of tactical situations. Currently, food service operations are curtailed in an NBC environment.

1.3.2.2 Combat Feeding. During combat, the food service standard is to provide at least one hot meal per soldier per day (IAW FM 100-10). The Chief of Staff, Army, has stated the Army standard to be two hot meals per soldier per day. The remaining meals will be operational rations. When hot meals cannot be served due to heavy and/or moderate levels of commitment, the operational ration will be the primary ration used. Commanders have the capability of serving hot meals to the maximum number of troops because of the organic food service equipment authorized, variety of rations available, and food service personnel staffing. All divisional units will be issued the MKT and units in Corps and Theater with a need for high mobility will be issued the MKT. Other units in Corps and Theater will be issued the MFK. MKTs and MFKs are designed to use disposable eating ware. The disposable eating ware will be prepackaged and shipped with the unitized rations (B or T Rations). A Consolidated Field Kitchen (CFK) is established when a sufficient number of units/personnel are located within a reasonable distance from each other, the level of commitment is low or the commander determines consolidation is advantageous. As a minimum, the Consolidated Field Kitchen will consist of two MKTs or two MFKs and a Sanitation Center. This configuration can support a maximum of 700-800 personnel. Troops unable to come to the CFK will be fed by use of the KCLFF or insulated food carriers, whichever is more practical. Disposable eating ware is the primary eating ware, but the CFK has full sanitation capabilities to clean permanent ware. The KCLFF is designed to support Light Infantry Division company-sized units (combat/combat support/combat service support) where centralized field feeding is not available. The KCLFF is a battalion asset which moves forward from battalion to support company size units. It then returns to battalion to pick up supplies and be assigned another feeding mission. Companies will then have the capability of heating and serving T Ration meals and be supplied with remote food carriers for sending hot T Ration meals to dispersed squad-sized elements. The company T Ration operations will use disposable eating and serving utensils. The disposables will be prepackaged and shipped with unitized T Ration. The back-up rations will be the Meal-Ready-to-Eat (MRE). Insulated beverage containers will be available for beverage preparation and serving. One KCLFF will support up to 200 personnel with one cook authorized. It is envisioned that upon mobilization, companies may deploy with the KCLFF set up to heat and serve T Ration meals when possible. Upon the commander's decision that full field feeding operations can begin, the full complement of food service personnel and equipment will be deployed. When the full complement arrives, battalion-consolidated field feeding operations supporting T Rations can start and the KCLFF returned to the battalion field kitchen. Remote feeding operations will continue as required.

1.3.2.3 Light Infantry Division. The system/method of field feeding light divisions is contained in the approved Operational and Organizational (O&O) Plan dated 27 February 1985 which identifies the food service personnel needed and the field feeding equipment required. This division is structured to feed operational and tray pack rations. The field feeding of light divisions is based on consolidation of food service personnel and equipment in the headquarters company/element of the supported battalions/units. The light division is designed to be primarily deployed by air. Due to equipment limitations and operational scenarios, the light divisions may only deploy with KCLFFs which are capable of supporting up to 200 soldiers eating T Rations and operated by one cook per KCLFF. When the commander authorizes and transportation is available, the remaining field feeding equipment and food service personnel will be deployed to start battalion consolidated field feeding operations.

a. The consolidated teams will be under the command of the HHC Commander with the following capabilities:

- Each battalion food service section will be capable of employing at least one consolidated field kitchen.
- The food service teams will prepare and serve T Rations meals for consumption at the preparation site.
- Teams will prepare T Rations meals for personnel at other locations; however, the pick up, delivery, serving, and return of remote food carriers will be the responsibility of personnel other than cooks as directed by the battalion commander.
- If required, battalion food service personnel can be deployed with a KCLFF to support company-level T Rations feeding.

b. The food service personnel requirements are:

- Staffing levels will permit the preparation of two hot T Ration meals per day. Augmentation will be required to support ingredient-type rations preparations or a ration policy of more than two hot meals a day.

- Total food service personnel required to support a light division (10,700 troop strength) is 229.

c. The food service field feeding equipment for a Light Infantry Division includes the following:

- Mobile Kitchen Trailers (MKT) - 46
- Sanitation Centers - 46
- Kitchen Company Level Field Feeding (KCLFF) - 90

1.4 TEST OBJECTIVES. The test objectives to be addressed by the Combat Field Feeding System, Force Development Test and Evaluation (CFFS-FDTE) are listed below.

1.4.1 Objective 1. To obtain data which describes the capability of the CFFS to operate according to the current O&O Plan.

1.4.2 Objective 2. To obtain data on the nutritional adequacy of the proposed rations.

1.4.3 Objective 3. To obtain data on the acceptability and effect on morale and unit cohesion of the proposed rations.

1.5 SCOPE AND TACTICAL CONTEXT.

1.5.1 Scope. The test will be conducted during a 12-week period and will consist of three phases. Phase I will consist of four weeks of training the food service operators, supervisors, and data collectors. It will include a pilot test and will culminate with the issuance of the Test Readiness Statement (TRS). Phase II will consist of a 21-day field training exercise conducted by the 25th Infantry Division Artillery. One battalion will be fed one hot T Ration and two MREs per day and another will be fed two hot T Rations and one MRE per day. A third battalion will be fed two hot A Rations and one MRE per day. A Combat Support (CS) Company will be fed two hot B Rations and one MRE per day. A Combat Service Support (CSS) Company (with assigned females) will be fed one hot T Rations and two MREs per day. During this phase, data will be collected to answer the issues concerning both the O&O Plan for the CFFS and the health and welfare of the troops. Phase III will continue the investigation of the health and welfare issues and will last from T+22 to T+47. During this phase, the unit size will be reduced to four batteries from the three battalions, the CSS company, and the CS company. All units will continue to be fed the same rations mix as in Phase II. One of the batteries from the two T Rations Battalion will have its T Rations augmented with enhancements from B and A Rations. All data for the test will be collected manually. Quantitative data will be collected on caloric and nutritional intake, body weight, fluid intake, hydration status, nutritional status, muscle strength, muscle endurance, food and water temperatures, times to operate equipment and prepare meals, waste, and amount of water and fuel required and consumed. Qualitative data will be collected on safety, human factors, food acceptability, ease of operations, health and welfare of troops, unit cohesion and morale, and staffing levels.

1.5.2 **Tactical Context.** The units participating in the test will conduct operations consistent with the Army Training and Evaluation Program (ARTEP) missions and tasks. Tactical scenarios and meal serving times will be at the discretion of the commander, but will be conducted using a rations cycle jointly prepared and agreed upon by the proponent, player unit, and tester prior to the start of testing. Data for the evaluation of the O&O Plan will be collected on a 24 hour basis. Data collectors will monitor food service operations at the brigade support area, battalion and company. Data for evaluation of the medical issues require 40 volunteer test subjects from each rations group. Test subjects will be monitored periodically for their dietary intake, caloric and nutritional intake, body weight and composition changes, hydration and physical performance. Test subjects will be required to provide urine samples weekly and blood samples four times during the test period. General healthand well being as well as morale and unit cohesion data will be collected weekly. During Phases II and III, unit activity will be scheduled to provide as uniform an activity level as possible.

1.6 TEST LIMITATIONS. This test will be conducted on a limited interference basis with a DIVARTY FTX. Data from this test will be collected and recorded by manual means. Much of the collected data will be based on the subjective opinions of the unit commanders, player personnel, or the evaluators. It should be noted that unlike units are participating in this test and are providing test volunteer groups for detailed data collection. In evaluating the capability of the CFFS to support the Light Infantry Division, light Infantry units would have provided the optimum test groups. Due to the size unit required, the desire for a remote area of operation, and major unit training schedules, the use of infantry units was not feasible. This is not a test of the entire CFFS, since only selected items of the CFFS will be evaluated. The need for data collection efforts to be conducted on a limited interference basis limits the ability to monitor food and fluid comsumption. It will be necessary to rely on self reported rather than observed data and on data collector estimates of quantities consumed rather than weighed values of foods served and leftovers. FTX requirements necessitate use of field feasible measures for evaluation of medical parameters including the use of skinfold and circumference measures for body composition and the use of overnight rather than 24-hour urine collections. A compressed time frame for the sustained feeding study necessitates data extrapolation. Ideally, troops would consume rations as the sole source of nutrition under field conditions for a 90-day period. Finally, no attempt will be made to simulate an actual combat environment beyond the level of realism furnished by the FTX itself. Field training exercises, such as the one to which this test is attached will be a basic component of military life in the new Infantry Division (Light), and therefore the ability of the CFFS to sustain troop health and morale during such field exercises is of considerable interest.

1.7 MAJOR TEST MILESTONES. The major milestones of the CFFS-FDTE as currently scheduled are as follows:

- Briefing TDP to major commanders 3 - 7 June.
- Training Phase (Phase I) 9 July - 2 August.

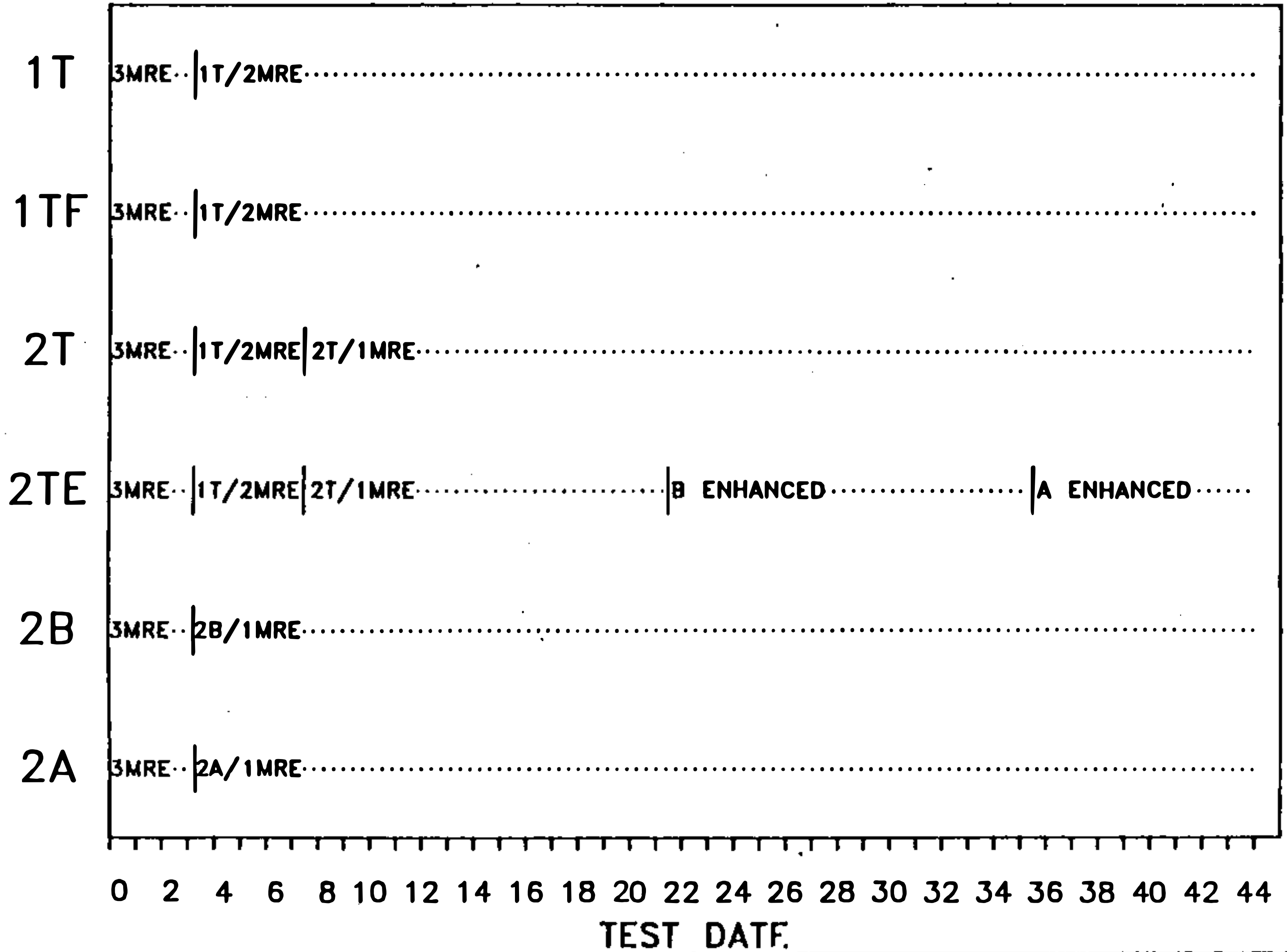
- Deployment to Training/Test Site 5 - 8 August.
- DIVARTY FTX (Phase II) 9 - 31 August.
- Company/Battery Training (Phase III) 29 August - 27 September.
- Final Report February 1986.

APPENDIX B

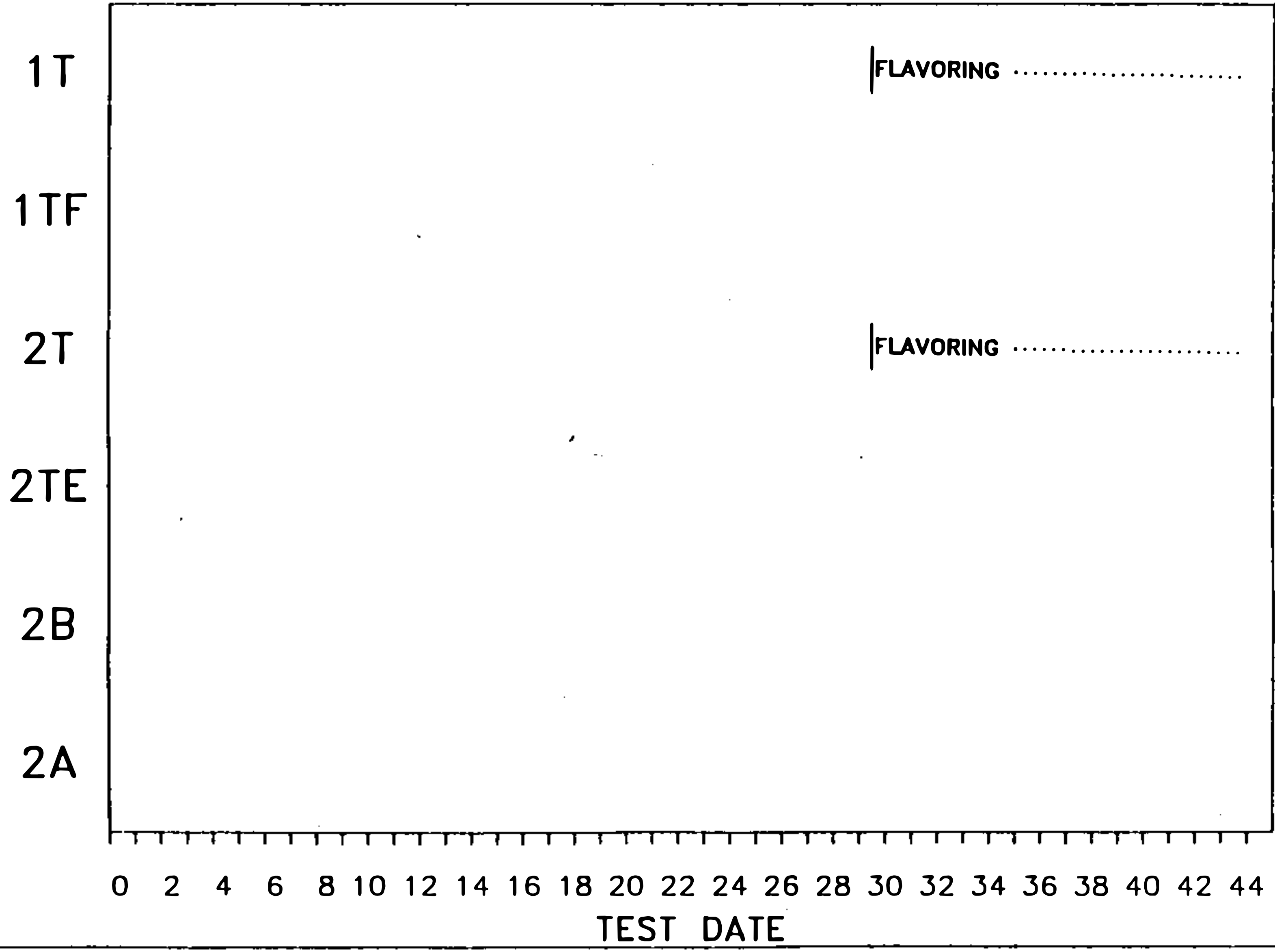
FOOD, BEVERAGE, AND ACTIVITY SCHEDULE

1. Ration schedule
2. Water flavoring schedule
3. Milk schedule
4. Ice schedule
5. Training schedule

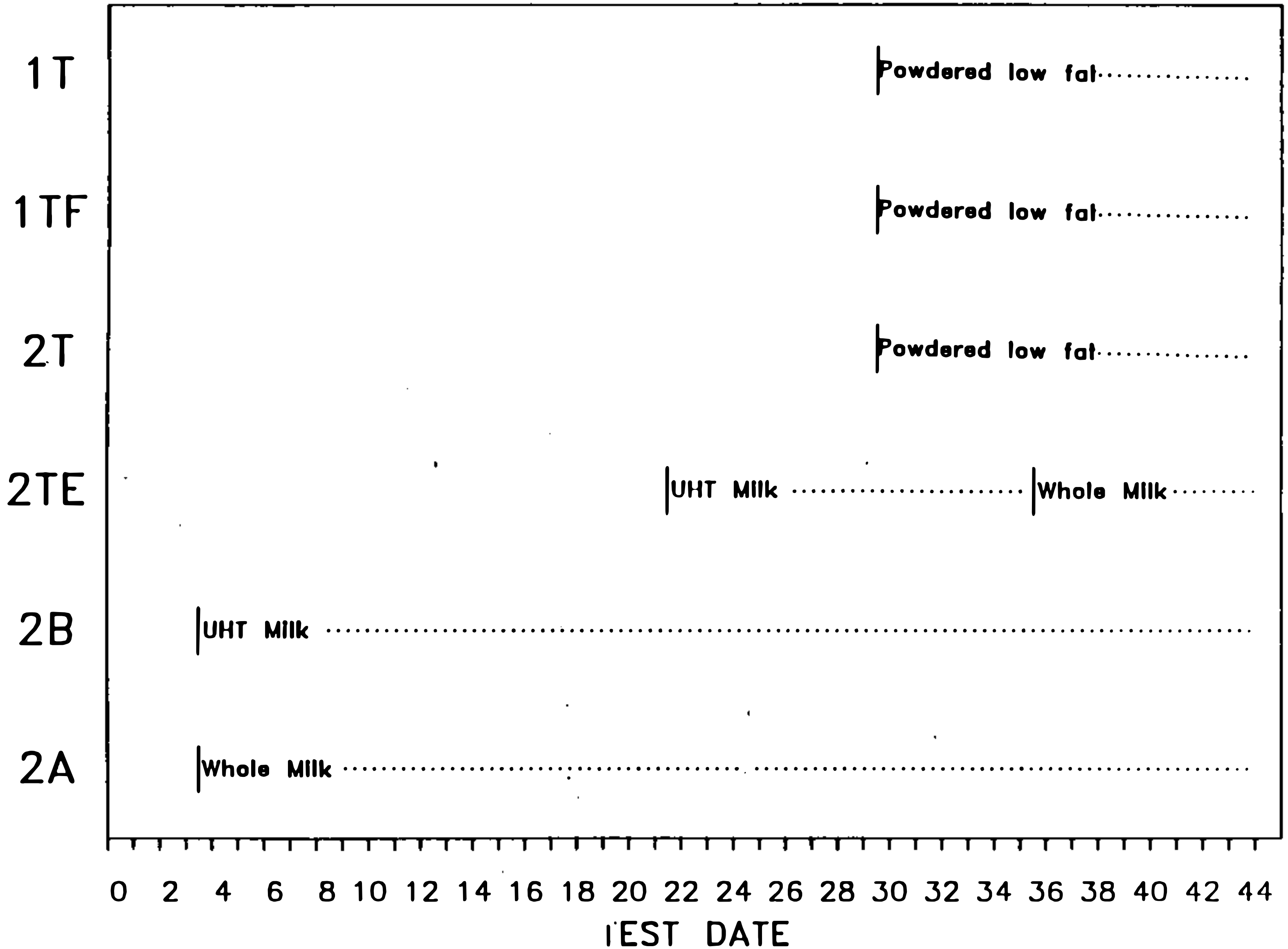
RATION SCHEDULE



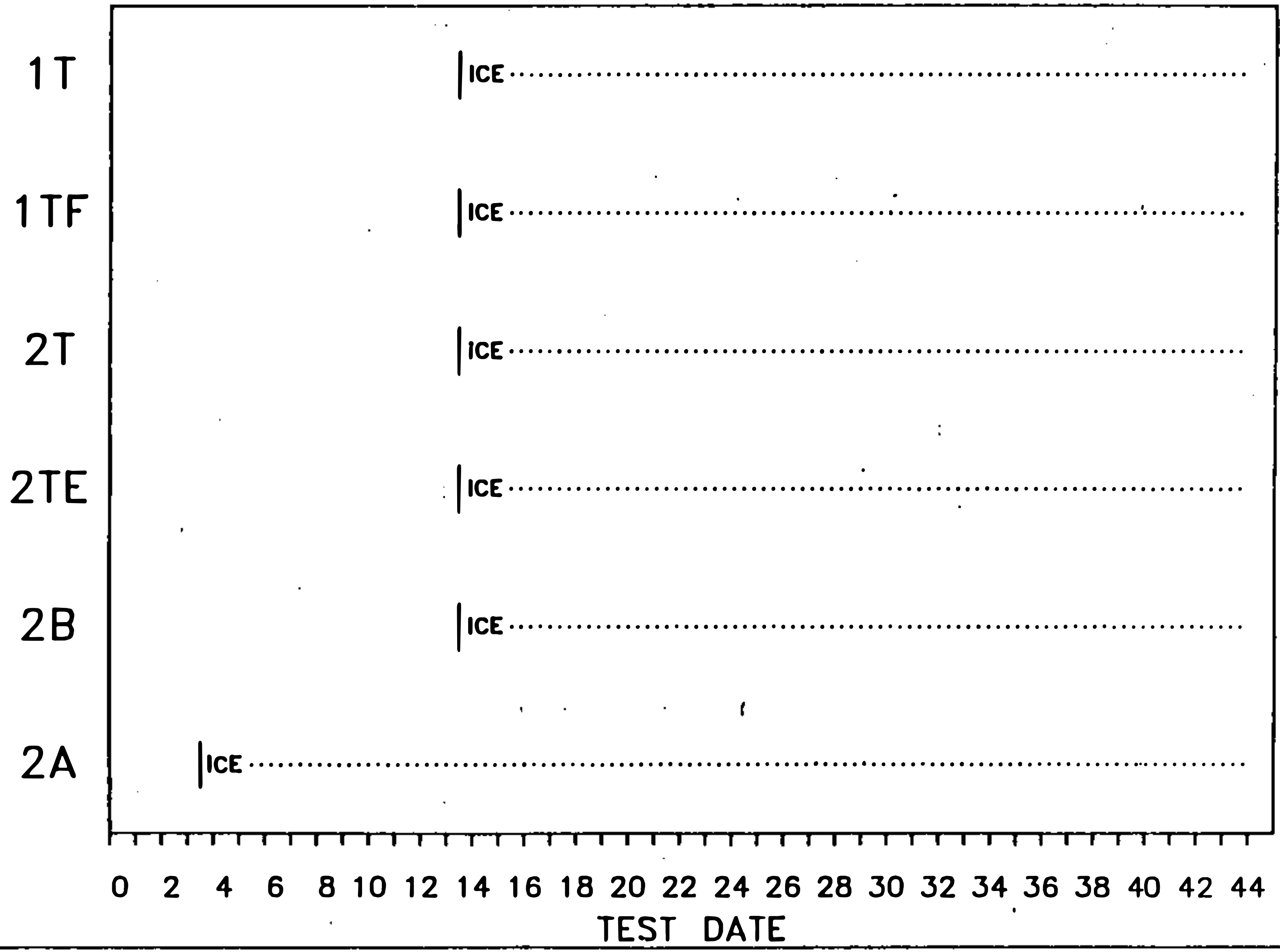
WATER FLAVORING SCHEDULE



MILK SCHEDULE



ICE SCHEDULE



APPENDIX C

NUTRITION ISSUES, CRITERIA, METHODS, AND INVESTIGATORS' PROPOSED CONCLUSIONS

ISSUE 2.1 Will troops eat a sufficient quantity of CFFS rations (T, B, and A rations and MREs) over an extended period (42-49 days) to meet the Surgeon General's Military Recommended Dietary Allowances (MRDAs) for protein, vitamins, minerals, fat, and energy?

CRITERIA

The average daily energy, protein, fat, vitamin, and mineral intake of a platoon or larger unit should meet all the MRDAs, as listed in Appendix E.

METHODS

Food consumption was estimated in the field by trained data collectors, who used a combination of observation, interview, and self-reporting techniques (see Appendix M for details). Nutritional adequacy of each feeding regimen was determined by multiplying the estimated food consumption by the nutrient composition of the ration component and comparing the product with the MRDAs for selected nutrients. Nutrient values for A and B rations were determined from handbook values and information on total recipe nutrients. MRE composition was determined from chemical analysis performed approximately 3 years ago on a similar lot. Data on T ration were obtained from chemical analysis and handbook-derived values.

PROPOSED CONCLUSIONS

The MRDAs for protein, vitamin A, ascorbic acid, thiamin, riboflavin, niacin, vitamin B_6, and phosphorus were met in all six test groups (see Appendix D).

The daily energy intakes averaged over the entire study were less than the lower limit of the MRDA range for all groups except Group 2A. However, all groups maintained their body weight within narrow limits ($\pm$ 3%).

The MRDAs for fat, iron, and calcium were met in all test groups except as noted:

- The MRDA maximum for fat intake (35% of total calories) was consistently exceeded in Group 2A.

- The MRDA for iron (18 mg) was consistently not attained in Group 1TF. However, iron intake by this group can probably be considered adequate, on the basis of evidence that ascorbic acid and the heme iron content of the diet are high, thus increasing the bioavailability of iron.

- The MRDA minimum for calcium (800 mg) was consistently met only in the groups consuming milk (Groups 2A and 2B) and the "enhanced" T-ration group (Group 2TE) when they were receiving milk. The deficit in calcium was particularly striking in the women (Group 1TF).

- The MRDA maximum for sodium (1,700 mg/1,000 kcal) was exceeded in all groups.

In accordance with the original study design, the MRDAs for vitamin D, vitamin E, folacin, vitamin B_{12}, magnesium, zinc, iodine, and copper were not evaluated.

ISSUE 2.2 Will troops subsisting on CFFS rations over an extended period (42-49 days) consume sufficient calories to meet energy demands associated with extended field operations?

CRITERIA

With compensation for dehydration, the average body-weight loss or gain of a platoon or large unit of physically fit soldiers should not exceed 3% of initial body weight at any time during the study.

METHODS

Body weights of volunteer subjects were measured at the start, at regular intervals, and at the end of the study. Methods used to determine adequacy of hydration status are described in the discussion of Issue 2.3.

PROPOSED CONCLUSIONS

None of the diet groups had a mean body-weight change that exceeded 3% of initial body weight at any time during the study (Appendix I). However, with the possible exception of Group 1T, energy intake of the groups when they were fed three MREs per day was too low (2,200-2,300 kcal/day) to maintain body weight of men. The data are consistent with those of an earlier study on prolonged feeding of the MRE.

The group with the lowest incidences of individual weight loss more than 3%, 5%, or 7.5% of initial body weight was Group 2A, which also consumed the most calories.

It must be noted that, during this test, the estimated energy expenditure of the men was low to moderate (3,000-3,200 kcal/day). It is not known whether soldiers with higher (3,600-4,000 kcal/day) energy expenditures (walking infantry carrying heavy packs) will consume more of the rations in question to enable them to maintain their body weights and muscle glycogen stores.

ISSUE 2.3 Will troops subsisting on CFFS rations drink sufficient fluids and water to maintain hydration status?

CRITERIA

The average urine specific gravity (SG) of a platoon or larger unit should not exceed a group average of 1.030 at any time. Samples exceeding this value are indicative of inadequate hydration.

METHODS

Adequacy of hydration was evaluated by monitoring appropriate indexes in the blood, plasma, and urine; by assessing morning-to-afternoon body-weight changes; and by measuring water and other fluid consumption. In addition, overnight urine samples were collected by the test subjects nine times during the study and quantitatively analyzed for SG, creatinine, sodium, potassium, and (by Multistix analysis) pH, protein, glucose, ketones, bilirubin, nitrates, urobilinogen, and ascorbic acid.

PROPOSED CONCLUSIONS

Urine SG on the average did not exceed 1.030 at any time (Appendix J). However, the data demonstrate a ration effect on hydration, as measured by urine SG, even in this temperate environment with low to moderate physical activity.

- At Schofield Barracks (pretest), only 6-18% of the soldiers had concentrated urine.

- The incidence of concentrated urine (SG greater than 1.030) among males was greatest (40%-60% of subjects) on study day 3, when all test groups had consumed three MREs per day for at least 2 consecutive days.

- On study day 7, the incidence of concentrated urine in Groups 2A and 2B immediately dropped to less than 20% and remained at or below that point for the remainder of the study. Both groups had been eating two hot meals and one MRE per day since study day 4.

- In contrast, the incidence of concentrated urine remained high on day 7 for Groups 1T, 2T, 2TE, and 1TF, which had all been eating one T ration and two MREs since day 4.

- The incidence of concentrated urine for groups 1T, 2T, and 2TE did not generally fall below 20% until after day 20.

- Individual canteen water flavorings were provided to Groups 1T and 2T on study day 30. No discernible differences in total daily water consumption or hydration status could be directly attributed to the water flavorings. The lack of effect might have been due both to the moderate ambient temperature and to the fact that the high incidence of concentrated urine occurred early in the study.

- The female group (Group 1TF) also had a high incidence (25-30%) of concentrated urine early in the study, with marked improvement on study day 13 and thereafter.

These data suggest that feeding three MREs per day might contribute to the problem of voluntary dehydration during initial deployment, even in a temperate environment. The T ration as tested was not as effective as the A or B ration in alleviating this problem. The use of individual canteen flavorings warrants further study in various climates.

ISSUE 2.4 Will troops subsisting on CFFS rations over an extended period (42-49 days) maintain their nutritional status?

CRITERIA

The biochemical indicators of nutritional deficiency in each volunteer will be compared with the criteria listed in Appendix F.

METHODS

Appropriate biochemical indexes in blood, serum, and plasma were measured. Standard anthropometric measurements--including height and weight, skinfold thicknesses, upper arm length, elbow diameter, and circumferences of chest, abdomen, and upper arm--were made.

PROPOSED CONCLUSIONS

o The vitamin A criterion was met. Essentially all subjects had serum retinol concentrations in the acceptable range.

o The vitamin C criterion was probably met. Serum ascorbate data are unreliable, because of failure to stabilize the samples before analysis. However, mean vitamin C intake was approximately twice the MRDA, according to nutrient analysis of rations as described (p. C-1).

o The thiamin criterion was probably met. Data on erythrocyte transketolase are not available, because the contractor did not perform the requested analysis; however, thiamin intake was 2-3 times the MRDA.

o The riboflavin standard was probably met. Data on erythrocyte glutathione reductase FAD effect were not provided, because the contractor did not have the capability to perform the requested analysis. The criterion of riboflavin intake was probably met, but intake did not greatly exceed the MRDA.

o The folate acid criterion was met. All groups met the recently recommended (NHANES Expert Group) criterion for plasma folate (3.0 ng/ml). The mean values did not significantly change during the study. Approximately 10-20% of test groups had plasma folacin concentrations below 3.0 ng/ml--a finding similar to that in healthy young adults in the recent NHANES survey.

o Final interpretation of iron status awaits receipt of transferrin saturation values from the contractor. On the basis of the available hemoglobin, hematocrit, plasma ferritin, and erythrocyte protoporphyrin data, it is reasonable to conclude that the iron criterion was met and that iron status did not decrease over time. All values for erythrocyte protoporphyrin were in the acceptable range, as were the mean serum ferritin values for both men and women. As expected, some of the females (4-21%) had low plasma ferritin, but the incidence did not increase during the study.

o Group 2A had increases in total cholesterol and LDL, a decrease in HDL, and an increase in cholesterol:HDL ratio. The fat and presumably cholesterol consumption of this group was higher than that of all other test groups. There was a general trend in all groups for HDL cholesterol to decrease with time in the study, possible because of a decrease in running activity during the training exercise.

o All groups maintained fat-free body mass throughout the study, as determined by the circumference technique in men and by the skinfold caliper technique and the Durnin and Womersley equation in women. The mean body-fat stores decreased slightly with time in all groups, but this was not interpreted as an undesirable response, in light of the adequate body-fat stores at the beginning of the study.

ISSUE 2.5 What is the incidence of food-related health disorders in troops subsisting on CFFS rations over an extended period (42-49 days)?

CRITERIA

The incidence of gastrointestinal or other food-related disorders is investigative.

METHODS

Maintenance of health and well-being was evaluated with an environmental systems questionnaire (ESQ) and the monitoring of sick-call records.

PROPOSED CONCLUSIONS

The incidence of health-related disorders requiring medical attention was very low in all test groups. Workdays lost because of gastrointestinal disorders were noted as follows: by all test subjects, 1.6 per 1,000 person-days; by female subjects, 3.7 per 1,000 person-days; and by male subjects, 1.1 per 1,000 person-days. Female subjects reported more gastrointestinal complaints than male subjects. Group 2T reported the highest incidence of gastrointestinal complaints, and those in Group 2A reported the lowest incidence.

Although more minor complaints of gastrointestinal problems (gas pressure and stomachache) were reported in the groups fed T rations, very few workdays were lost. The higher overall incidence of complaints and sick-call visits reported by female soldiers than male soldiers is consistent with results of numerous other studies regarding food-related or non-food-related symptoms.

ISSUE 2.6 Will troops subsisting on CFFS rations over an extended period (42-49 days) maintain muscle strength and muscular endurance?

CRITERIA

Average muscle strength and muscular endurance must not decrease by more than 10% from the initial prestudy results.

METHODS

Adequacy of muscle strength and muscular endurance was evaluated with measures of handgrip strength and endurance, upright pull, and incremental dynamic lift. Eye-hand coordination was evaluated with the arm-hand steadiness test and the ball-pipe test.

PROPOSED CONCLUSIONS

Muscle strength, muscular endurance, and eye-hand coordination were maintained by the subjects in this study.

APPENDIX D*

MACRONUTRIENT AND MICRONUTRIENT INTAKE

1. Average Daily Nutrient Intakes:

   Sodium
   Potassium
   Calcium
   Phosphorus
   Iron

2. Average Daily Nutrient Intakes:

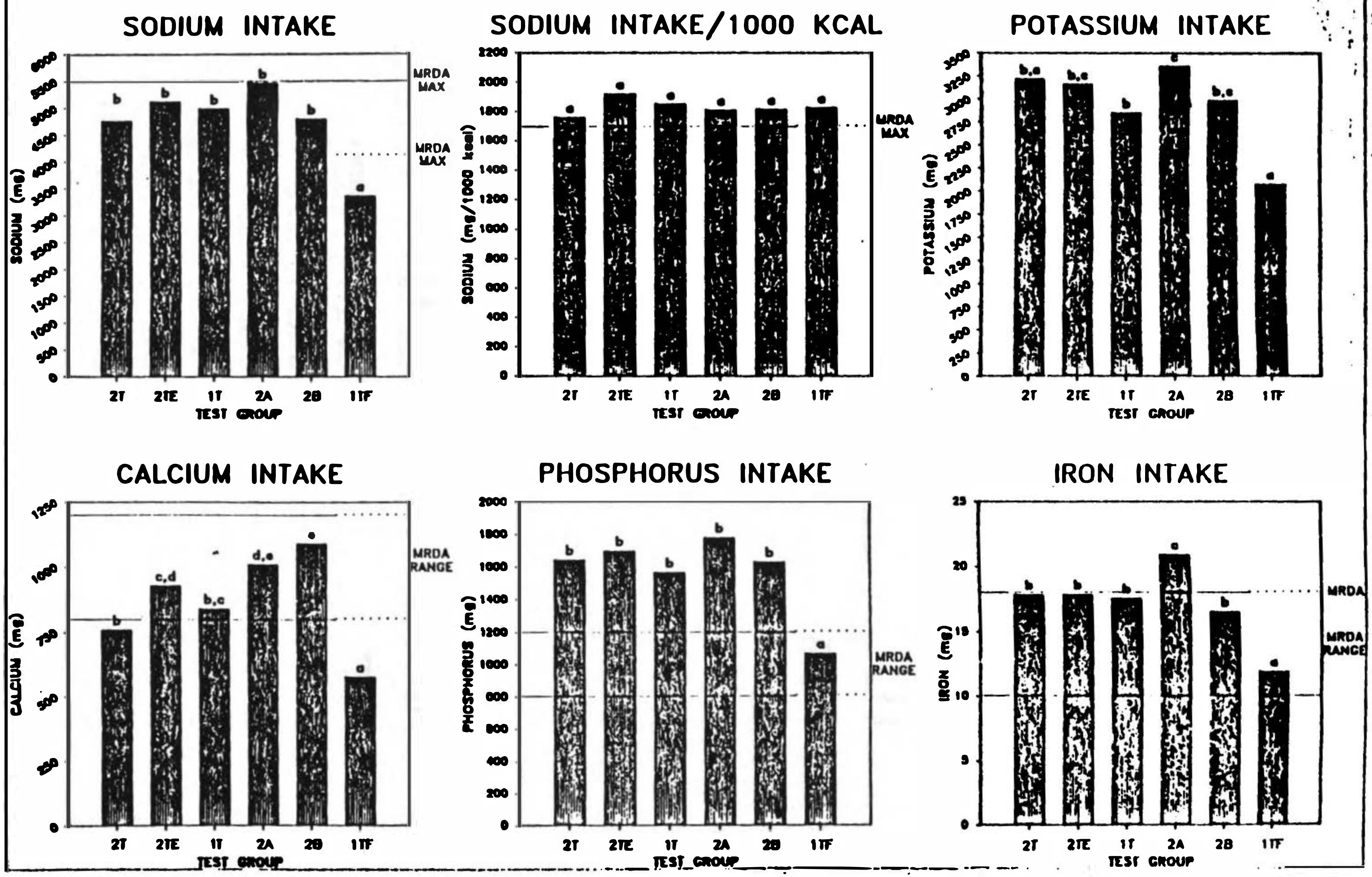
   Thiamin
   Riboflavin
   Niacin
   Vitamin B_6
   Vitamin A
   Vitamin C

3. Average Daily Nutrient Intakes:

   Energy
   Total fat
   Percent of kcals from fat
   Carbohydrate
   Percent of kcals from CHO

*Data provided by the Nutrition Research Task Force of USARIEM, Lt. Col. David Schnakenberg, Team Director and Director of Nutrition Research.

AVERAGE DAILY NUTRIENT INTAKES

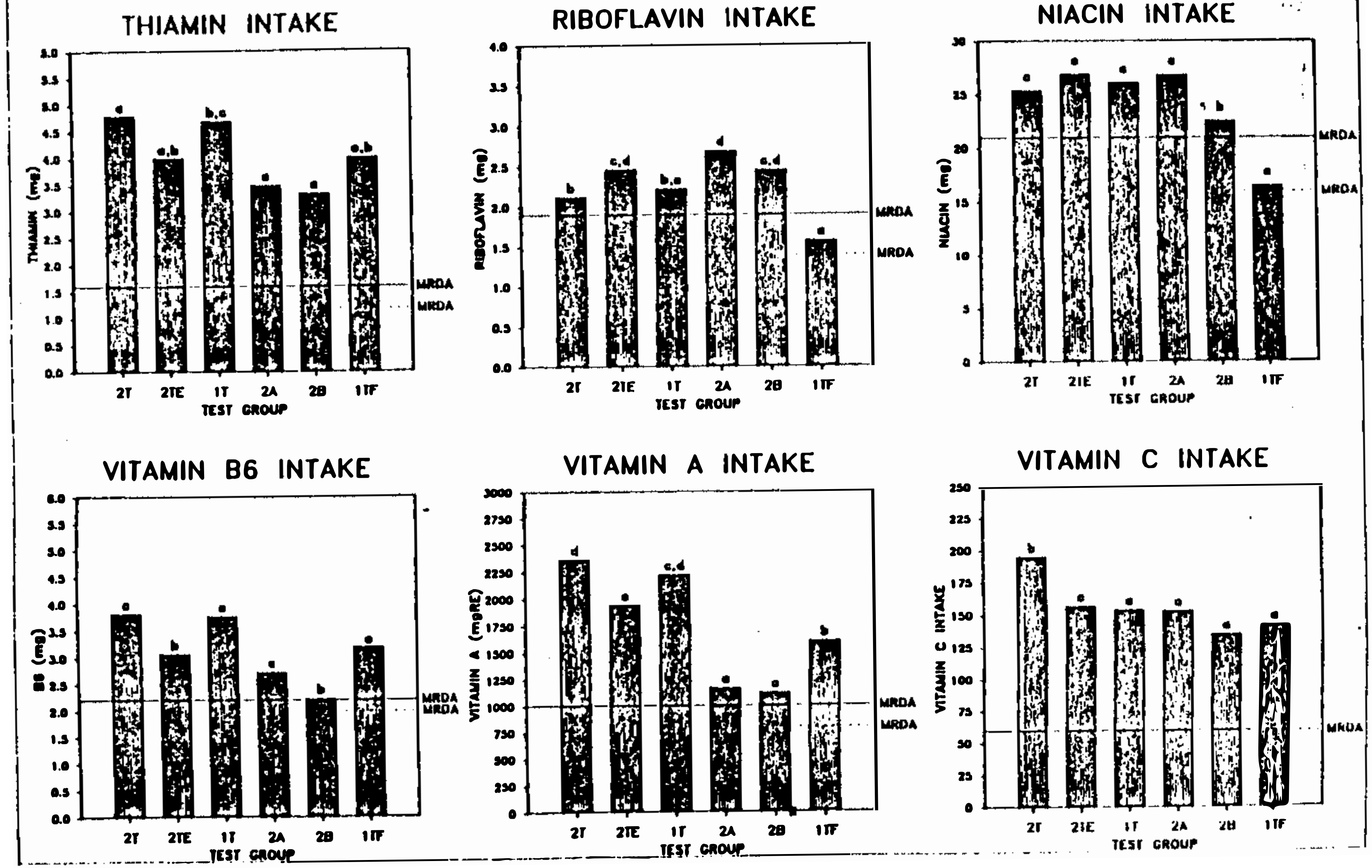


*Different letters indicate significant difference: p 0.05

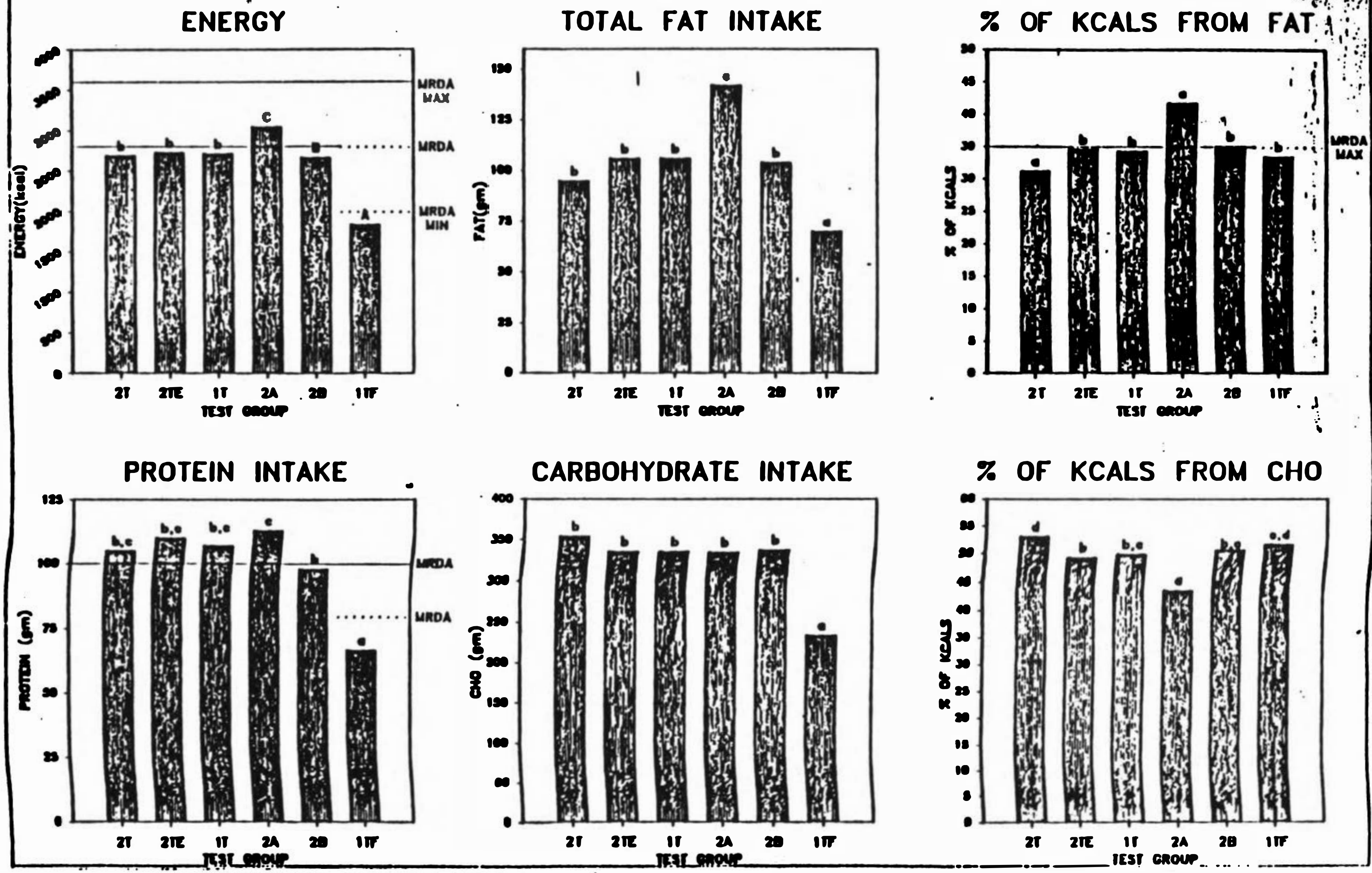
—— MRDA = female

------ MRDA = male

AVERAGE DAILY NUTRIENT INTAKES



AVERAGE DAILY NUTRIENT INTAKES



APPENDIX E

MRDAs FOR SELECTED NUTRIENTS

MRDAs FOR SELECTED NUTRIENTS[a]

Nutrient	Unit	Male	Female
Energy[b]	kcal	3,200 (2,800-3,600)	2,400 (2,000-2,800)
	MJ	13.4 (11.7-15.1)	10.0 (8.4-11.7)
Protein[c]	g	100	80
Vitamin A[d]	μg RE	1,000	800
Vitamin D[e,f]	μg	5-10	5-10
Vitamin E[g]	mg TE	10	8
Ascorbic acid	mg	60	60
Thiamin (B_1)	mg	1.6	1.2
Riboflavin (B_2)	mg	1.9	1.4
Niacin[h]	mg NE	21	16
Vitamin B^6	mg	2.2	2.0
Folacin	μg	400	400
Vitamin^{12}	μg	3.0	3.0
Calcium[f]	mg	800-1,200	800-1,200
Phosphorus[f]	mg	800-1,200	800-1,200
Magnesium[f]	mg	350-400	300
Iron[f]	mg	10-18	18
Zinc	mg	15	15
Iodine	μg	150	150
Sodium	mg	[i]	[i]

[a]MRDAs for moderately active military personnel, aged 17-50, are based on RDA, ninth revised edition, 1980.

[b]Energy allowance ranges are estimated to reflect the requirement of 70% of moderately active military production; 1 megajoule (MJ) = 239 kilocalories (kcal). Dietary fat calories should not contribute more than 35% total energy intake.

[c]Protein allowance is based on estimated protein requirement of 0.8 gram/kilogram (g/kg) of desirable body weight. According to reference body weight ranges for males of 60-79 kg and for females of 46-63 kg, protein requirement is approximately 48-64 g for males 37-51 g for females. These amounts have been approximately doubled to reflect usual protein consumption by Americans and to increase diet acceptability.

[d]One microgram of retinol equivalent (1 μg RE) = 1 μg of retinol, or 6 μg of beta-carotene, or 5 international units (5 IU).

[e]As cholecalcifernol; 10 μg of cholecalciferol = 400 IU of vitamin D.

[f]High values reflect greater vitamin D, calcium, phosphorus, magnesium, and iron requirements for 17- to 18-year-olds than for older people.

[g]One milligram of alpha-tocopherol equivalent (1 mg TE) = 1 mg of d-alpha-tocopherol.

[h]One milligram of niacin equivalent (1 mg NE) = 1 mg of niacin or 60 mg of dietary trytophan.

[i]Safe and adequate daily sodium intake of 1,100-3,300 mg published in RDA are currently impractical and unattainable within military food service systems. However, average of 1,700 mg of sodium per 1,000 kcal of food served is target for military food service systems. This equates to a daily sodium intake of approximately 5,500 mg for males and 4,100 mg for females.

APPENDIX F

STANDARD VALUES INDICATIVE OF NUTRITIONAL DEFICIENCIES

STANDARD VALUES INDICATIVE OF NUTRITIONAL DEFICIENCIES[a]

Item	Age/Sex Category	Deficient (High Risk)	Low (Medium Risk)	Acceptable (Low Risk)
Vitamin A: plasma retinol, μg/100 ml	All ages	>10	10-19	≥20
Vitamin C: serum ascorbic acid, mg/100 ml	All ages	<0.20	0.20-0.29	≥0.30
Thiamin RBC transketolase: TPP effect, TPP stimulation %	All ages	>20	16-20	0-15
Riboflavin RBC glutathione: reductase FAD effect (activity coefficient)	All ages	>1.40	1.20-1.40	<1.20
Folic acid: serum folacin, ng/ml	All ages	<3.0	3.0-5.9	≥6.0
Hemoglobin, g/100 ml	Adult males	<12.0	12.0-13.9	≥14.0
	Adult females	<10.0	10.0-11.9	≥12.0
Hematocrit, %	Adult males	<37	37-43	≥44
	Adult females	<37	31-37	≥38
Iron (3 measures used; deficiency = 2 of 3 abnormal):				
Transferrin saturation, %	All ages except infant	<15.0	15.0-19.9	≥20.0
	All adults	<16		≥16
Erythrocyte protoporphyrin, g/dL of RBC	15-74 years old	>70	--	<70
Serum ferritin, ng/ml	15-74 years old	<12	--	≥12

[a]Sauberlich, H.E., R.P. Dowdy, and J.H. Skala. Laboratory Tests for the Assessments of Nutritional Status. Cleveland, Ohio: CRC Press, 1974.

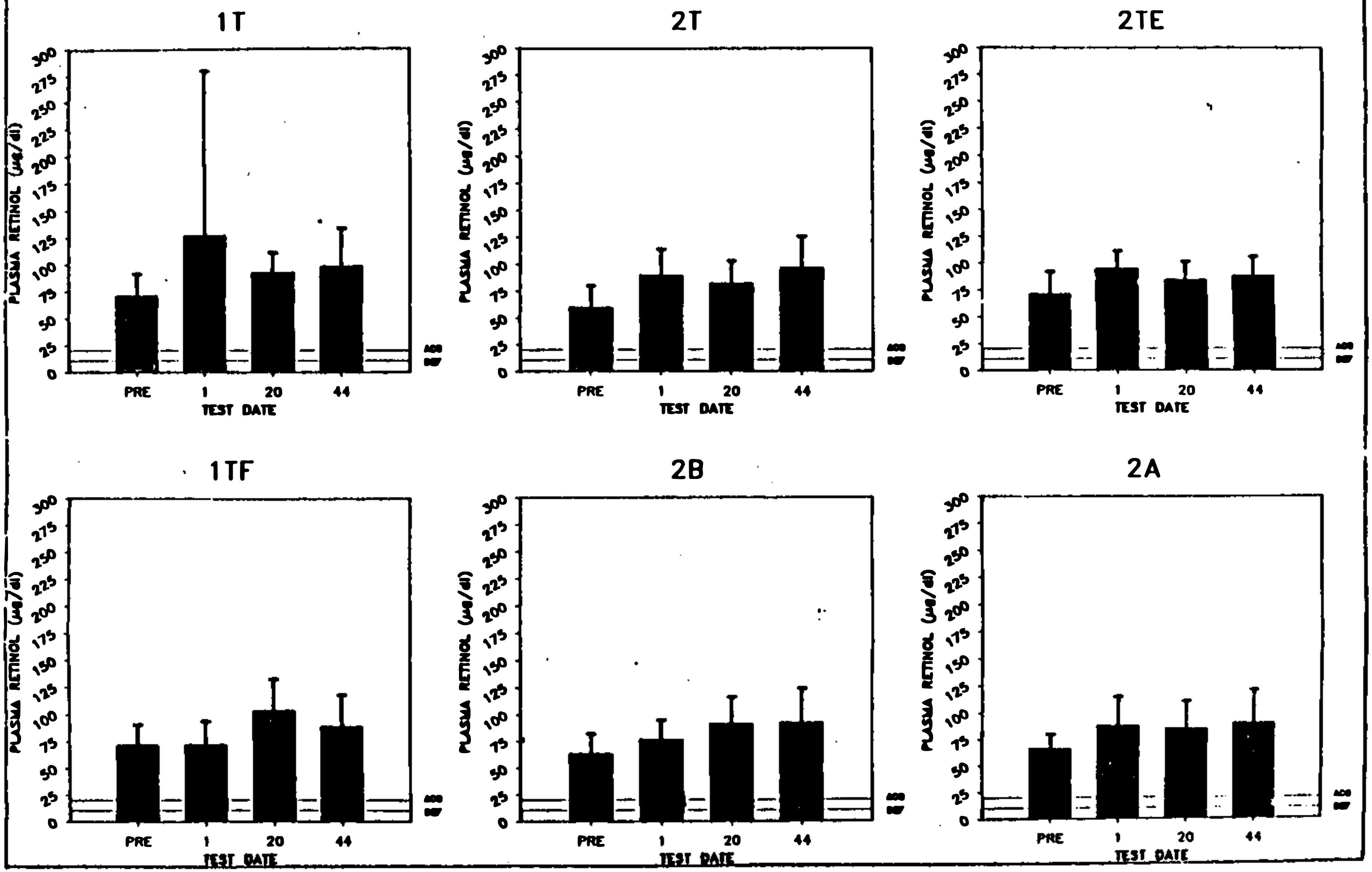
APPENDIX G*

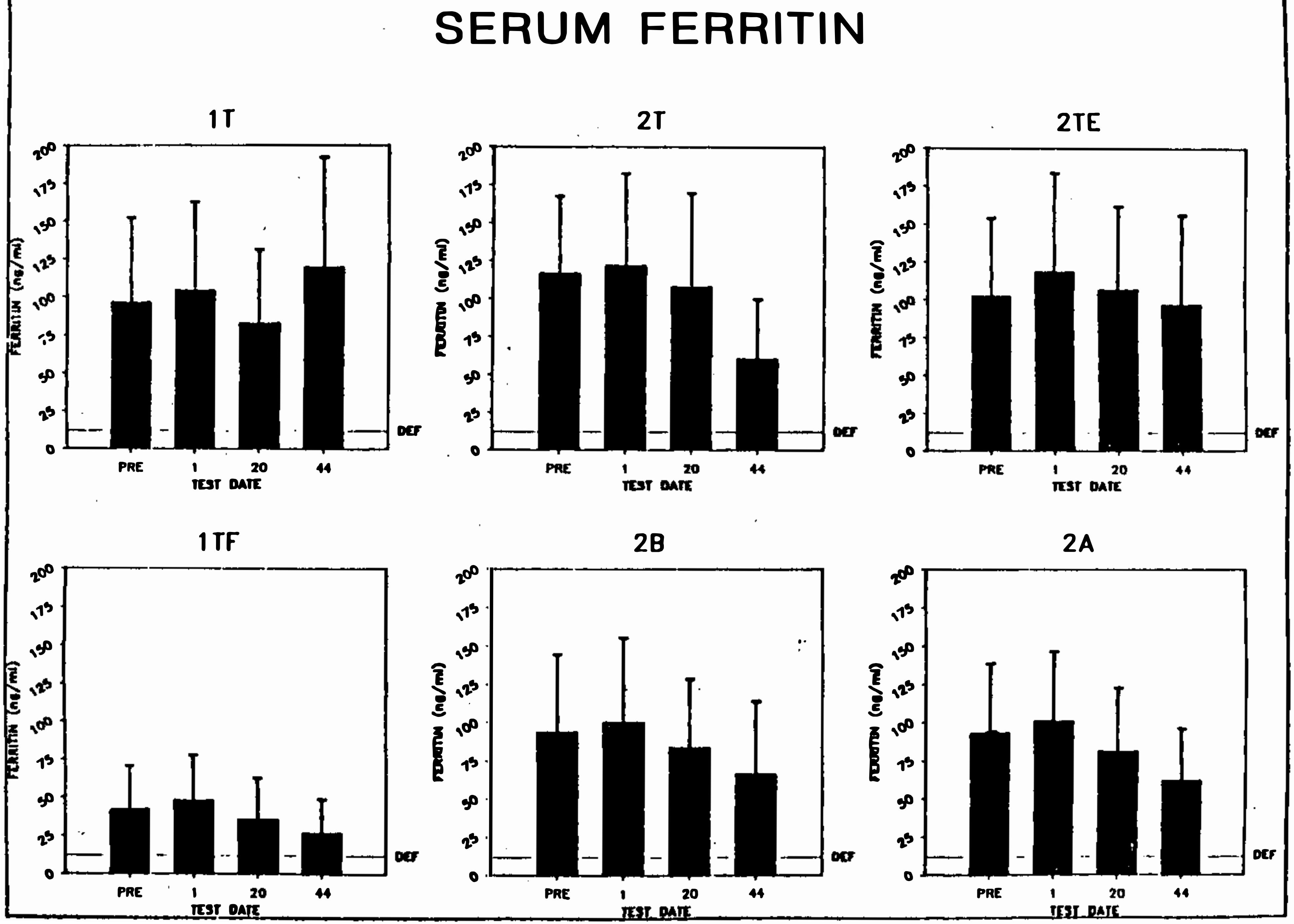
NUTRITIONAL STATUS INDICATORS

1. Serum vitamin A
2. Serum ferritin--absolute values
3. Serum ferritin--percent of population with deficient and acceptable values
4. Erythrocyte protoporphyrin
5. Serum folate--absolute values
6. Serum folate--percent of population with deficient and acceptable values
7. Serum cholesterol
8. Serum HDL cholesterol
9. Cholesterol/HDL
10. Serum LDL cholesterol
11. Serum triglycerides

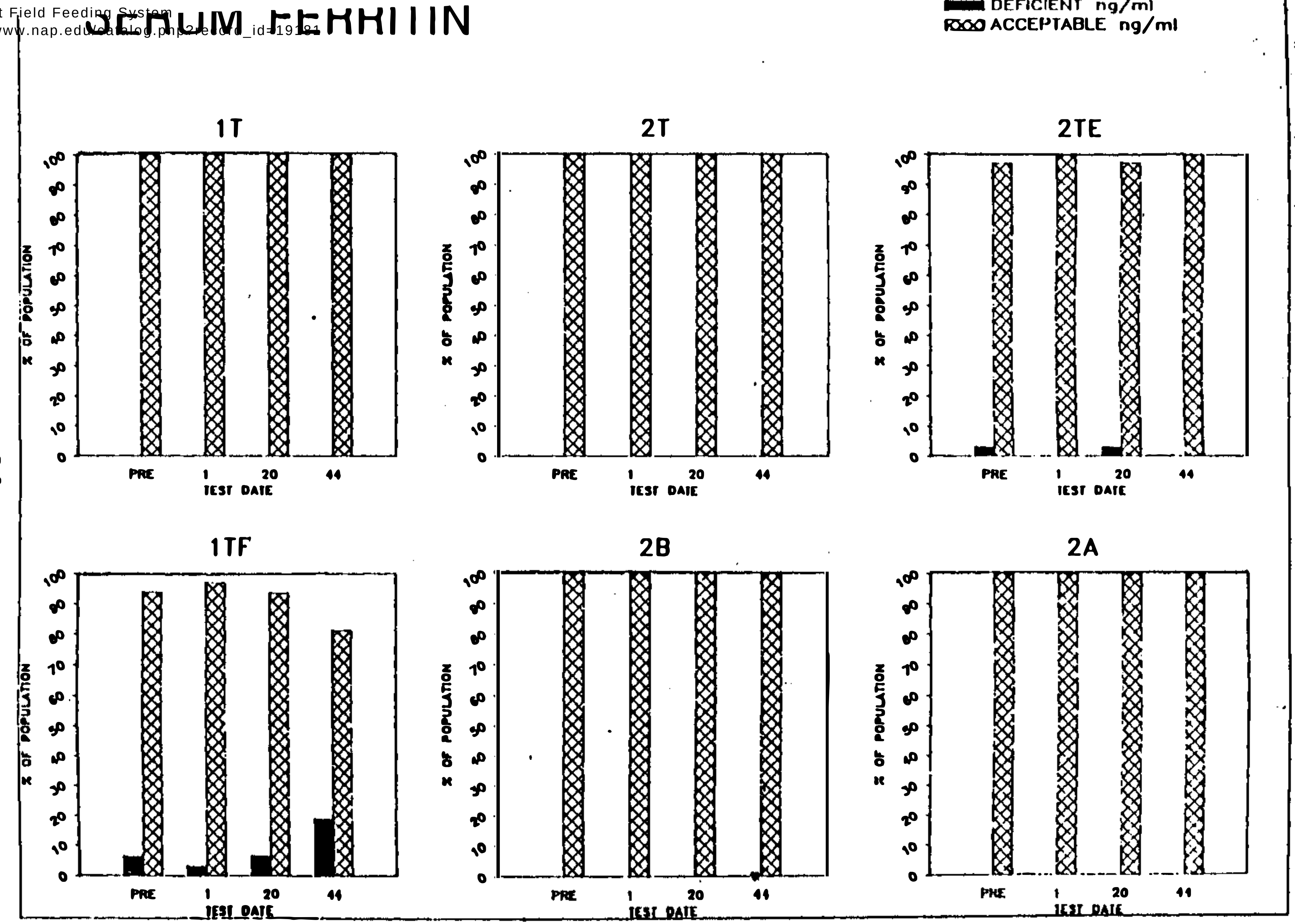
*Data provided by the Nutrition Research Task Force of USARIEM, Lt. Col. David Schnakenberg, Team Director and Director of Nutrition Research.

SERUM VITAMIN A

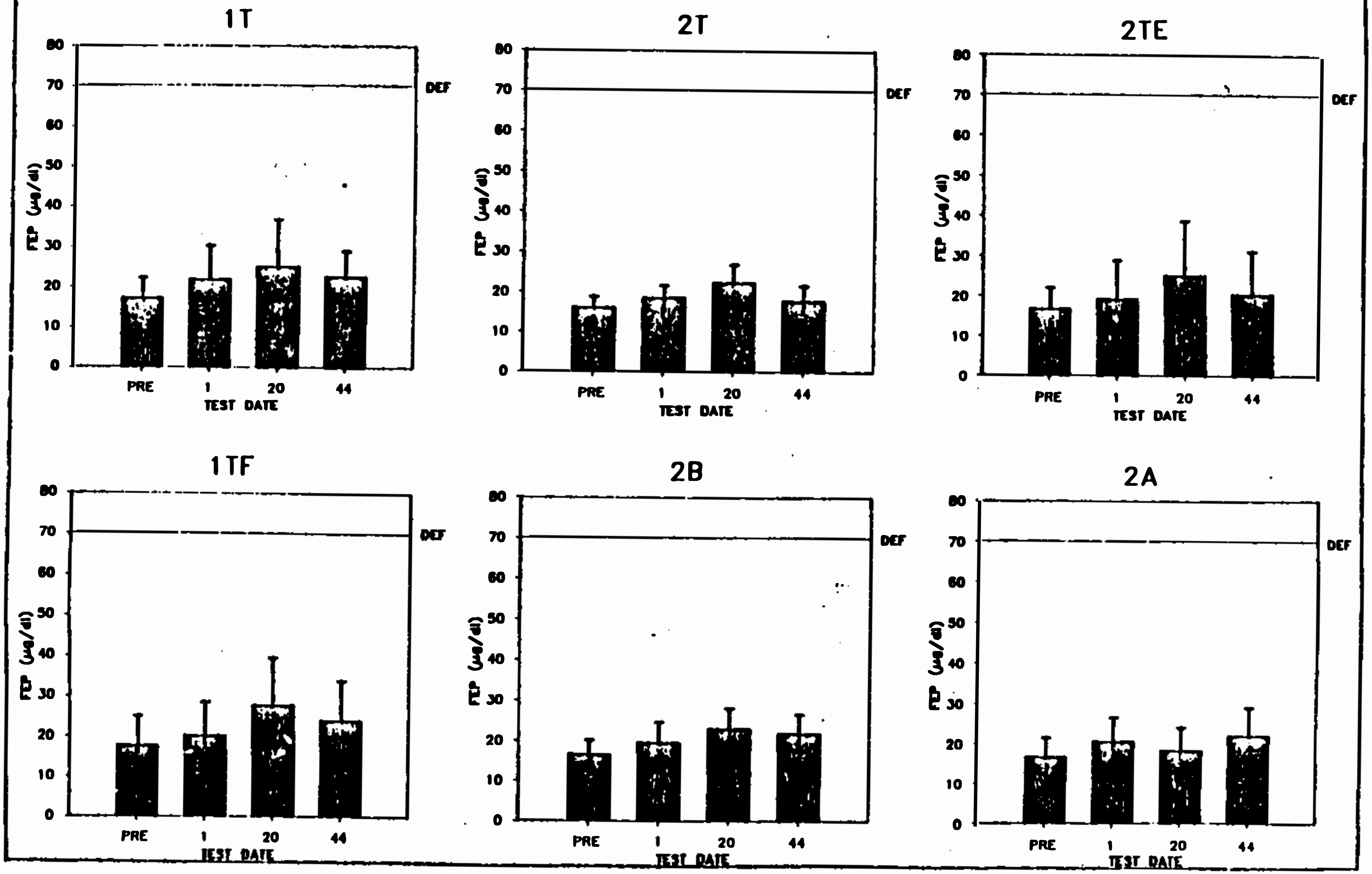



SERUM FERRITIN
1T
2T
2TE
1TF
2B
2A
FERRITIN (ng/ml)
0
25
50
75
100
125
150
175
200
DEF
PRE
1
20
44
TEST DATE

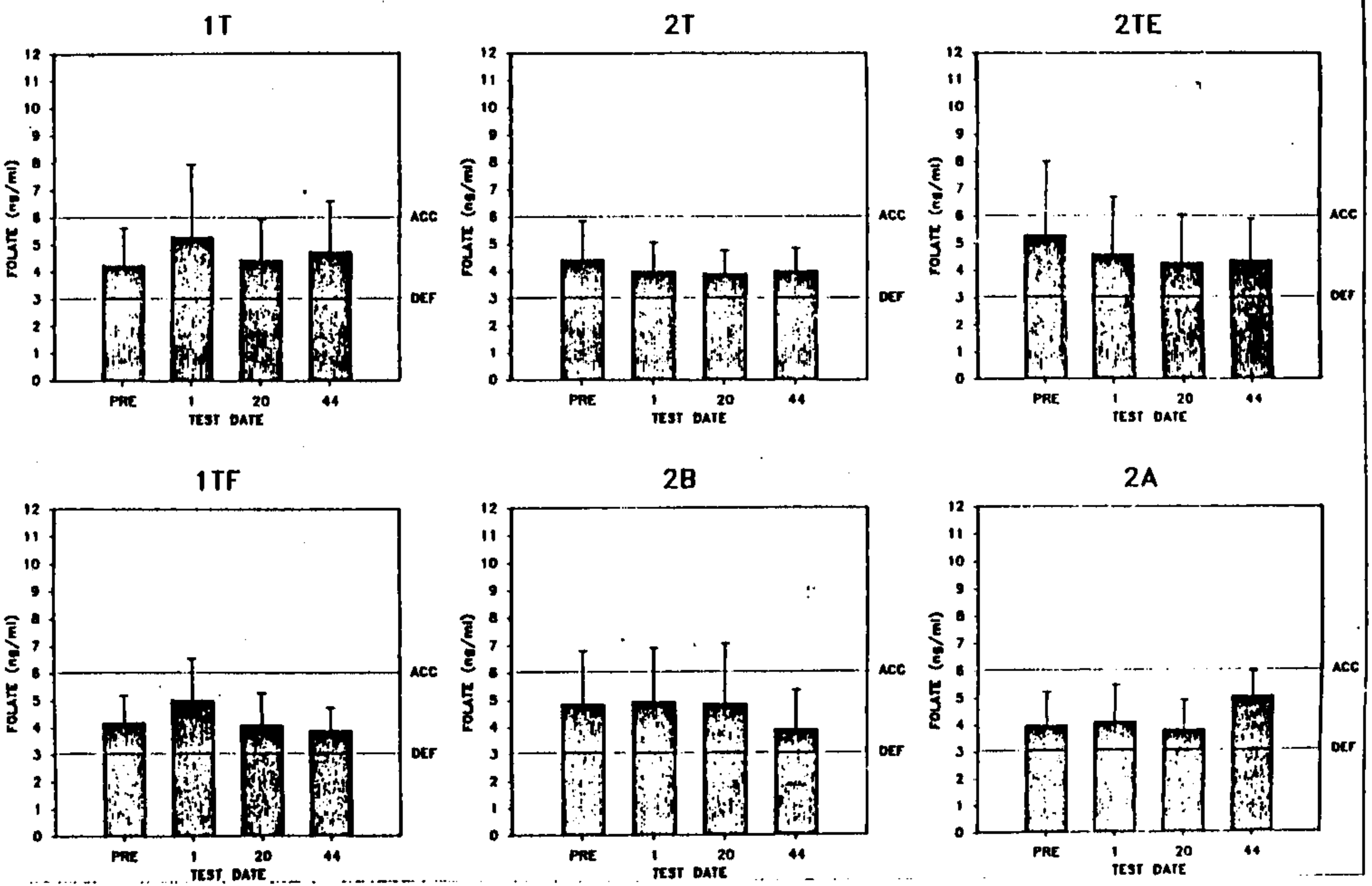
SERUM FERRITIN



SERUM FEP

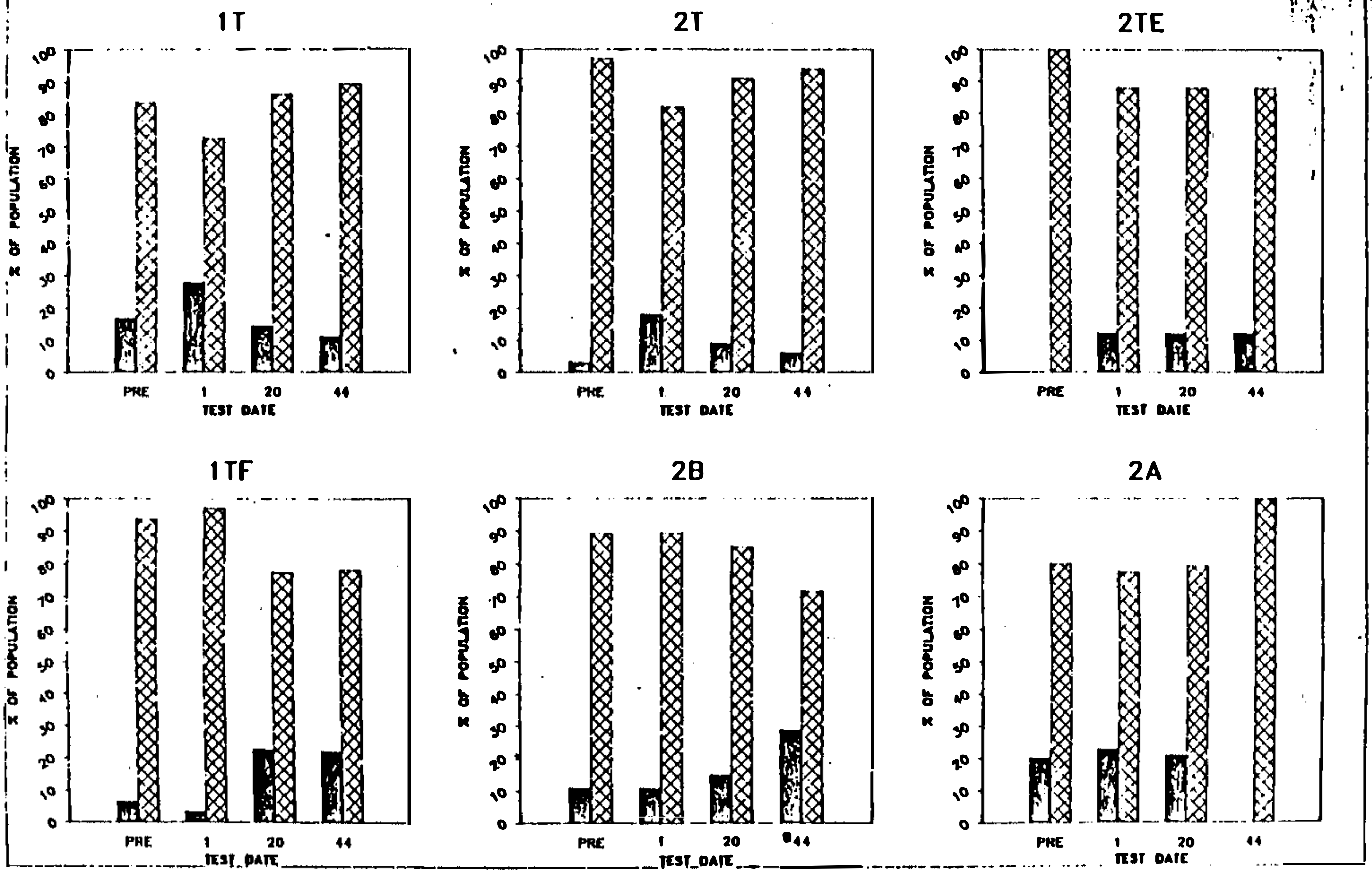

1T
2T
2TE
1TF
2B
2A
FEP (µg/dl)
80
70
60
50
40
30
20
10
0
DEF
PRE
1
20
44
TEST DATE

SERUM FOLATE

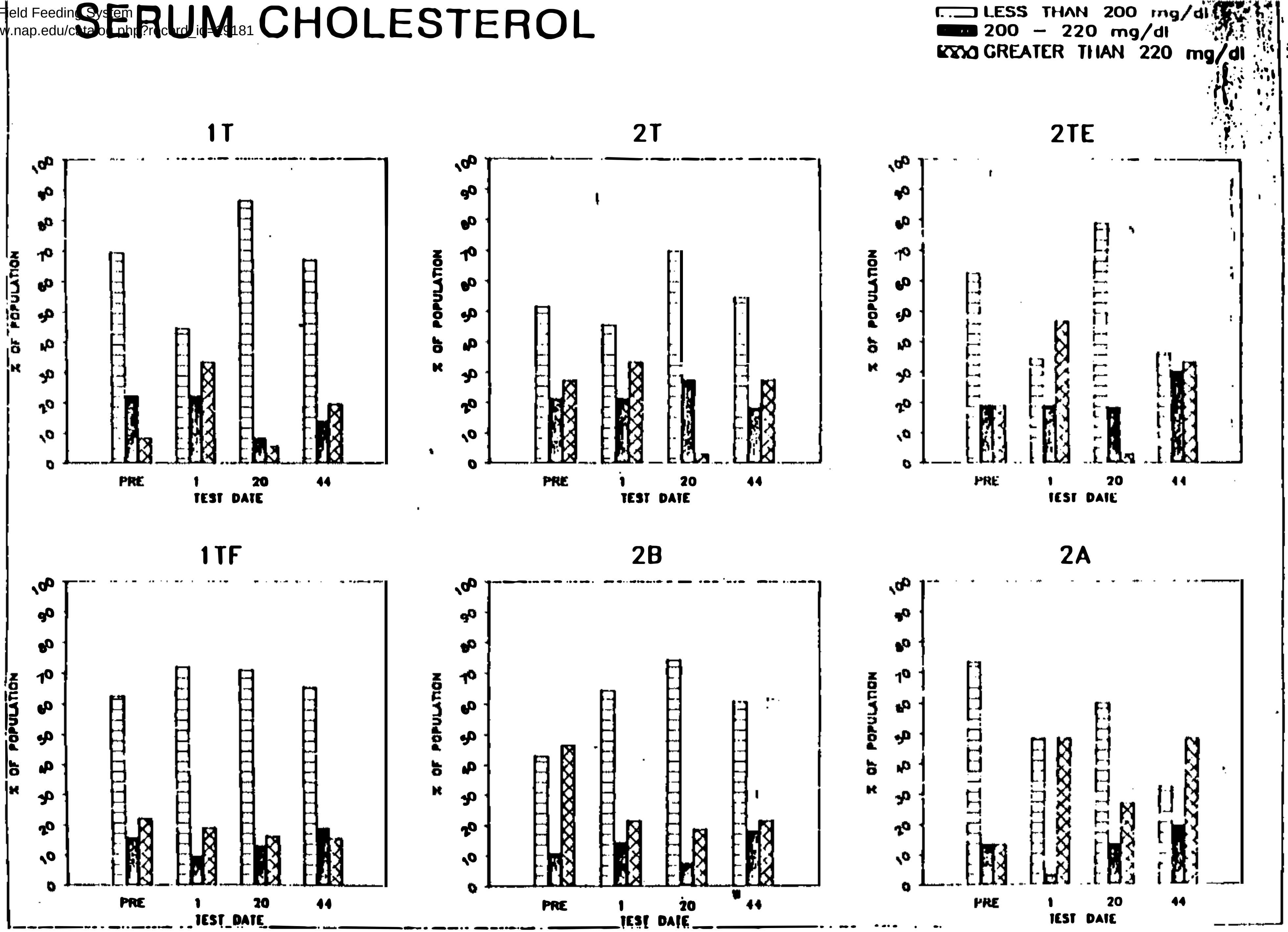


SERUM FOLATE

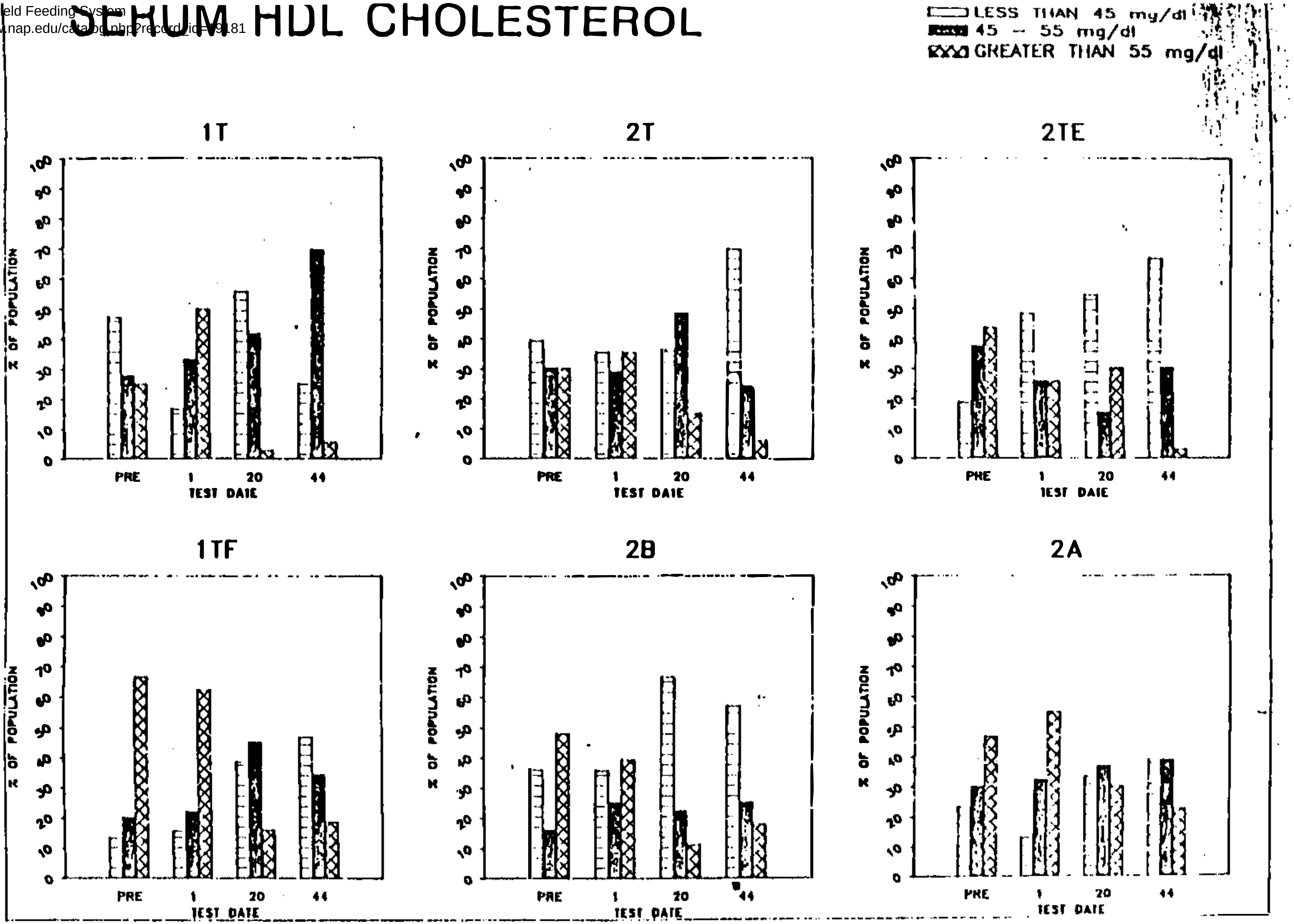
LESS THAN 3 ng/ml
GREATER THAN 3 ng/ml



SERUM CHOLESTEROL

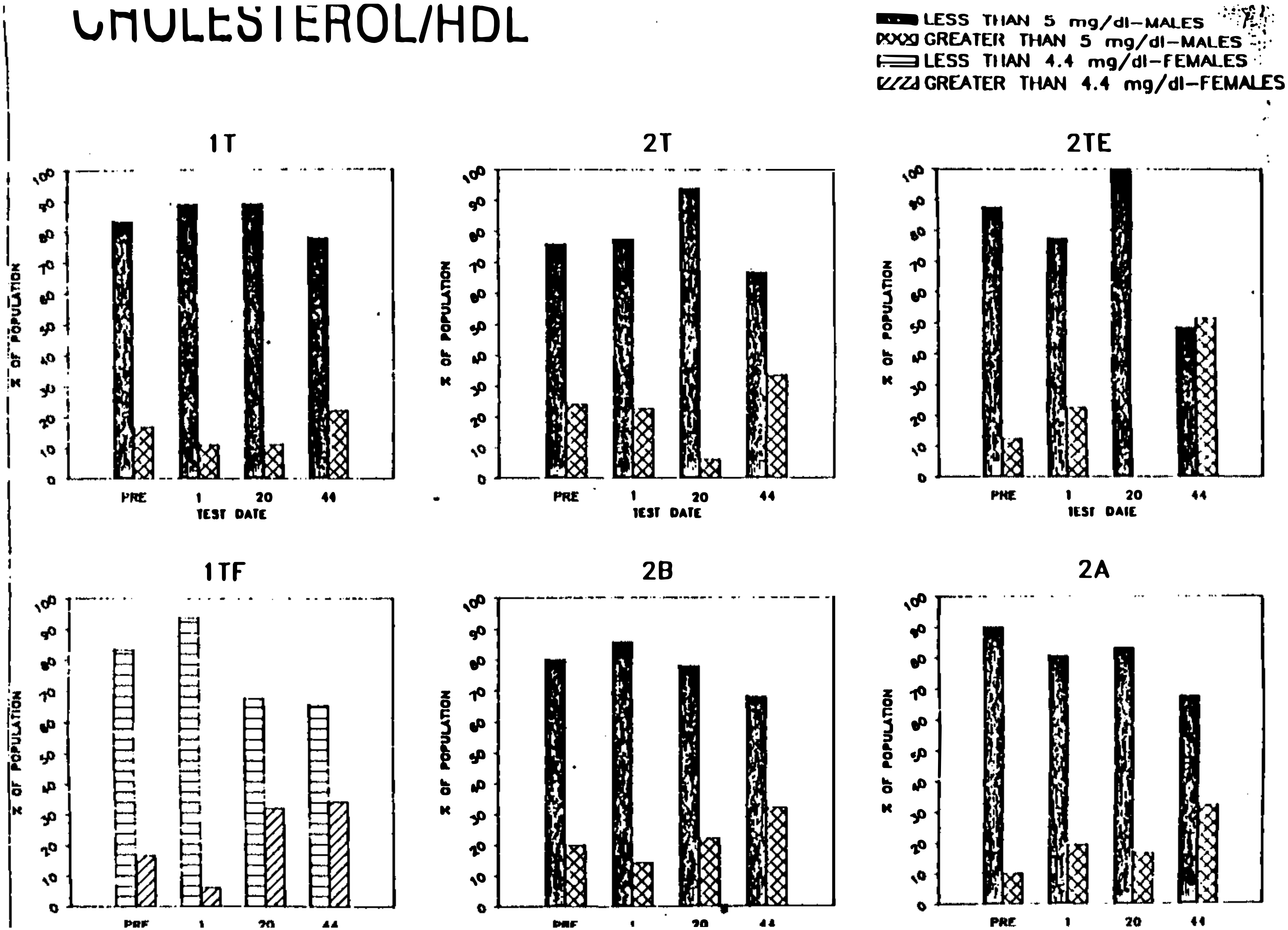


SERUM HDL CHOLESTEROL



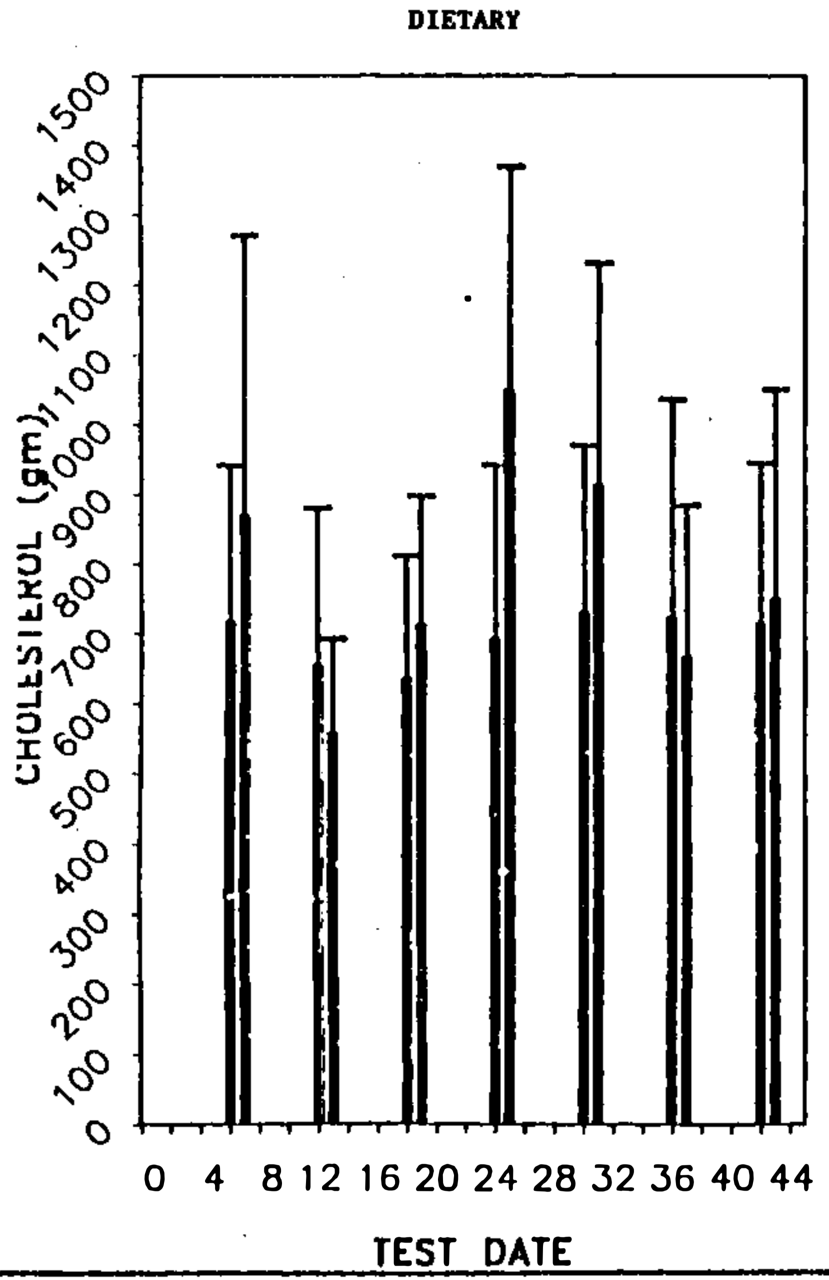
G-8

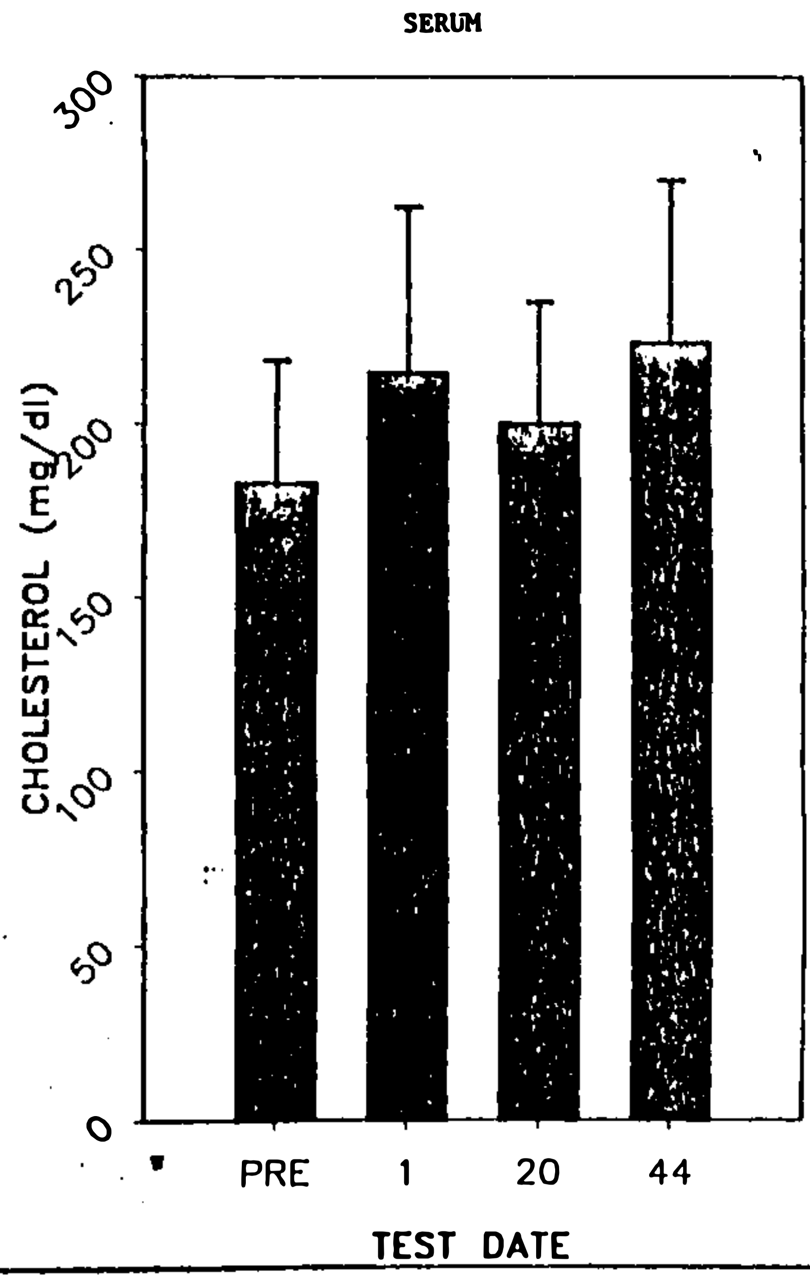
CHOLESTEROL/HDL



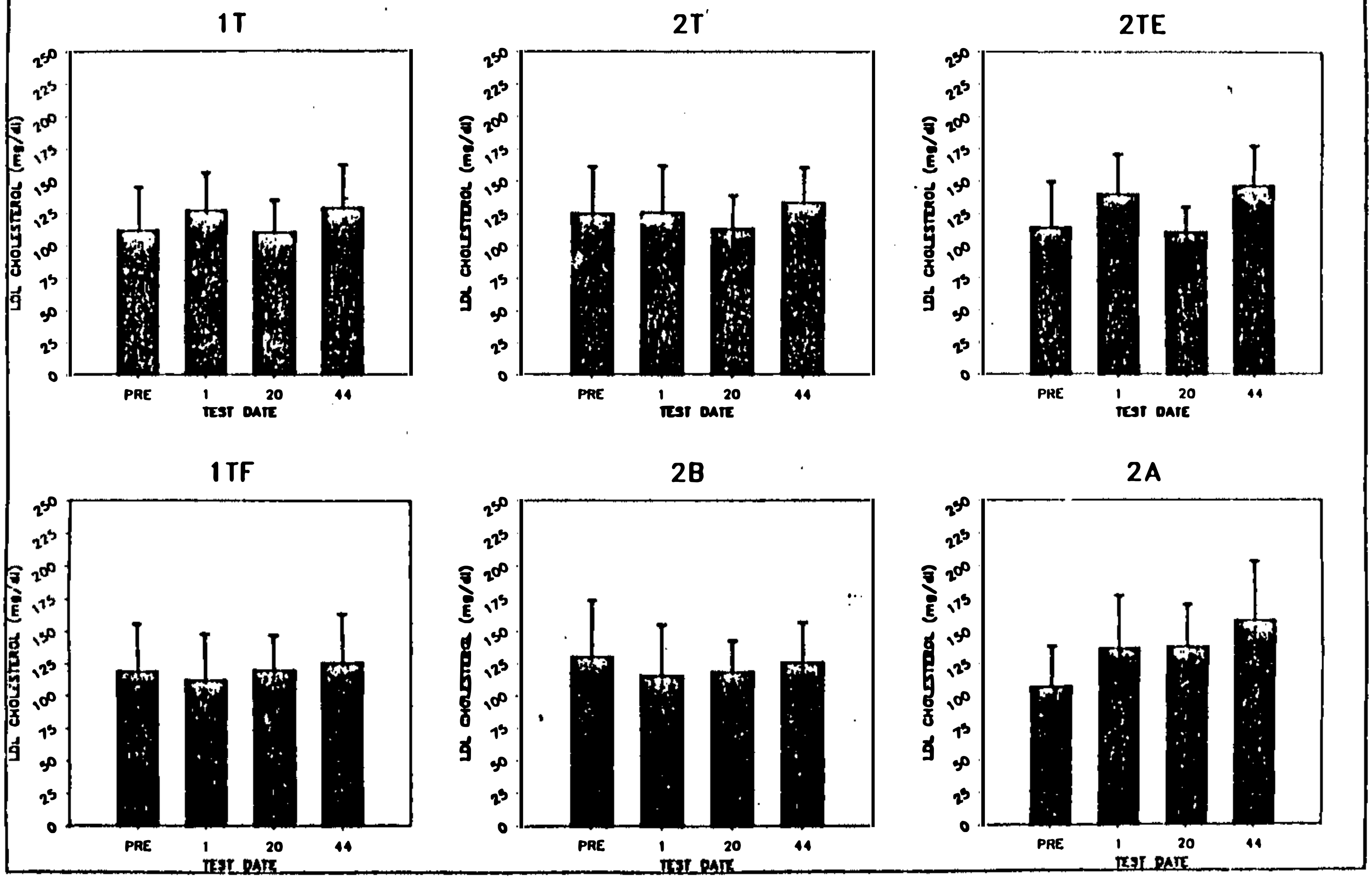
6-9

A RATION CHOLESTEROL





SERUM LDL CHOLESTEROL



APPENDIX H*

SELECTED HEMATOLOGIC AND HYDRATION VARIABLES

1. Hematocrit, hemoglobin, and plasma osmolality

2. Serum protein, plasma inorganic ions, blood urea nitrogen, and creatinine

*Data provided by the Heat Research Division of USARIEM, Dr. Roger Hubbard, Director.

HEMATOCRIT, % RBC
(Normal, 40-54, male)
(Normal, 37-47, female)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	45.8	48.2	48.6	49.0
2TE	47.3	49.1	49.2	50.9
1T	47.8	48.1	48.4	50.7
1TF	43.3	44.0	45.8	45.3
2A	46.8	48.6	48.8	50.4
2B	46.9	48.1	48.6	49.7

HEMOGLOBIN, g/dL
(Normal, 13-18, male)
(Normal, 11-16 female)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	16.33	16.94	16.45	16.69
2TE	17.32	16.98	16.65	17.19
1T	16.37	17.16	16.50	17.53
1TF	14.56	15.01	15.14	15.55
2A	16.30	16.60	16.26	17.50
2B	16.60	16.34	16.37	16.83

OSMOLALITY, mOsm/kg
(Normal, 280-300)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	290.9	292.1	289.6	291.0
2TE	290.3	289.9	290.2	289.3
1T	292.1	285.4	286.5	290.8
1TF	285.3	293.8	288.8	285.2
2A	286.3	294.1	289.8	288.0
2B	289.4	289.9	289.9	291.6

TOTAL PROTEIN, g/dL
(Normal, 6.2-8.5)

	Day of Study			
Test Group	Day 0	Day 1	Day 20	Day 44
2T	7.85	8.15	8.11	8.11
2TE	8.05	8.26	8.12	8.31
1T	7.80	8.16	7.98	8.19
1TF	7.87	8.06	8.14	7.88
2A	8.16	8.28	8.00	8.20
2B	8.00	8.27	8.14	8.20

SODIUM, mEq/L
(Normal, 135-155)

	Day of Study			
Test Group	Day 0	Day 1	Day 20	Day 44
2T	141.6	142.7	140.5	141.8
2TE	140.4	137.6	138.7	140.6
1T	141.2	139.9	140.2	141.4
1TF	139.2	138.9	139.7	143.8
2A	140.5	141.2	139.1	140.2
2B	140.7	140.1	139.5	141.5

POTASSIUM, mEq/L
(Normal, 3.6-5.5)

	Day of Study			
Test Group	Day 0	Day 1	Day 20	Day 44
2T	4.20	4.77	4.50	4.20
2TE	4.42	4.41	4.53	4.43
1T	4.46	4.48	4.61	4.48
1TF	4.43	4.52	4.41	4.56
2A	4.46	4.59	4.61	4.55
2B	4.43	4.72	4.64	4.58

MAGNESIUM, mEq/L
(Normal, 1.4-2.4)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	1.78	1.78	1.80	1.76
2TE	1.81	1.76	1.88	1.87
1T	1.80	1.78	1.99	1.77
1TF	1.75	1.74	1.76	1.72
2A	1.70	1.77	1.82	1.80
2B	1.84	1.78	1.83	1.79

CHLORIDE, mEq/L
(Normal, 94-106)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	94.8	94.9	97.9	96.9
2TE	96.5	95.7	97.2	95.8
1T	96.3	97.1	100.2	96.7
1TF	96.4	100.5	101.2	97.1
2A	95.1	98.3	96.8	98.1
2B	96.4	97.7	96.6	98.8

UREA NITROGEN, mg/dL
(Normal, 7-18)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	13.7	15.0	14.0	14.7
2TE	14.3	16.0	15.0	16.5
1T	14.3	14.0	16.1	14.7
1TF	12.0	12.5	10.4	11.6
2A	13.7	13.4	19.4	17.8
2B	15.1	14.8	14.7	16.1

CREATININE, mg/dL
(Normal, 0.9-1.5, male)
(Normal, 0.7-1.35, female)

Test Group	Day of Study			
	Day 0	Day 1	Day 20	Day 44
2T	1.17	1.09	1.15	1.05
2TE	1.16	1.05	1.16	1.16
1T	1.15	1.15	1.19	1.30
1TF	0.97	0.91	0.97	0.98
2A	1.12	1.03	1.13	1.18
2B	1.08	1.08	1.09	1.17

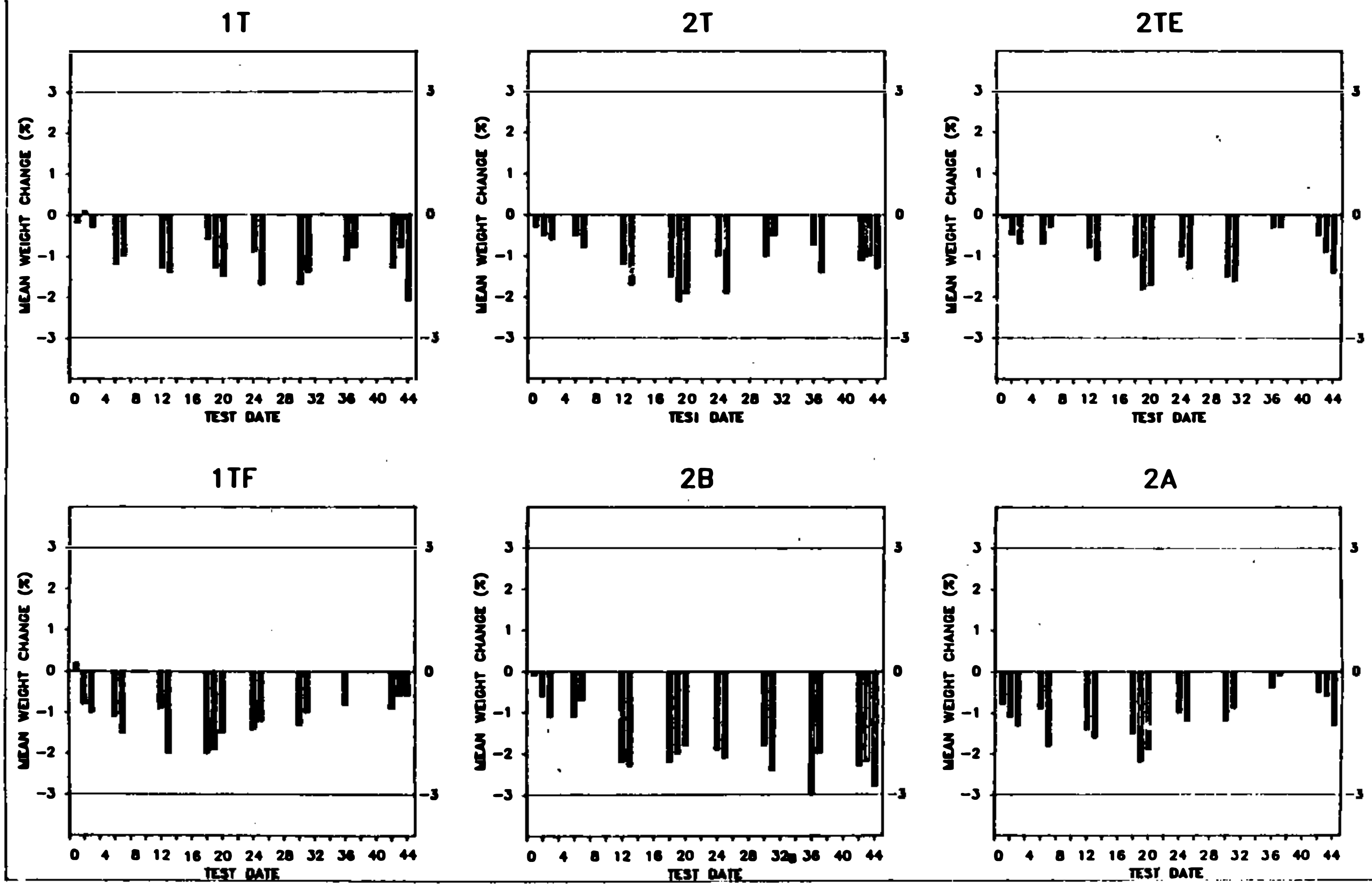
APPENDIX I*

BODY-WEIGHT-CHANGE DATA

1. Daily body-weight change
2. Daily weight loss exceeding 3%
3. Daily weight loss exceeding 5%
4. Daily weight loss exceeding 7.5%
5. Mean body-weight change vs. time

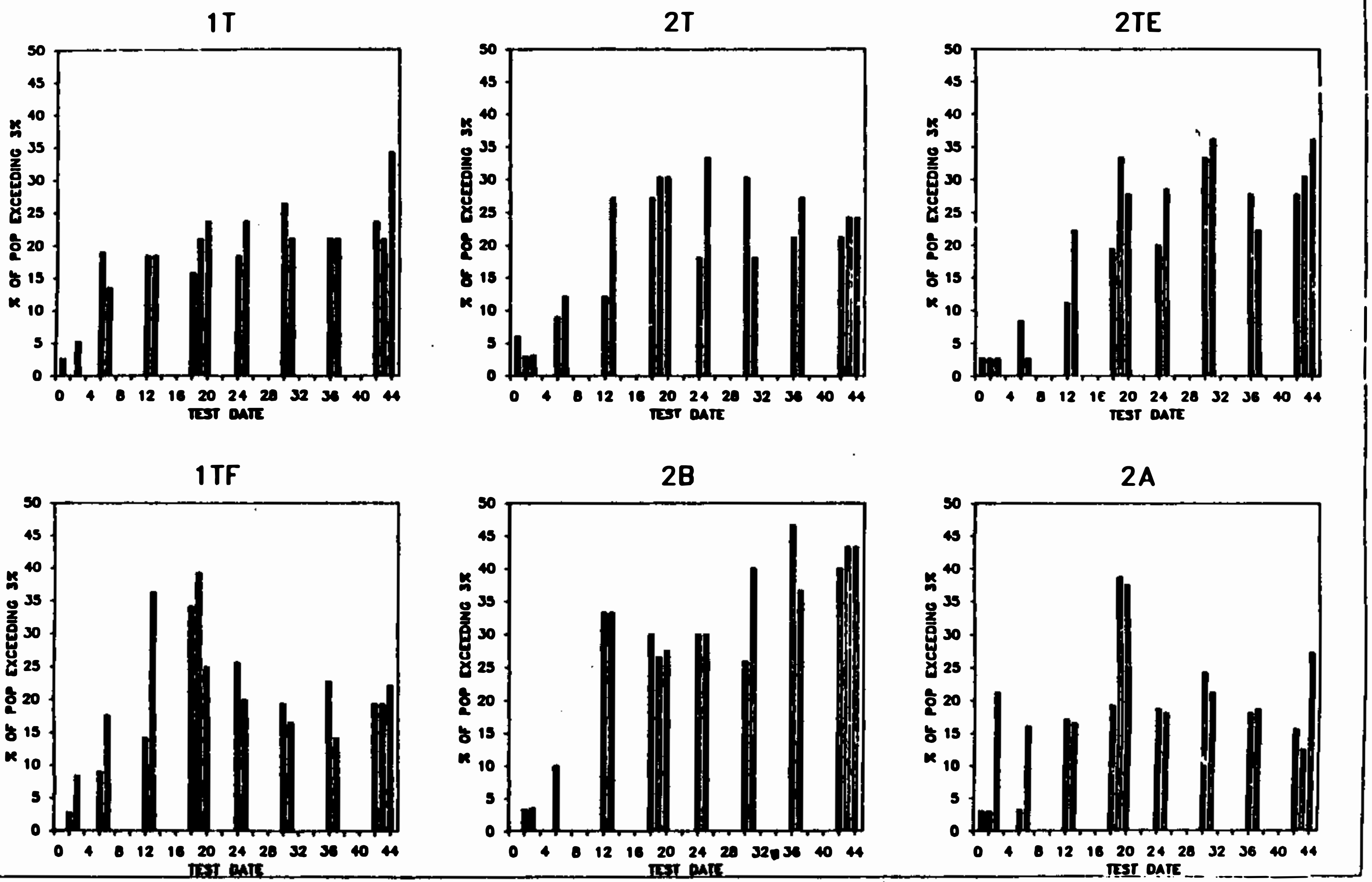
*Data provided by the Nutrition Research Task Force of USARIEM, Lt. Col. David Schnakenberg, Team Director and Director of Nutrition Research.

DAILY BODY WEIGHT CHANGE

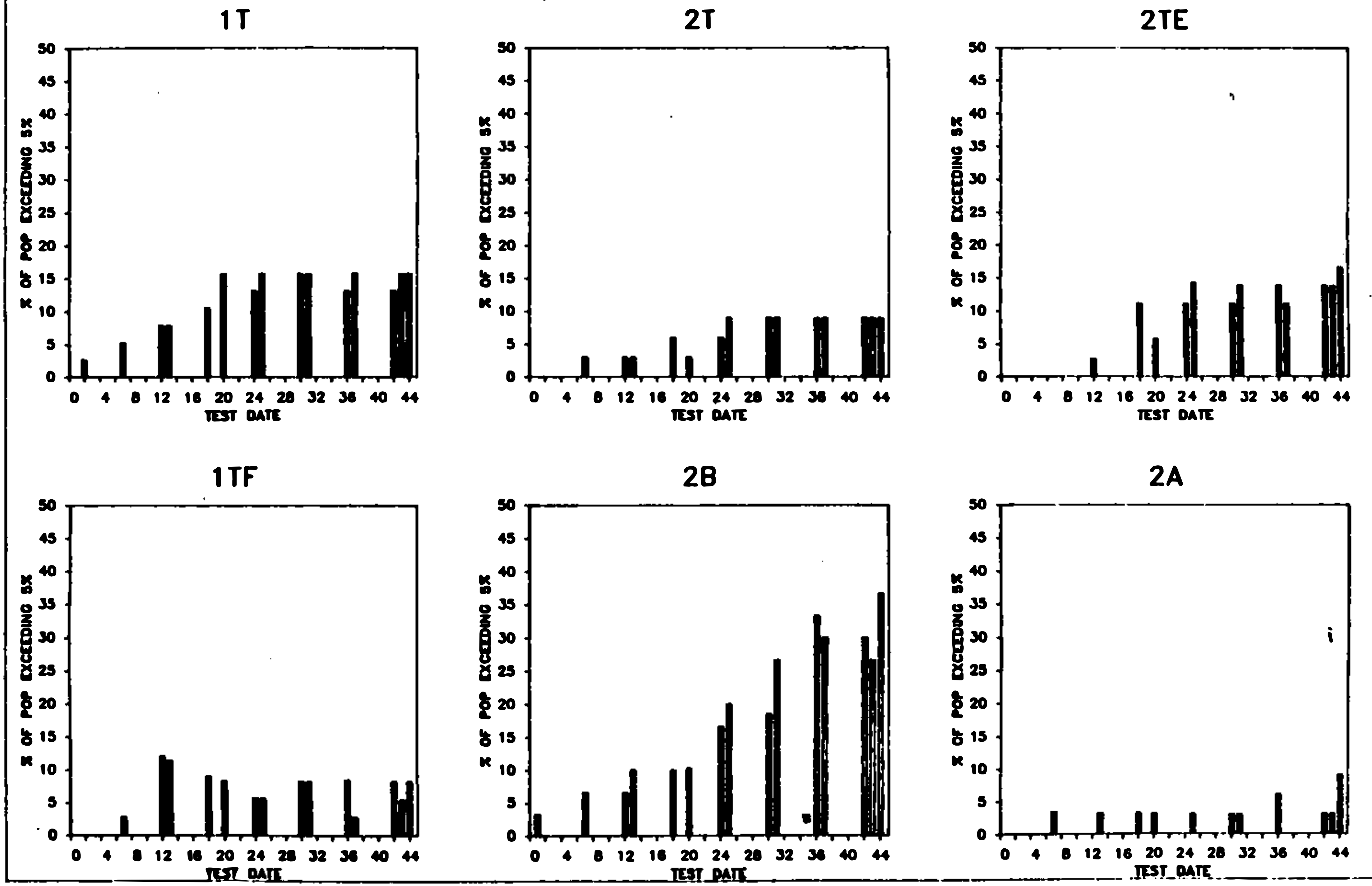


I-1

DAILY WEIGHT LOSS EXCEEDING 3%

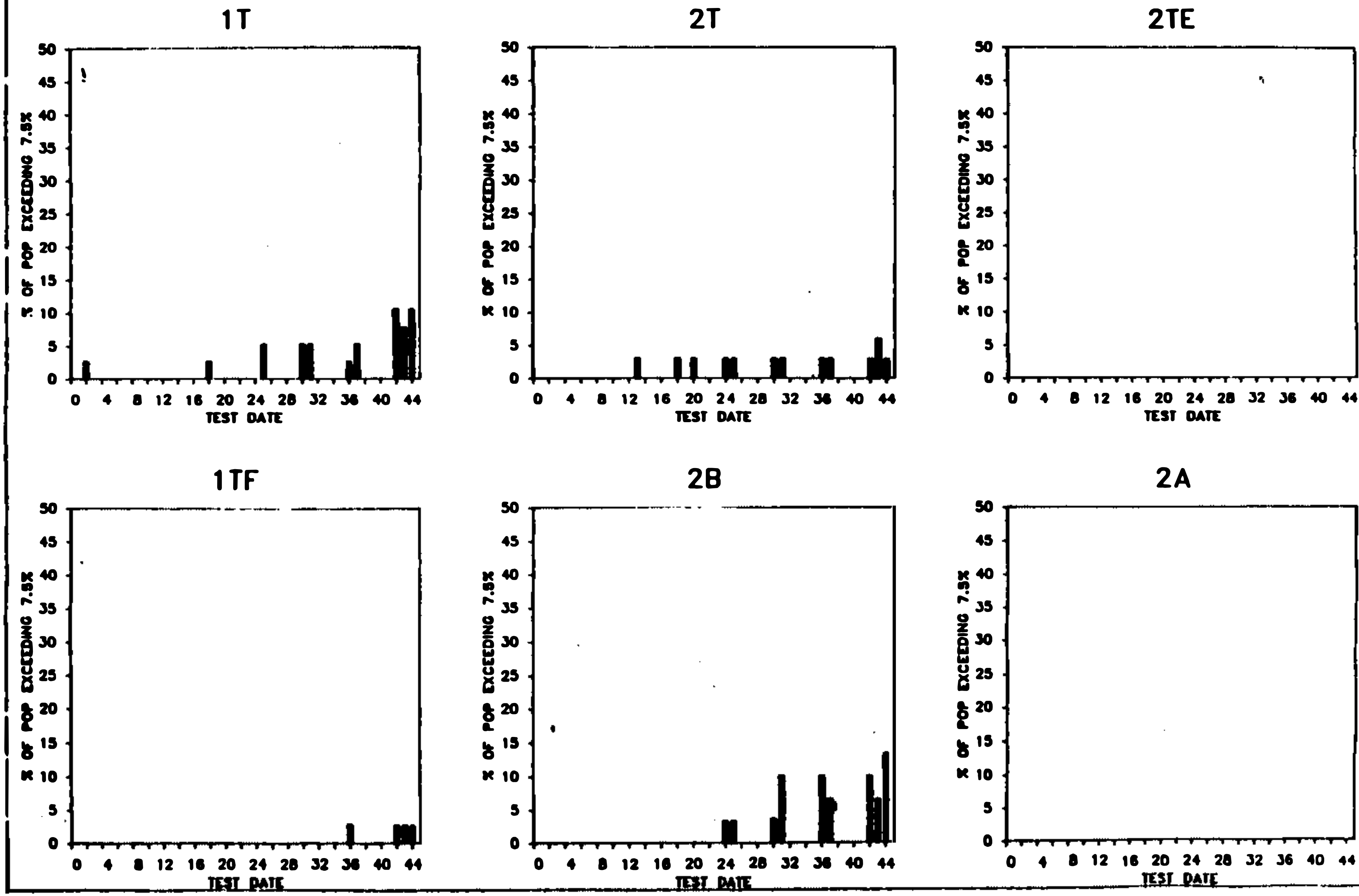


DAILY WEIGHT LOSS EXCEEDING 5%



I-3

DAILY WEIGHT LOSS EXCEEDING 7.5%



COMBAT FIELD FEEDING SYSTEM TEST MEAN BODY WEIGHTS (KG) VS TIME FOR EACH RATION GROUP

Group	PRE	T-1	T-20	T-44	% Δ
2T	76.70 ± 10.59	76.46 ± 10.51	75.15 ± 9.81	75.55 ± 9.52	-1.50
2TE	79.80 ± 11.08	79.71 ± 11.02	78.32 ± 10.44	78.51 ± 10.04	-1.62
1T	77.62 ± 8.87	77.14 ± 8.92	76.00 ± 8.09	75.48 ± 7.87	-2.76
1TF	64.32 ± 7.78	64.42 ± 7.56	63.33 ± 7.63	63.88 ± 7.65	-0.68
2A	76.22 ± 10.59	75.59 ± 10.62	74.88 ± 10.21	75.08 ± 9.82	-1.50
2B	75.03 ± 11.19	74.87 ± 10.94	73.73 ± 10.27	72.74 ± 9.94	-3.05

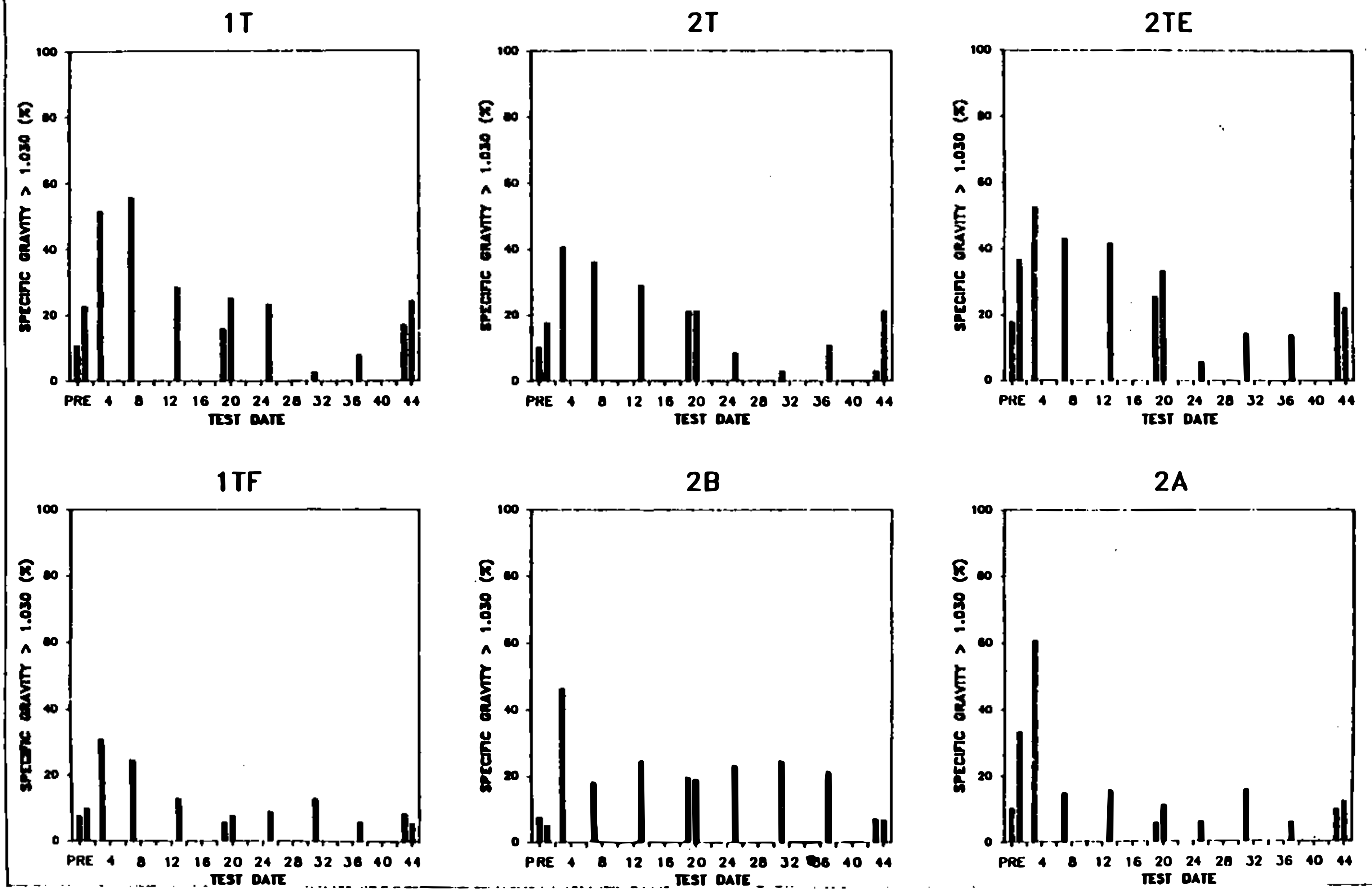
APPENDIX J*

URINE SPECIFIC GRAVITY AND OSMOLALITY

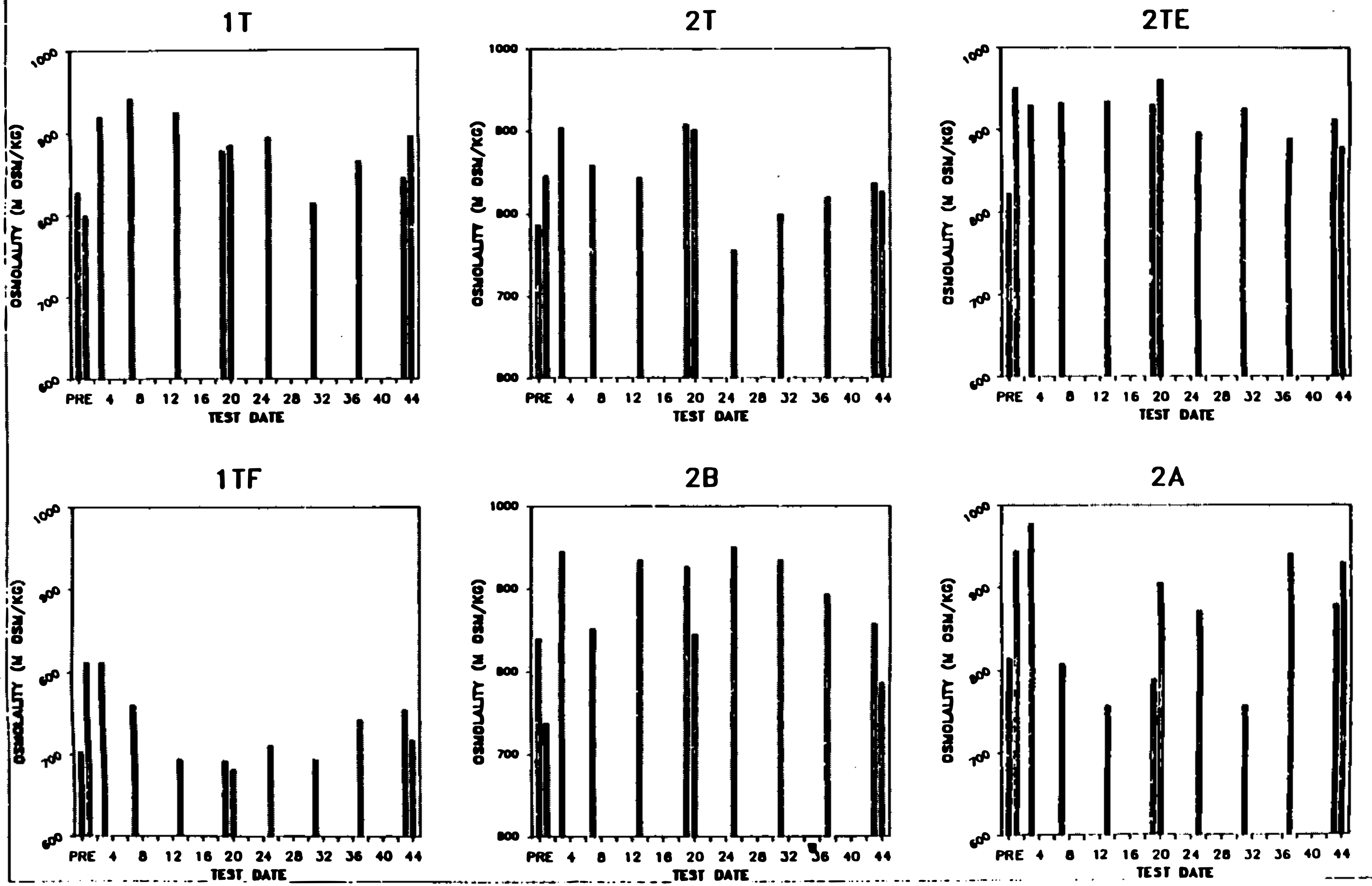
1. Urinary specific gravity
2. % of population with urine specific gravity 1.030
3. Urinary osmolality
4. % of population with urine osmolality 1,000 mO_sm/kg
5. Daily water intake

*Data provided by the Heat Research Division of USARIEM, Dr. Roger Hubbard, Director, and the Nutrition Research Task Force of USARIEM, Lt. Col. David Schnakenberg, Team Director and Director of Nutrition Research.

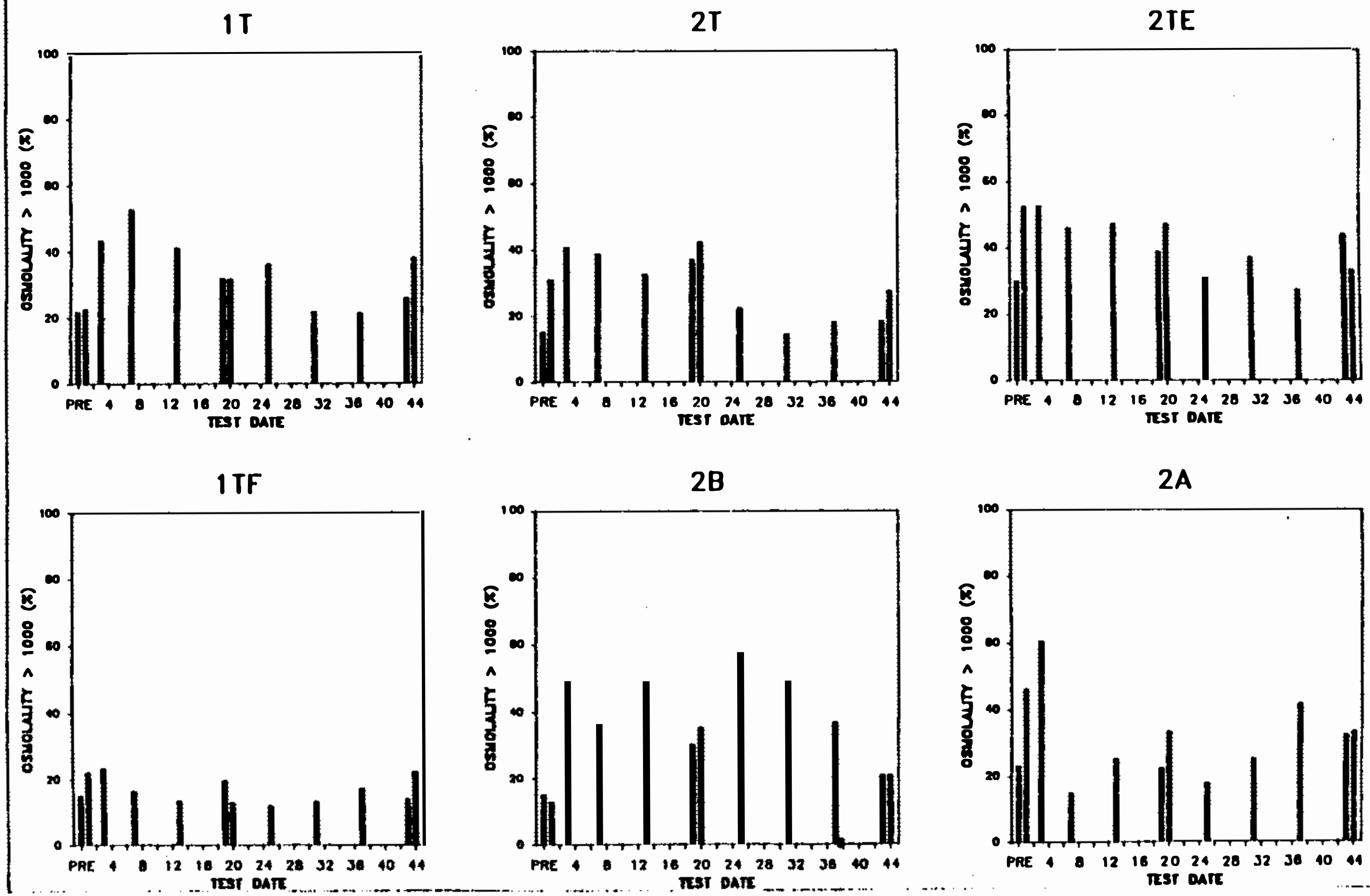
...OPULATION WITH URINE SPECIFIC GRAVITY > 1.030



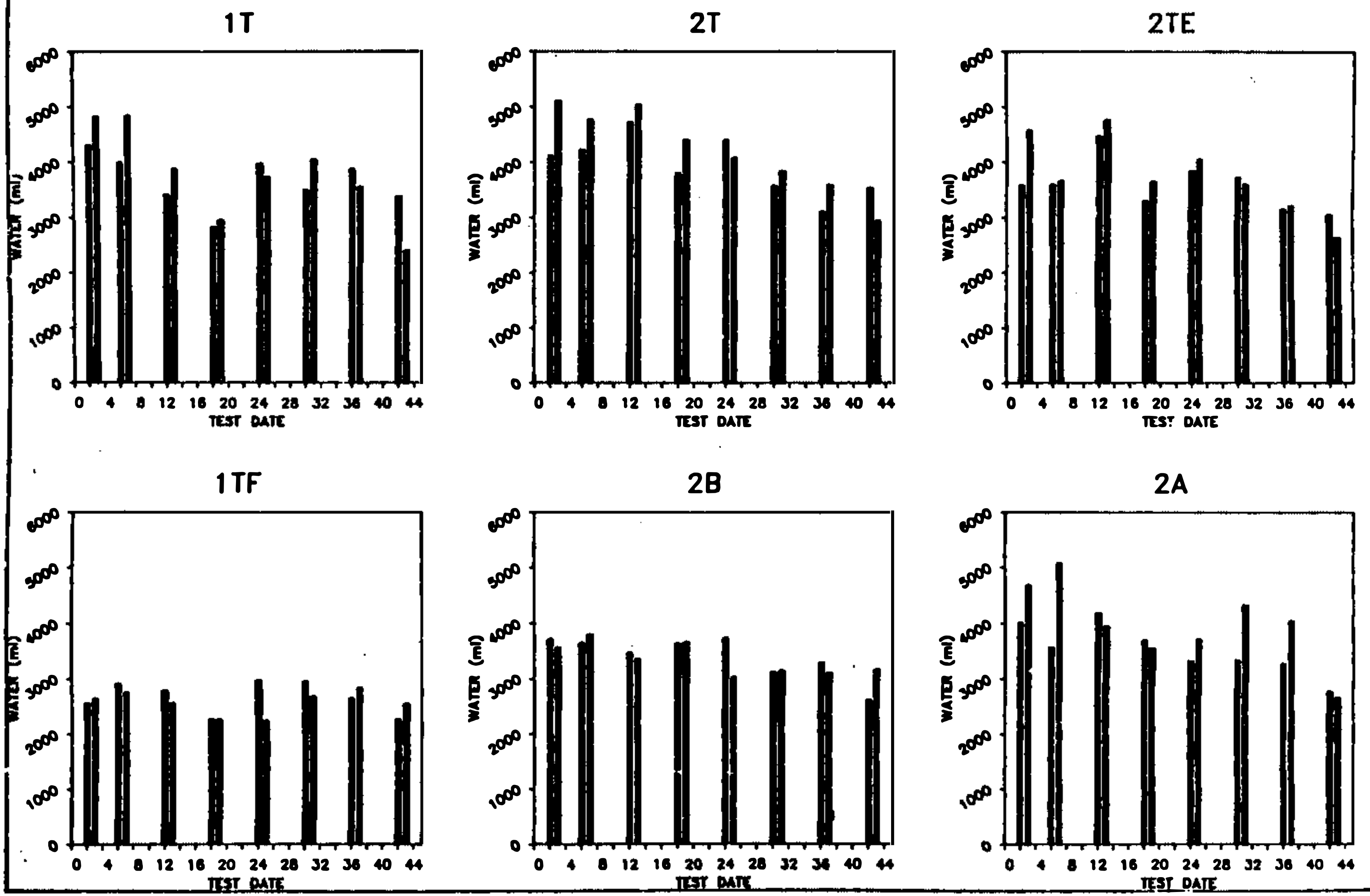
URINARY OSMOLALITY



% OF POPULATION WITH URINE OSMOLALITY > 1000



DAILY WATER INTAKE



APPENDIX K*

BODY COMPOSITION DATA

1. Percent body fat of males
2. Fat-free mass of males
3. Body composition of females

*Data provided by the Exercise Physiology Division of USARIEM, Dr. James Vogel, Director.

Percent of Body Fat of Males Determined by Circumference Technique[a] of Each Treatment Group at Each Time of Measurement (Mean ± SD)

Group	n	Day 0	Day 1	Day 20	Day 44
2T	33	19.0 ± 5.6	18.9 ± 5.9	17.7 ± 5.2	17.6 ± 5.1
2TE	36	20.0 ± 5.1	19.7 ± 5.1	18.7 ± 4.4	18.3 ± 4.4
1T	36	18.3 ± 4.4	18.2 ± 4.9	17.4 ± 4.0	16.7 ± 3.5
2A	33	19.2 ± 4.6	18.5 ± 4.6	17.6 ± 4.3	17.2 ± 4.1
2B	29	19.6 ± 5.4	19.9 ± 5.1	19.0 ± 4.5	17.8 ± 4.1
All	167	19.2 ± 5.0	19.0 ± 5.1	18.1 ± 4.5	17.5 ± 4.2

F value for group comparison = 0.69

F value for repeated measures = 76.26

[a]The body fat procedure for men consisted of the Army's new circumference technique, which will replace the skinfold procedure in 1986. This new method estimates body fat from measures of neck and abdominal circumference and body height according to the following equation:

$$\text{Percent body fat} = 46.892 - [(68.678)(\log_{10}\text{height})(\log_{10}\text{abdominal-neck circumference})]$$

Cloth anthropometric tapes were used to measure circumference of the neck at a level just below the larynx and the abdomen at a level coinciding with the midpoint of the navel. Fat-free mass was estimated by subtracting fat mass from total body weight.

Fat-free Mass (kg) of Males Determined by Circumference Technique of Each Treatment Group at Each Time of Measurement[a] (Mean ± SD)

Group	n	Day 0	Day 1	Day 20	Day 44
2T	33	61.8 ± 7.0	61.7 ± 6.9	61.6 ± 7.0	62.0 ± 6.8
2TE	36	63.5 ± 6.9	63.7 ± 7.3	63.4 ± 7.1	63.9 ± 7.2
1T	36	63.3 ± 6.8	63.2 ± 6.9	63.0 ± 6.8	63.2 ± 6.8
2A	33	61.3 ± 6.6	61.2 ± 6.6	61.1 ± 6.5	61.9 ± 6.3
2B	29	60.1 ± 6.6	59.8 ± 6.6	59.4 ± 6.4	59.9 ± 6.7
All	167	62.1 ± 6.8	62.0 ± 7.0	61.8 ± 6.8	62.3 ± 6.8

F value for group comparison = 1.66

F value for repeated measures = 7.46

[a]Fat-free mass was estimated by subtracting fat mass from total body weight.

Body Composition As a Function of Time in Group 1 TF (Females)[a] (Mean ± SD)

Variable	n	Pre	Day 1	Day 20	Day 44	Repeated Measure F-value
Percent body fat	36	28.6 ± 3.9	26.8 ± 4.1	26.2 ± 4.2	25.5 ± 4.1	63.33
Fat-free mass, kg	36	45.9 ± 5.2	47.0 ± 4.9	46.6 ± 5.0	47.5 ± 4.9	24.72
Fat mass, kg	36	18.5 ± 4.0	17.4 ± 4.0	16.7 ± 4.0	16.4 ± 4.1	44.09
Upper arm muscle vol., L	36	0.995 ± 0.344	0.941 ± 0.236	0.960 ± 0.174	1.007 ± 0.187	0.57

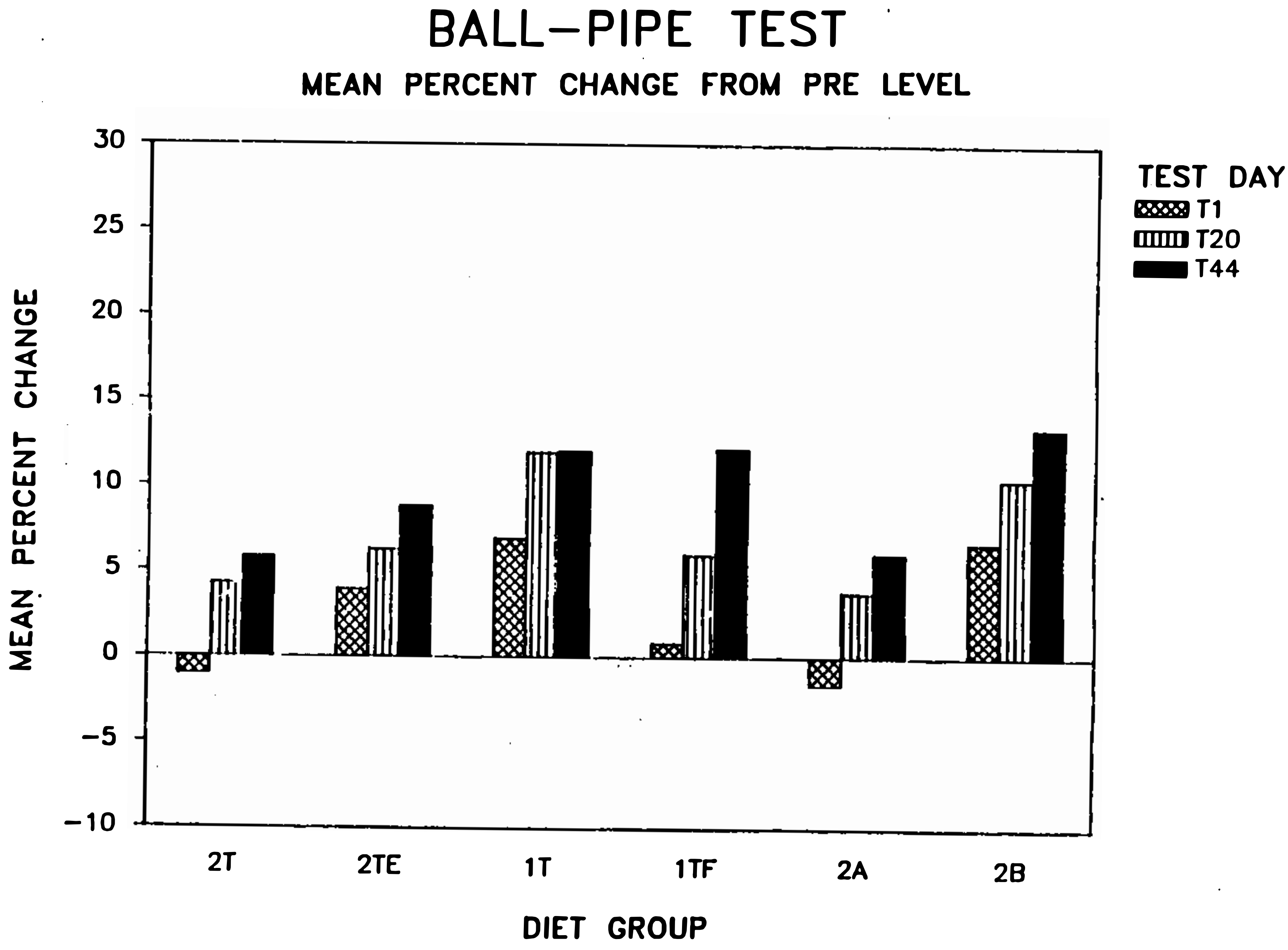
[a]Body fat was estimated in women by the Army's present skinfold caliper technique using the Durnin and Womersley formulas (Brit. J. Nutr. 32:77, 1974). The Harpenden caliper was used to measure skinfold thickness at four locations (biceps, triceps, subscapular, and suprailiac), and these were then transformed into body density and then into fat mass as a percentage of body weight or total fat mass in kilograms. Fat-free mass was estimated by subtracting fat mass from total body weight.

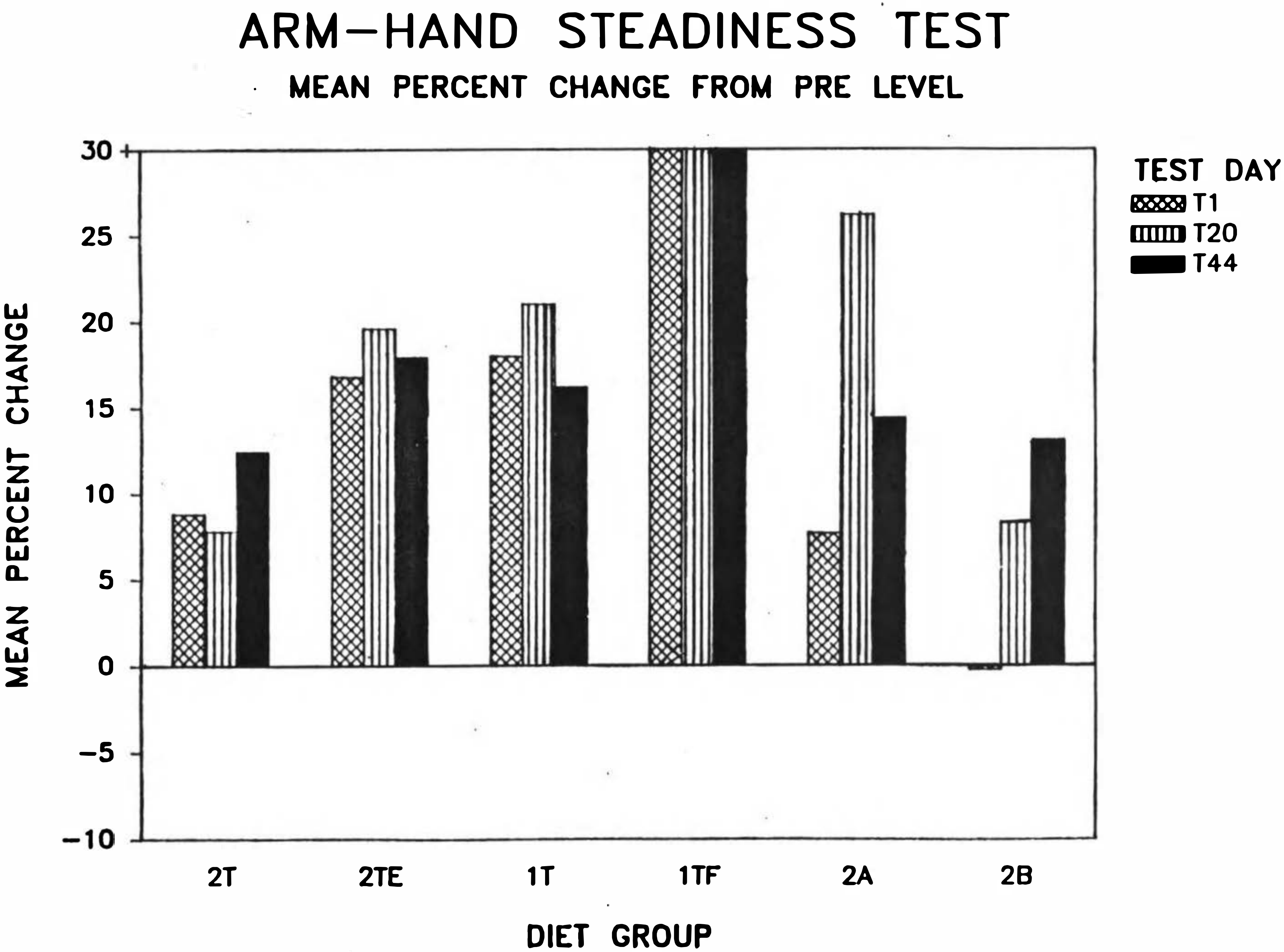
APPENDIX L*

HAND-EYE COORDINATION

1. Ball-pipe test
2. Arm-hand steadiness test

*Data provided by the Health and Performance Division of USARIEM, Dr. Richard Johnson, Member.


BALL-PIPE TEST
MEAN PERCENT CHANGE FROM PRE LEVEL
MEAN PERCENT CHANGE
30
25
20
15
10
5
0
-5
-10
TEST DAY
T1
T20
T44
2T
2TE
1T
1TF
2A
2B
DIET GROUP


ARM—HAND STEADINESS TEST
MEAN PERCENT CHANGE FROM PRE LEVEL
TEST DAY
T1
T20
T44
MEAN PERCENT CHANGE
30
25
20
15
10
5
0
−5
−10
2T
2TE
1T
1TF
2A
2B
DIET GROUP

APPENDIX M*

MEASUREMENT OF FOOD AND WATER CONSUMPTION

*Data provided by the Nutrition Research Task Force of USARIEM, Lt. Col. David Schnakenberg, Team Director and Director of Nutrition Research.

Civilian dietitians and nutrition students hired on a temporary basis served as data collectors, because previous nutrition training was considered important in optimizing the accuracy of portion-size estimates. Data collectors were divided into three teams, each consisting of a group leader and four data collectors. Each team collected data on two test groups. Each data collector followed 10 subjects per unit to facilitate collecting data without delaying meal service and consumption. To encourage development of the rapport and commitment needed for complete and accurate data, each data collector followed the same subjects throughout the test.

The dietary-team chief trained data collectors, providing classes on CFFS rations and equipment and on data collection forms and procedures. The data validators provided training in estimating portion sizes. Data collectors performed dry runs of the collection procedure with forms to be used throughout the test during the Quartermaster School pilot test for the cooks. The Combat Developments Experimental Center provided training on range safety, driving of military vehicles, use of radios, and map-reading.

Food and water consumption data were collected for 2 days at a time approximately once a week over the 7 weeks of the prolonged feeding test with a combination of observation, interview, and self-reporting. Data collectors traveled to field sites to collect meal consumption data, planning arrival time at the site for 30 minutes before the meal service time scheduled by the unit. After each volunteer subject collected his food, he showed both his plate and beverage to the assigned data collector, who recorded the food selections on a prepared ration record card. Data collectors observed menu selections and estimated portions served and returned at group meals which include A, B, and T rations. The group leader prepared a tray with standard portion sizes for the data collectors to use as a frame of reference in estimating portions served and returned. Volunteers completed food consumption records for MRE meals. During the first 3 days of the study, troops from all ration groups ate MREs for all three meals. Breakfast and dinner meals were consumed in group settings and data collectors trained the volunteers in the use of food records ensuring that each subject knew how to complete the form. Troops saved and turned in empty or partially empty wrappers and any food items they chose not to eat; that allowed data collectors to assess the accuracy of portion estimates and consumption information. Troops were allowed to trade foods with each other and to save foods for snacks. Snacks consumed between dinner and breakfast were recorded on snack records, which were turned in the following morning. Troops also reported water intake on a specially developed water intake record on which canteens and canteen cups were used as units of measure to facilitate estimation of quantities consumed. Correlating with actual food consumption data, troops provided overall ratings for foods consumed, using a nine-point hedonic scale and provided reasons for not consuming of foods that they chose not to select or consume.

All food and water consumption data were collected manually in the field. Data collectors checked and coded data forms in the base camp and provided them to personnel responsible for entering the data into Digital Equipment Corporation PC 350 desktop computers. Each data collector checked his own printouts against the manual data forms to ensure that data had been entered accurately.

The degree of accuracy with which data collectors estimated portion sizes was evaluated by comparing recorded estimates with portions of measured weight. Data collectors estimated portion sizes as fractions of the standards. Data validation procedures were performed at the beginning, middle, and end of the feeding test, to document changes over time and training effects. The data validator performed data validation during data collection, accompanying teams to field sites and evaluating interviewing and estimating techniques. On September 15 and 16, data collectors performed a validation test in which they estimated portion sizes of 18 breakfast and 20 dinner T ration meals. Each data collector estimated each tray four times, providing intercollector and intracollector reliability.

Group leaders maintained daily logs in which they recorded subjective information on factors that might have affected food and water consumption at each meal. Information recorded included whether sufficient juice or beverage base was available for all dinners, whether any food items ran out during meal service, whether all listed menu items were available, and whether volunteers ate first or last, or were interspersed. Leaders also recorded observations on weather and environmental conditions and a description of any activity in which troops were engaged during the meal period.

APPENDIX N*

MUSCULAR STRENGTH AND MUSCULAR ENDURANCE

1. Maximal isometric handgrip force of males by treatment group and time of measurement
2. Isometric handgrip endurance time of males at 60% of maximal force
3. Maximal lift capacity of males to the height of 132 cm
4. Maximal isometric 38-cm upright pull force of males
5. Muscular strength of females as a function of time in Group ITF

*Data provided by the Exercise Physiology Division of USARIEM, Dr. James A. Vogel, Director.

Maximal Isometric Handgrip Force of Males by Treatment Group and Time of Measurement

Group	n	Force, kg (mean ± SD) Day 0	Day 1	Day 20	Day 44
2T	33	57.2 ± 8.3	57.9 ± 7.8	57.8 ± 8.2	57.6 ± 9.7
2TE	36	60.3 ± 8.9	60.3 ± 8.6	59.9 ± 10.0	58.9 ± 9.4
1T	36	59.9 ± 8.6	63.1 ± 11.6	63.6 ± 10.2	61.9 ± 9.6
2A	33	55.2 ± 8.2	58.6 ± 9.2	57.9 ± 10.2	58.9 ± 9.1
2B	29	54.7 ± 6.9	56.4 ± 7.7	56.3 ± 8.4	55.6 ± 8.1
All	167	57.6 ± 8.5	59.4 ± 9.3	59.3 ± 9.7	58.7 ± 9.3

F value for group differences = 27.8
F value for repeated measures = 7.46

Isometric Handgrip Endurance Time of Males at 60% of Maximal Force

Group	n	Endurance Time, sec (mean ± SD) Day 0	Day 1	Day 20	Day 44
2T	19	50.6 ± 15.8	61.1 ± 17.8	53.7 ± 17.3	53.3 ± 16.1
2TE	17	51.9 ± 18.9	59.2 ± 20.4	61.6 ± 25.7	57.1 ± 22.3
1T	17	49.9 ± 13.7	47.1 ± 16.4	55.1 ± 21.4	47.2 ± 15.8
2A	17	46.1 ± 10.3	58.2 ± 16.6	51.9 ± 18.9	53.8 ± 14.0
2B	14	58.3 ± 14.8	52.3 ± 13.9	55.6 ± 17.1	49.1 ± 19.1
All	84	51.1 ± 15.1	55.8 ± 17.7	55.6 ± 20.1	52.2 ± 17.5

F value for group comparison = 0.56
F value for repeated measures = 3.22

Gr

2T

2T

1T

2

2

Maximal Lift Capacity of Males to the Height of 132 cm

Group	n	Lift Capacity, kg (mean ± SD) Day 0	Day 1	Day 20	Day 44
2T	33	56.9 ± 11.3	59.2 ± 11.8	62.9 ± 12.3	62.3 ± 12.3
2TE	34	65.7 ± 13.7	65.2 ± 13.5	66.9 ± 13.2	68.8 ± 12.1
1T	35	64.5 ± 13.9	68.7 ± 14.0	70.9 ± 12.1	72.1 ± 12.7
2A	32	67.3 ± 13.5	65.8 ± 13.5	68.0 ± 14.3	70.3 ± 13.5
2B	29	62.9 ± 12.6	63.1 ± 12.6	65.6 ± 13.3	65.7 ± 12.4
All	163	63.5 ± 13.4	64.5 ± 13.3	66.9 ± 13.3	68.0 ± 13.0

F value for group comparison = 2.51
F value for repeated measures = 27.04

Maximal Isometric 38-cm Upright Pull Force of Males

Group	n	Pull Force, kg (mean ± SD) Day 0	Day 1	Day 20	Day 44
2T	33	134.0 ± 28.3	138.0 ± 28.6	142.9 ± 31.0	148.6 ± 38.7
2TE	34	139.1 ± 24.8	151.4 ± 31.9	155.1 ± 32.2	150.5 ± 31.9
1T	35	127.8 ± 20.1	151.7 ± 25.2	157.5 ± 24.3	158.7 ± 23.9
2A	32	120.6 ± 26.3	136.4 ± 26.1	140.9 ± 30.6	144.9 ± 27.8
2B	29	115.6 ± 15.8	133.9 ± 19.1	140.9 ± 26.3	138.8 ± 21.9
All	163	127.8 ± 24.8	142.7 ± 13.3	147.8 ± 29.7	148.8 ± 29.8

F value for group comparison = 2.77
F value for repeated measures = 19.27

Var

Max

Ha
a

38

Ma

a