REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
May 1995

3. REPORT TYPE AND DATES COVERED
Technical Report

4. TITLE AND SUBTITLE
Health, Performance, and Nutritional Status of U.S. Army Women during Basic Combat Training

5. FUNDING NUMBERS

6. AUTHOR(S)
LTC Kathleen A. Westphal, MAJ Karl E. Friedl, Ms. Marilyn A. Sharp, LTC Nancy King, Dr. Tim R. Kramer, LTC Katy L. Reynolds and Mr. Louis J. Marchitelli

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Medical Research and Materiel Command
Ft. Detrick
Frederick, MD 21702-5012

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This study was undertaken to examine the relationship(s) between health, nutrition, body composition, and physical performance in female soldiers during the 8 weeks of basic combat training (BCT). The study investigated female soldiers assigned to three platoons within a single all-female basic training company over the period of 22 March 1993 to 20 May 1993 at Fort Jackson, South Carolina. Volunteer soldiers participated in pre-training (pre-BCT; 174 original volunteers with a mean age of 21.4 yrs) and post-training (post-BCT; 158 successful BCT graduates) performance and body composition testing, as well as three separate blood draws (pre-BCT, midpoint of BCT, and post-BCT). Additionally, a 7-day dining facility dietary assessment survey was performed on a subset of 49 randomly selected soldiers during the second week of training. Questionnaires were utilized to acquire demographic information, as well as to assess nutrition knowledge and beliefs and food attitudes.

14. SUBJECT TERMS
women, basic training, nutrition, body composition, muscle strength, physical tasks, iron and folate status, injury and illness

15. NUMBER OF PAGES
161

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

Technical Report No. T96-2

HEALTH, PERFORMANCE, AND NUTRITIONAL STATUS OF U.S. ARMY WOMEN DURING BASIC COMBAT TRAINING

[1]Kathleen A. Westphal, LTC, Ph.D., M.P.T.
[3]Karl E. Friedl, MAJ, Ph.D.
[1]Marilyn A. Sharp, M.S.
[2]Nancy King, LTC, Ph.D., R.D.
[4]Tim R. Kramer, Ph.D.
[5]Katy L. Reynolds, LTC, M.D.
[1]Louis J. Marchitelli, M.S.

[1] Occupational Physiology Division, [2] Military Nutrition Division,
[5] Occupational Medicine Division
Occupational Health and Performance Directorate
U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

[3] Army Systems Hazards Research Program
U.S. Army Medical Research and Materiel Command
Fort Detrick, MD 21702-5012

[4] Vitamin and Minerals Laboratory
Beltsville Human Nutrition Research Center
U.S. Department of Agriculture
Beltsville, MD 20705

November 1995

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

This was a multifaceted study which required the assistance of many individuals. Most notably, the personnel assigned to the 1/28th Infantry Battalion at Fort Jackson, South Carolina, made many allowances in order to assure the success of this study. CPT Greg Gaweda and 1SG John Bonner deserve the highest of accolades for their tolerance in dealing with such an intrusion into their daily training schedule. Similar applause is due each and every member of the cadre for their considerable flexibility and support. The foundation for this excellent assistance was established through the guidance and encouragement of LTC Bill Fields, CPT Kevin Palgutt, and CSM Alphonsa Smith.

Other individuals at Fort Jackson also served in pivotal roles over the duration of this study. The invaluable insight of LTC John McNally and CPT Sheila Taylor of the 1/20th Reception Battalion was instrumental in the successful acquisition of subjects. 1LT Margaret Kinney and CPT Regina Bass of the Fort Jackson USAMEDDAC deserve gratitude for assisting in providing critical laboratory technical assistance. The absolutely gracious treatment which we received from the supervisors and staff of the 1/28th dining facility was remarkable and without precedent.

No study of this magnitude and duration can even be initiated without considerable logistical support. MAJ Jessie White of DPTM at Fort Jackson provided us with all of the guidance and introductions necessary to secure a site for data collection. Ms. Leah Meador and Mr. John Cecerio then helped us in the maintenance of the site over the subsequent weeks of the study.

Besides these individuals from Fort Jackson, many personnel from within our own ranks deserve special recognition. The nutrition assessment portion of the study was particularly personnel and energy intensive. All members of the nutrition data collection team expended lengthy hours gathering, verifying, and filing the dietary intake data. This team was composed of Susan H. Boquist, Deborah A. Jezior, MAJ Ronald L. Shippee, Dr. Catherine Champagne, and SSG Josia S. Gamble as visual estimators; Joanne E. Arsenault, LTC T. Clifton Murphy, Susan M. McGraw, Doris E. Sherman, and Kevin D. Gilley as recipe specialists; and David Corn and MAJ Ronald L. Shippee who assisted with data entry and computer support. Recognition is due Carol J. Baker-Fulco for training the recipe specialists, and Joanne E. Arsenault and Susan M. McGraw for training the visual estimators. Besides these training tasks, Joanne E. Arsenault and Susan M. McGraw were also responsible for nutritional analysis of the recipes and designing the nutrient data base. Susan H. Mutter designed, administered, and analyzed the "Background Questionnaire", which provided considerable valuable information during data analysis. The efforts of all of these individuals are greatly appreciated.

Once data collection was completed, the lengthy analysis phase had to be confronted. Several key individuals deserve awards for patience and perseverance, as the primary investigators attempted to address a multitude of questions from an oftentimes unwieldy data base. Those individuals who were particularly instrumental in the statistical analysis phase were Susan H. Boquist, who examined the nutritional intake information, and SGT Bradley Nindl, who managed the performance data. LTC Joseph R. Dettori and SGT Julie Barnes provided many answers regarding injury and illness inquiries. The following individuals were responsible for the collecting of blood samples and the analysis of blood biochemistries: Dr. Richard Tulley and staff, Pennington Biomedical Research Center, Baton Rouge, LA, and Elaine Christenson, and SPC Sabrina Carson. Statistical support was provided by Boston Biostatistics Inc.

EXECUTIVE SUMMARY

This study was undertaken to examine the relationship(s) between health, nutrition, body composition, and physical performance in female soldiers during the 8 weeks of basic combat training (BCT). The study investigated female soldiers assigned to three platoons within a single all-female basic training company over the period of 22 March 1993 to 20 May 1993 at Fort Jackson, South Carolina. Volunteer soldiers participated in pre-training (pre-BCT; 174 original volunteers with a mean age of 21.4 yrs) and post-training (post-BCT; 158 successful BCT graduates) performance and body composition testing, as well as three separate blood draws (pre-BCT, mid-point of BCT, and post-BCT). Additionally, a 7-day dining facility dietary assessment survey was performed on a subset of 49 randomly selected soldiers during the second week of training. Questionnaires were utilized to acquire demographic information, as well as to assess nutrition knowledge and beliefs and food attitudes.

HEALTH

The health of the soldiers was monitored through a review of sick call visits and clinical analysis of blood samples.

Medical Records Review

One or more injuries were incurred by 66.7% of the soldiers, with 89% of these resulting in additional time lost from duty. Overuse injuries were the most frequently reported injury (74.1%) and resulted in the greatest number of lost duty days. One or more illnesses were incurred by 57.0% of the soldiers, with 13% of these resulting in additional lost time from duty. Gynecological conditions were the most frequently reported illness (34.3%). Low pre-BCT fitness, lower age, alcohol consumption, and cigarette smoking were all found to increase the risk of injury in this population.

Biochemical Analysis

Unlike the significant findings of immunosuppression observed in studies of

more intensive Army training involving energy deficits, this current study of female basic trainees suggested an improvement in cell-mediated immunocompetence, an aspect of immune function, over the BCT period. T-lymphocyte proliferative responsiveness was improved, and systemic production of interleukin-6 was enhanced.

Iron deficiency was determined to be more prevalent in this population of military female soldiers than in similar cohorts of civilian females. The prevalence of iron-deficiency anemia within the general non-pregnant civilian female population is reported to approximate 10%. However, analysis of the hematological data from this current study revealed a pre-BCT prevalence of 15%, which increased to 19% post-BCT. A relationship was also seen between poor iron nutriture and poor aerobic performance on the Army Physical Fitness Test. Serum folate levels, which are felt to reflect recent folate intake, were determined to be low normal and declined significantly over BCT.

NUTRITION

Nutritional intakes showed a reduction in the percentage of energy from fat from 34% in 1988 to 32% in 1993. Dietary cholesterol was up 12% , in spite of its reduction in the menu. The difference was accounted for by the higher consumption of visible eggs in 1993. Sodium intake decreased from 1792 mg/1000 kcal in 1988 to 1541 mg/1000 kcal in 1993, mainly through a decrease in table salt usage. Mean intakes of < 100% MRDA were noted for vitamin B_6, folic acid, calcium, magnesium, iron, and zinc in 1993.

Nutrition knowledge was not significantly different between the female soldiers that entered BCT in 1988 and those that entered in 1993. The improvements seen in the nutritional intake of female soldiers in 1993 were most likely due to the passive intervention of modifying the menu, not to the individual choices. Nutritional education remains the cornerstone for motivating soldiers to adopt healthier eating practices.

The majority of soldiers fell well within the normal range on all assessed scales of an Eating Disorder Survey.

The menu that was provided to the soldiers over a 7-day period was determined to be adequate in energy content, but inadequate in the provision of certain micronutrients. These nutritional deficits may have had an effect upon particular performance parameters, since poor iron intake was associated with slower 2-mile run times. No comparable association was observed between iron intake and cell-mediated immunity. In fact, proliferative responsiveness appeared to be enhanced.

BODY COMPOSITION

There was a very small, but significant, increase in weight over BCT (0.8 kg), which included a significant decline in total body fat (1.2 kg) and increase in fat-free mass (2.0 kg). Changes in each of these parameters were dependent on pre-BCT body fat status. The fatter the soldier pre-BCT, the greater the likelihood that she would lose fat; soldiers > 25% body fat tended to lose while leaner soldiers gained fat. Because most soldiers gain lean mass, only the most overfat pre-BCT soldiers (i.e., >35% body fat) lost weight. Fat-free mass increased significantly for all soldiers, regardless of pre-BCT body fat status. The female Army circumference equation received a rather favorable review in a couple of respects. First, the soldiers who were classified as overfat by the Army circumference equation appeared to be appropriately categorized when compared with dual energy X-ray absorptiometry measurements. Second, analysis of the various circumference equations used by each of the military services suggested that the hip and wrist circumference measurements that are used in the Army equation are indeed key correlates of female fatness. Despite these positive observations, the equation was also found to have some inadequacies. First, it appeared to underestimate body fat (which many would not consider a significant detriment to the soldier). And second, probably due to the fortuitous deposition of adipose in areas that preclude discovery by the hip measure, of the Army equation (i.e., abdomen), many overfat women were overlooked. Therefore, the equation appears to be relatively accurate in assessing the body fat of women who preferentially deposit fat in a peripheral pattern, but is limited in the accurate assessment of fat in those women who preferentially deposit fat in more of a central pattern. This, too, may not be the problem it seems, because these women tended to also be stronger than the women who are correctly predicted to be overfat.

Though BCT may have increased the physical activity level of many of the soldiers, this increased energy demand did not necessarily result in a weight loss. This is an important observation since, despite the requirement that individuals meet the weight-for-height standards IAW AR 40-501 prior to entering BCT, 28.4% of this class of 174 basic trainees failed to meet these standards at the time of the pre-BCT data collection. Eight weeks later, 17.9% of the successful graduates failed to meet these same standards. Interestingly, however, excess weight was not associated with performance deficits, nor with the presence of increased cardiovascular risk factors.

PHYSICAL PERFORMANCE

All assessed strength and performance measures improved pre- to post-BCT, but performance was somewhat dependent upon body composition. Soldiers who exceeded the Army body fat standards were as strong or stronger than those soldiers who were in compliance with this regulation. This same trend was observed with each of the service-specific female body fat equations; regardless of the equation, the fatter group of soldiers, which was also heavier, was stronger on the machine lift, bench press, and military press, and produced more power during the vertical jump. Also, soldiers with a higher body mass index regardless of fatness, or higher waist-to-hip ratio also performed better on these strength-oriented tasks. Conversely, correlations between performance and body composition variables revealed poor relationships between regional fat-free mass and the events of the Army Physical Fitness Test (APFT), suggesting that the APFT events are not highly representative of muscle strength or power, but instead are better indicators of muscular endurance and aerobic capacity. These data highlight that fat-free mass, not fat, is the aspect of body composition that predicts performance of a task involving strength and/or power. This is important since military occupational specialties (MOS) are classified based upon strength or lifting requirements, not endurance or power.

The results of this study suggest that the basic combat training environment elicits an improvement in body composition, as reflected by decreases in fat and increases in fat-free mass, and concomitant improvements in physical performance. However, the positive changes in physical performance were not adequate for all soldiers to be able to successfully achieve the physical demands required of their chosen military occupational specialty.

INTRODUCTION

Congressional legislation (the Women's Armed Services Integration Act of 1948) mandated the permanent status of women in all the armed services. Later changes eliminated some of the restrictions that were initially part of the 1948 Act. These changes occurred because of the need for the military services to find alternative sources of personnel during times of demand, and were aided by parallel social and political movements that were directed at eliminating discriminatory treatment of women in the armed forces.

These inclusion policies did not consider if inclusion of women would have a deleterious effect upon the health and performance of these soldiers. Most of the rules and regulations that governed the training and billeting of the soldier were predicated upon a male fighting force. For example, when Congress mandated gender integration of the military academies in 1977, female cadets were confronted with a regimen that had been designed for males. Female physique and physiology had not been a necessary variable in the training equation prior to that time. When issues surrounding pregnancy in the military were reversed, the decisions were based largely upon legal questions of gender discrimination regarding unfair loss of livelihood. No immediate data were available to provide answers as to whether, and how, training guidance should be altered for the pregnant and postpartum soldier. When previously restricted military occupational specialties began to open to females, the assignment of MOSs to Department of Labor physical categories was based upon minimal actual knowledge of the physical task requirements.

In each of these cases, legal action has dictated a major administrative change within the military services. It is now incumbent upon the services to seek the scientific evidence upon which they should base future training guidance. This would require a considerable increase in the number of research studies that examine the physical fitness of the female soldier. Since physical fitness involves many factors, it cannot be adequately described by assessing a single measure (such as the APFT). This current investigation attempts to describe the fitness of a small group of female soldiers, the basic combat trainee, through simultaneous analysis of several variables: health, performance, and nutritional status.

Health is no less a multidimensional construct than is physical fitness. In this study, general health was assessed through examination of the basic trainees' medical records for information about the occurrence of injuries and/or illnesses over the period of basic training. Training-related injuries are the leading cause of morbidity in military medical treatment facilities (Jones et al., 1988; Cowan et al. 1988; Jones et al., 1992; Jones et al., 1993). Most of these injuries are caused by physical training and/or vigorous operational training activities and often result in hospitalization. Physical training is considered an essential element of combat readiness, since it is integral to the development and maintenance of the physical fitness required for the performance of various military tasks. Operational training activities are equally important, since they provide the soldier the opportunity to function in a simulated combat environment. So, the primary issue regarding training-related injuries is a need to determine the level of fitness and skill necessary to minimize injury rates and concomitantly produce a combat-ready soldier. To do this requires information on the incidence and types of injuries associated with vigorous physical military activities, as well as knowledge about the causes and risk factors for these injuries.

Several recent military studies have identified a number of risk factors for training injuries. Jones et al. (1993) demonstrated a higher incidence of injuries in older male trainees, and other military studies have found the same to be true for stress fractures (Brudvig et al., 1983; Gardner et al., 1988). Results are varied regarding differences in body size. For example, individuals with either a very high, or very low, body mass index have been shown to be at greater risk for injury (Jones et al., 1992; Jones et al., 1993). This has been shown to be true for both men and women. Low levels of physical fitness, especially low aerobic fitness, appears to be a risk factor for injury among both male and female military trainees (Jones et al., 1992; Jones et al., 1993). Since physical training is a major component of basic training, and since basic training is intended to be a shared introductory experience of all enlisted personnel, it is very important to determine if there may be any gender differences in the effects of this training upon injury and illness incidence rates.

Health was also examined through analysis of blood biochemical and immunological variables, with a special emphasis on immunological status. It has been shown that energy-deficit alone (Field et al., 1991; Holm and Palmblad, 1976), or in combination with high levels of strenuous exercise (Moore et al., 1992) cause suppressed immune responses, whereas adequate energy intake combined with moderate exercise promote heightened immune responses (Soppi et al., 1982). T-lymphocyte activation _in vitro_ (i.e., cellular proliferation, cytokine [interleukins] production, and release of soluble interleukin [IL] receptors [IL-R]) is an established method for determining the immune potential of individuals. These activities can be determined in T-lymphocytes stimulated with specific vaccine antigens or a plant lectin such as phytohemagglutin (PHA). The immunological objective of this study was to determine the effects of BCT on T-lymphocyte activation immune responses _in vitro_ in female basic trainees.

Body composition also provides valuable health information. For example, excess adipose tissue or, perhaps more importantly, differences in the distribution of adipose tissue have been found to be important predictors of cardiovascular morbidity and mortality (Lapidus et al., 1984). A positive relationship has also been shown to exist between body weight and bone mineral density (Dawson-Hughes et al., 1987). Within the military services, body composition is also used as a presumption of competence; i.e., a soldier who is excessively fat may not be able to perform a task or skill. Body composition assessment of the female service member is performed through the use of different measures by each of the various uniformed services due to differences of opinion about which site(s) of female fat deposition should be measured. However, the measures used for assessment of body composition in males are consistent between the military services. These are reasonably accurate and also work to predict change in body fat. The validity of the female circumference equations and of the military services association with health and performance goals of the services Weight Control Programs need to be similarly established.

Most studies that have investigated military physical performance have involved only male soldiers, and this information has subsequently been extrapolated to females, often without appropriate rationale. The lower upper-body strength in women compared to men has been a cause of concern in the assignment of women to some MOSs. In fact, the topic of physical strength and endurance was one of the primary

primary issues reviewed by members of the 15-person Presidential Commission when they studied the assignment of women in the armed forces (Presidential Commission, 1992). It was their recommendation that some sort of gender-neutral occupational strength testing be developed for certain MOSs, although strength testing will clearly discriminate against women because of the inherent differences in strength between genders. Additional concern regarding the ability of women to meet the physical requirements for specific fields was voiced when Army Secretary Togo West suggested opening more MOSs to females.

With the increasing involvement of women in sports and fitness activities, it is important to determine if women entering the Army today are of equal, or greater, strength than those examined in previous studies. By measuring strength before and after basic combat training, it may be possible to determine if adequate attention is being given to this essential element of job performance. Pre- to post-BCT measurements will also shed light on the correlation between changes in body composition and changes in muscle strength.

The science of nutrition today is very dynamic in its contribution to health and particularly to the prevention of many illnesses. The nutritional intake, requirements, and nutritional status of males have been assessed in many military studies, but comparable information about female service members is lacking. Separate studies have documented the nutritional intake, decreased fat weight, and increased aerobic capacity and strength in women basic trainees at Fort Jackson (Rose et al., 1987, 1989a), but no investigation has examined how these changes affect the health status of these women.

From 1948 to 1969, approximately 1% - 2% of the armed forces was composed of women, and most of these individuals served in health care and clerical positions. However, women currently comprise 12.0% of active-duty military personnel and 12.6% of Army active-duty personnel (as of Dec 31,1993), and these women are serving in a wide range of occupational specialties. Standards and strategies for the protection and sustainment of these women should be established on the basis of sound scientific rationale. It is the purpose of this current study to expand this knowledge base for policy makers.

METHODS

EXPLANATION OF BASIC COMBAT TRAINING

The Basic Combat Training (BCT) Course is an 8-week program designed to provide an individual with "soldierization skills." Upon arrival at Fort Jackson, soldiers are initially in-processed at a reception battalion where they fulfill various administrative requirements, such as the initiation of various personnel, finance and medical records; fitted for uniforms; receive immunizations; and assessed for their ability to perform push ups.

All males must be able to perform 13 push-ups, while all females must be able to perform 1 push-up in order to progress to a training company from the reception battalion. If a soldier is not able to achieve these minimum push up standards, he or she is assigned to the fitness training company. While assigned to the fitness company, the soldier is provided fitness instruction, as well as time to work on fitness activities. These fitness activities include aerobic and anaerobic exercises, but push-up performance remains the standard by which a soldier is assessed for advancement to BCT. A trainee has up to 21 days to successfully achieve the push-up standards of the fitness company. Females must perform 6 push-ups while males must perform 20. If a soldier is unable to achieve these standards, he or she is separated from the Army on grounds of not meeting medical fitness standards (Chapter 11 separation; Department of the Army, 1990a).

A soldier's length of stay at the reception battalion generally is at least 3 days in duration in order to allow adequate time for administrative in-processing. However, the length of stay may be extended depending upon the "fill rate," or the arrival of enough soldiers to "fill" a training company. Once this fill has been established, soldiers are assigned and transported to a training company. Upon arrival at the training company, they are randomly assigned to platoons within the company. The soldiers are billeted with the other members of their platoon within a bay in a barracks facility, with the exception of any nights spent in a field environment. Each platoon of soldiers is supervised by at least two assigned drill sergeants, who direct training and enforce standards of physical, personal, and professional performance. All soldiers follow the same schedule each day (Table 1), with the exception of those individuals who are assigned to kitchen patrol, or those who report to sick call.

Table 1. Typical daily BCT schedule.

TIME	ACTIVITY
0430-0500	Wake-up
0500-0600	Physical training
0600-0700	Personal hygiene
0700-0800	Breakfast
0800-1100	Road march and/or classes
1100-1230	Lunch
1230-1730	Road march and/or classes
1730-1900	Dinner/Training meeting
1900-2000	Drill sergeants' time/Personal hygiene
2000-2100	Personal time
2100	Lights out

Graduation from BCT requires proficiency in: (1) Basic Rifle Marksmanship (BRM), (2) the APFT, and (3) the End of Cycle Individual Proficiency Test (EOC IPT), as well as the demonstration of appropriate military bearing and interpersonal behavior. Demonstration of proficiency in BRM requires attainment of a score of at least 23 out of a possible 40 hits. Considerable time is devoted to training for this task; soldiers are provided practice in the use of an M16 rifle on various firing ranges under different environmental conditions. Successful completion of the APFT requires attainment of a score of 50% on each of the three APFT events on the EOC APFT. In preparation for this test, the soldiers participate in daily (except Sunday) organized, supervised physical training which is approximately one hour in duration. The focus of this daily training alternates between an emphasis on aerobic and cardiovascular conditioning and an emphasis on anaerobic and strengthening activities. Additionally, soldiers may participate in some voluntary individual physical fitness training during some of the some of the evening and Sunday hours. The BCT schedule allows three testing opportunities for the cadre and command to evaluate fitness levels prior to the EOC APFT. These three tests are graded by the drill sergeants of the training company, while the EOC APFT is graded by noncommissioned officers not assigned to the training company. The EOC IPT includes tasks in which the soldier is instructed over the course of BCT (Table 2). Comparable to the EOC APFT, these tasks are graded by noncommissioned officers not assigned to the training company.

Table 2. Tasks in which a soldier must demonstrate proficiency in order to receive a passing grade on the EOC IPT.

Tasks	
1. Put on, wear, and remove a protective mask	11. Evaluate a casualty
2. Nerve agent antidote to self	12. Splint a suspected fracture
3. Recognize/react to an NBC hazard	13. Perform mouth-to-mouth resuscitation
4. Decontaminate skin and equipment	14. Clear an object from throat
5. Nerve agent antidote to buddy	15. Correct malfunctioning M16A1/A2
6. Determine magnetic azimuth	16. React to challenge and password
7. Measure distance on a map	17. Employ a claymore mine
8. Apply field pressure dressing	18. Prepare AT-4 for firing
9. Put on a tourniquet	19. Misfire procedures for AT-4
10. Treat for shock	20. Battle sight zero M16A1

EXPERIMENTAL DESIGN

This project was designed as a descriptive correlational study, concerned with describing general characteristics of female basic trainees and comparing variables of interest among the soldiers. The study examined female soldiers assigned to D Company, 1/28 Infantry Regiment at Fort Jackson, South Carolina. The dates of the class extended from 29 March 1993 to 20 May 1993. Prior to beginning BCT, the inductees were administratively in processed through the 120th AG Battalion at Fort Jackson where they were introduced to the intent and objectives of the project by study investigators. These briefings were provided by the same briefers on two occasions to audiences of approximately 125 individuals each. Besides receiving written and verbal information regarding the purposes and duration of the study, the women were also informed that participating in the study would have no effect, positive or negative, on BCT. Volunteers were also told that they retained the right to withdraw from the study at any time without penalty. Pregnancy was the only exclusion criteria.

The general schedule for this study is shown in Figure 1. After giving their written informed consent, the 174 volunteers participated in a pre-training (pre-BCT) test phase which consisted of approximately four hours of performance and body composition testing per individual. Each participant also completed a questionnaire at this time. In order to accommodate all of the participants, as well as the schedule at the reception battalion, this pre-BCT test phase took place over a period of four days immediately prior to the beginning of BCT. The morning of one of these days was devoted to drawing fasted blood samples from the soldiers, followed by time for breakfast and lunch prior to afternoon testing of performance and body composition. In order to determine changes occurring during BCT, all baseline tests were repeated just prior to graduation (post-BCT), and an additional blood draw was performed at the mid-point of BCT (mid-BCT). A nutrition data collection team performed a 7-day dining facility dietary assessment survey on a subset of 49 randomly selected soldiers during the second week of training.

At the time the soldiers actually began BCT, they were randomly assigned to three platoons of an all-female basic training company (platoons 1, 3, and 4). An

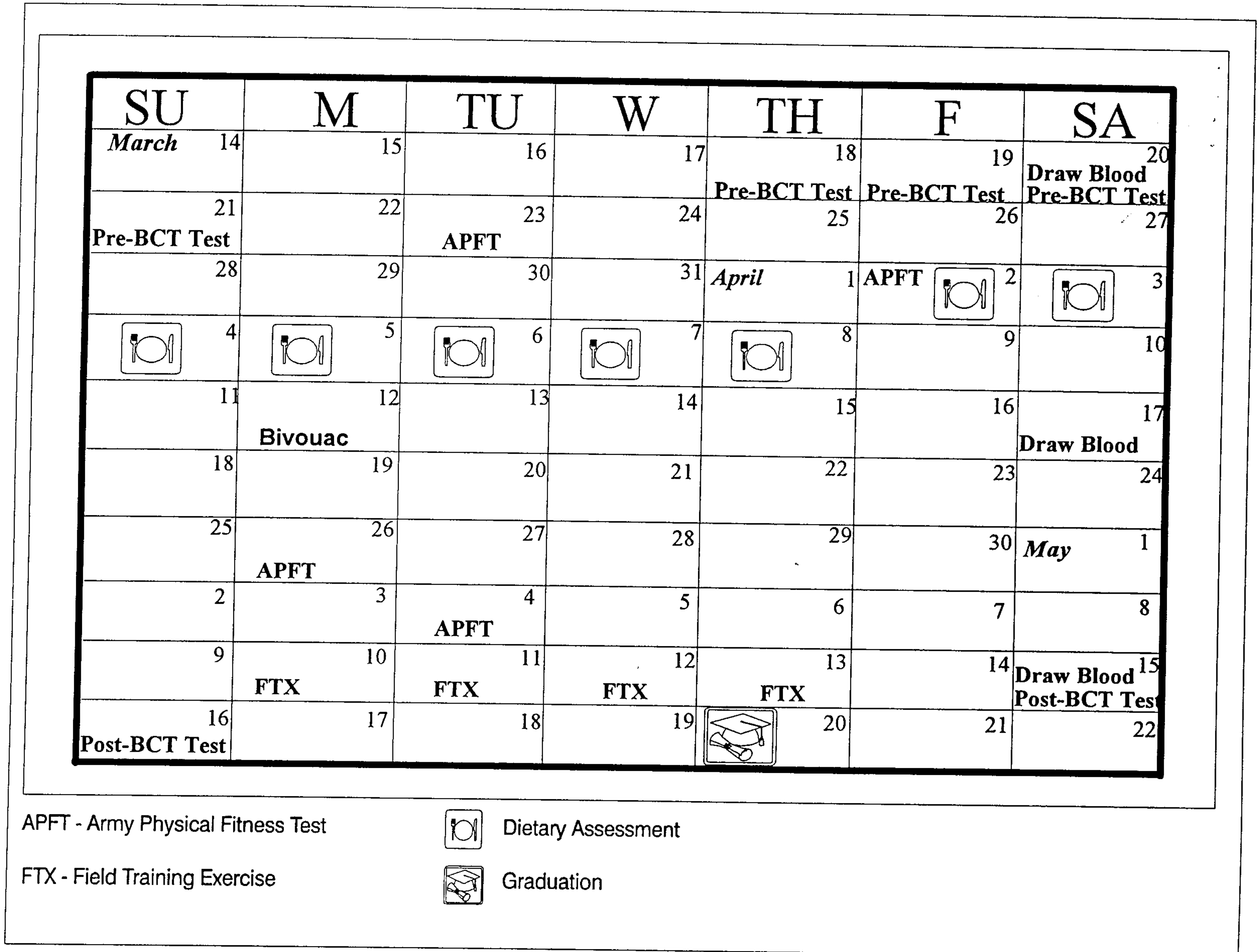


Figure 1. General study schedule.

additional platoon (platoon 2) consisted of study nonparticipants. There were no differences in the schedules or training events for the participant and nonparticipant platoons. The only variation between platoons was in the management styles and methods of instruction employed by the different drill instructors. Two of the four platoons had female drill instructors (Table 3). All other individuals assigned to D Company, with the exception of the supply sergeant, were males.

Table 3. Platoon cadre distribution and number of assigned soldiers.

PLATOON	DRILL INSTRUCTORS		NUMBER OF ASSIGNED SOLDIERS	
	Male	Female	Pre-BCT	Post-BCT
#1	1	1	58	55
#2 (nonparticipants)	***3***	***0***	***54***	***41***
#3	2	1	58	50
#4	2	0	59	53

TEST SUBJECTS

This study was reviewed and approved by the USARIEM Human Use Review Committee, the Human Use Review Office at USAMRDC, and was conducted IAW USAMRDC Reg No. 70-25 (USAMRDC, 1989) and AR 70-25 (Department of the Army, 1990c).

The original study population consisted of 174 female volunteers. Of these 174 volunteers, 158 of the study participants successfully completed BCT. No soldier requested to be removed from the study. The reasons for attrition from the course are explained in Table 4. Participant population demographic information is in Table 5.

Table 4. Reasons for BCT attrition based upon AR 635-200.

PLATOON (size)	REASON FOR SEPARATION			TOTAL
	Chapter 2[1]	Chapter 5-13[2]	Chapter 5-11[3]	
1 (58)	0	1	2	3
2 (54)	3	0	10	13
3 (58)	0	2	5	7
4 (59)	4	0	2	6
TOTAL (PARTICIPANTS ONLY)	4	3	9	16
TOTAL (INCLUDING NONPARTICIPANTS)	7	3	19	29

[1]Medical problem was determined to exist prior to service.
[2]Personality disorder.
[3]Did not meet procurement medical fitness standards.

Table 5. Soldier demographics.

Variable	Participant Beginners (n=174)	Participant Finishers (n=158)	Nutrition Group (n=49)	Medical Records Group (n=164)
Age (years) (mean±SD; range in ( ))	21.4±3.4 (17-33)	21.4±3.5 (17-33)	21.2±3.4 (18-31)	21.4±3.5 (17-33)
Weight (kg) (mean±SD; range in ( ))	62.2±9.0 (46.3-89.6)	62.9±8.1 (45.7-87.9)	63.4±9.2 (48.1-87.5)	62.2±9.0 (46.3-89.6)
Height (cm) (mean±SD; range in ( ))	162.9±6.5 (150.3-183.4)	163.2±6.4 (150.4-185.7)	165.4±6.8 (154.9-188.0)	162.9±6.5 (150.3-183.4)
Initial body fat_{DEXA} (%) (mean±SD; range in ( ))	31.0±6.4 (7.2-44.9)	28.5±5.6 (13.7-39.6)	31.9±5.9 (20.1-42.8)	30.9±6.2 (17.0-44.9)
Body mass index (kg/m^2) (mean±SD; range in ( ))	23.4±2.6 (17.1-29.8)	23.4±2.6 (17.1-29.8)	23.8±2.5 (18.7-29.3)	23.4±2.6 (18.3-29.8)
Ethnicity (*first figure represents absolute number; second figure in parentheses represents population percentage*)				
Nonhispanic white	100 (57.5)	90 (57.0)	32 (65.3)	93 (56.7)
Black	44 (25.3)	40 (25.3)	11 (22.4)	43 (26.2)
Hispanic	22 (12.6)	21 (13.3)	5 (12.2)	21 (12.8)
Asian	2 (1.1)	1 (0.6)	0	1 (0.6)
Native American	2 (1.1)	2 (1.3)	0	2 (1.2)
Other	4 (2.3)	4 (2.5)	0	4 (2.4)
Marital Status (*first figure represents absolute number; second figure in parentheses represents population percentage*)				
Single (never married)	136 (78.2)	127 (80.4)	40 (81.6)	132 (80.5)
Married	26 (14.9)	21 (13.3)	4 (8.2)	21 (12.8)
Widowed/Divorced	10 (5.7)	9 (5.7)	4 (8.2)	10 (6.1)

Table 5. Soldier demographics (continued).

Variable	Participant Beginners (n=174)	Participant Finishers (n=158)	Nutrition Group (n=49)	Medical Records Group (n=164)
Did not respond	2 (1.1)	1 (0.6)	1 (2.0)	1 (0.6)
Education Level (*first figure represents absolute number; second figure in parentheses represents population percentage*)				
High school or GED	107 (62)	94 (60)	29 (59.2)	102 (62)
Some college	65 (37)	62 (39)	19 (38.8)	60 (37)
Some postgraduate	2 (1)	2 (1)	1 (2)	2 (1)
Prior Pregnancy Status (*first figure represents absolute number; second figure in parentheses represents population percentage*)				
Ever pregnant	61 (35)	52 (33)	16 (33)	54 (33)
Never pregnant	113 (65)	106 (67)	33 (67)	110 (67)

ENVIRONMENTAL CONDITIONS

Temperature, humidity, and precipitation data for the duration of the study (as provided by the National Weather Service in Columbia, South Carolina) are reflected in Figures 2 and 3.

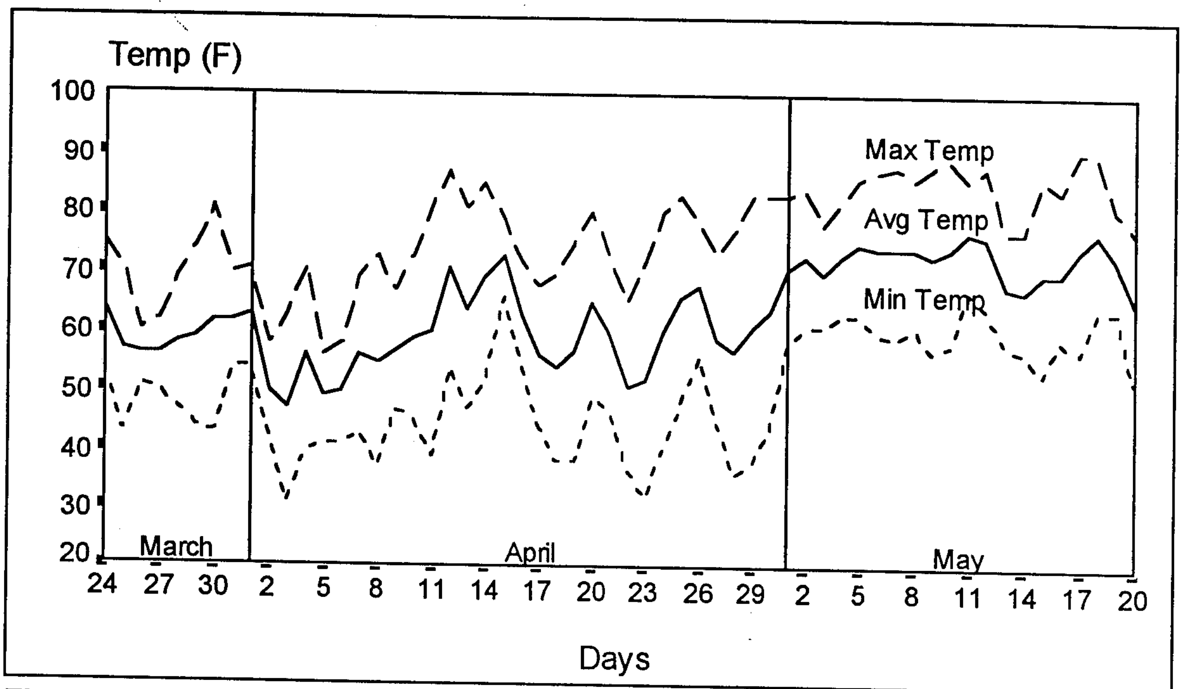


Figure 2. Maximum, average, and minimum temperatures during BCT.

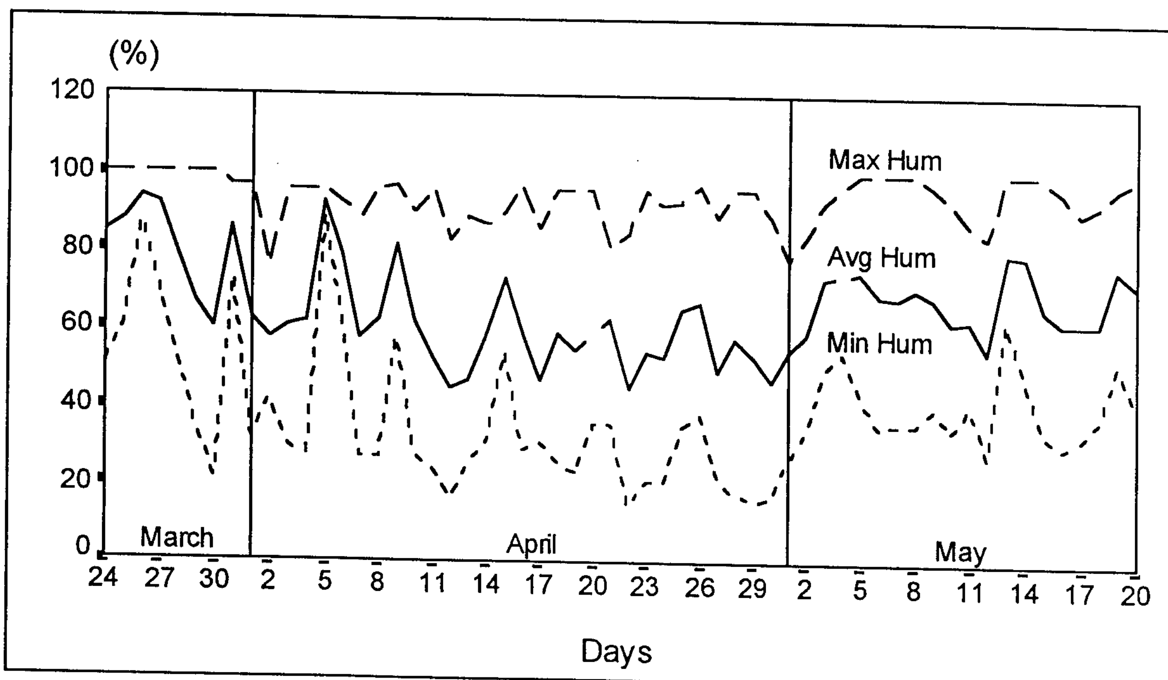


Figure 3. Maximum, average, and minimum humidities during BCT.

NUTRITION

Dietary Assessment

A randomly selected subsample of 49 soldiers voluntarily participated in the dietary assessment portion of this study. Food and fluid intakes of these soldiers were determined for all meals (3 meals per day) over a period of 7 consecutive days, during the second week of BCT. Assessment of other intake was done by asking questions regarding food and fluids consumed between meals or away from the designated dining facility (i.e., hospital dining facility).

All meals provided during this time were A-rations[1] served cafeteria-style. Though most of these meals were consumed in the 1/28th dining facility, four of the seven lunch meals were served in a field environment. This meal format was no different from the format provided to any other basic training company involved in the second week of training.

Trained data collectors (*recipe specialists*) observed the preparation of food for all meals provided over this 7-day period, regardless of whether the meal was to be served in the dining facility or the field environment. Although the Armed Forces Recipe Service (Departments of the Army, Navy, and Air Force, 1989) was utilized by the Food Service Contractor, occasional recipe modifications were necessary. The recipe specialists recorded the recipes and documented preparation methods. They also noted any modification in the type and/or amount of ingredients.

Food and fluid intakes were determined using a modified visual estimation method, which has been previously validated (Rose et al., 1987; Schnakenberg et al., 1987). Data collectors trained in this method (*visual estimators*) worked in the dining facility and at the field site during meal service hours, assessing dietary intake of the participant soldiers. The visual estimators estimated the amount of food on a soldier's

---

[1] The A-ration consists of perishable foods. It is used in garrison dining facility settings or when food service personnel and equipment, including refrigeration, are available in the field environment (NRDEC, 1992).

tray by visually comparing portion sizes to pre-weighed standards. These pre-weighed standards were provided by the recipe specialists and were available to the visual estimators throughout each meal assessment period. Each soldier was directed to show her tray to the same visual estimator immediately before and after eating each meal, at which time food intake was recorded. If the visual estimator determined that the soldier had consumed less than half of any selected food portion, the soldier was asked the reason for the lack of consumption. These reasons were recorded in one of eight categories: (1) not hungry, (2) do not like, (3) sickness, (4) not enough time, (5) saving food for later, (6) dieting, (7) too full, or (8) food was cold.

The data collected by the recipe specialists (i.e., recipe data files) and the visual estimators (i.e., dietary intake data) were then combined to calculate nutritional intakes (energy, protein, fat, carbohydrate, vitamin C, thiamin, riboflavin, niacin, vitamin B_6, folic acid, vitamin B_{12}, vitamin A, calcium, phosphorus, magnesium, iron, zinc, potassium, and sodium) using the Computerized Analysis of Nutrients (CAN) System developed at USARIEM (Rose et al., 1989b). The macronutrient distribution (percentage of energy provided by carbohydrate, protein, and fat) was also determined.

A more comprehensive report and discussion of the nutrient intake methodology used in this study has been published elsewhere (King et al., 1994).

Food Attitudes

Eating attitudes, feelings, and behavior as they relate to food, eating, and self-image were assessed using the Eating Disorder Inventory (Garner et al., 1983) . This survey was administered before and after BCT in order to determine if the soldiers had altered their attitudes toward food over the eight weeks of training. This 64-item questionnaire asks the respondent to assess statements as being true for herself using a 6-point scale (6 = "always," 5 = "usually," 4 = "often," 3 = "sometimes," 2 = "rarely," 1 = "never"). The 64 questions are separated into eight scales: (1) *Drive for Thinness*, (2) *Bulimia*, (3) *Body Dissatisfaction*, (4) *Ineffectiveness*, (5) *Perfectionism*, (6) *Interpersonal Distrust*, (7) *Interoceptive Awareness*, and (8) *Maturity Fears*. Interpretation of the results of this survey are based upon the comparison of individual scores on the various scales with established mean scores received by individuals with known eating disorders as determined by a previous validation of the test (Garner et al., 1983). For example, receipt of a score at or above the mean score received by diagnosed anorexics on the *Drive for Thinness* scale may be an indication of preoccupation with weight. However, this preoccupation with weight is considered to be "exceptional" only if the respondent scores at or above the mean score for diagnosed anorexics on the *Drive for Thinness, Bulimia*, and *Body Dissatisfaction* scales. Scores at or above the mean scores for known anorexics on at least five of the eight scales indicate tendencies toward eating disorders.

Nutrition Knowledge and Beliefs

Nutrition knowledge and beliefs were assessed using the nutrition knowledge and beliefs section from the Nutrition Knowledge, Attitudes, and Awareness Questionnaire used in the Fort Jackson dietary assessment in 1988 (Rose et al., 1989a). This questionnaire was selected to allow the comparison between nutrition knowledge and beliefs of women entering BCT in 1988 with that of women entering BCT five years later. This questionnaire, which consists of 21 nutrition knowledge questions and 7 to 10 nutrition beliefs questions (7 questions on the pre- and 10 questions on the post-assessment questionnaire), was administered before and after BCT in order to determine if the soldiers' nutrition knowledge changed over the course of BCT. (During the 8-week BCT, the soldiers receive one 1-hour briefing on nutrition and are exposed to nutrition posters and table tents in the dining facility.) The 21 nutrition knowledge questions are divided into 14 multiple choice and 7 true or false questions. Three nutrition beliefs questions asked the soldier to choose the food from a number of paired foods that would help them practice better nutrition. For the other seven nutrition belief questions, the soldier expressed either agreement or disagreement on a 5-point scale (1 = "strongly disagree," 3 = "neutral or undecided," and 5 = "strongly agree").

Field Feeding Issues

Field feeding issues were assessed using a questionnaire designed to capture information pertinent to the soldier's field feeding experience during a Field Training Exercise (FTX). This questionnaire was administered after the completion of the FTX. The questionnaire ascertained if the soldiers perceived that they ate less during the FTX and, if so, identified possible reasons for the decreased food consumption.

BODY COMPOSITION ASSESSMENT

Total Body Composition

Total body composition was determined by dual-energy X-ray absorptiometry (DEXA) (DPX-Plus, LUNAR Corp., Madison, WI), soft tissue and bone mass analyses pre- and post-BCT (Mazess et al., 1990). The DEXA instrument was packed, moved, set-up, and calibrated at the test site by a manufacturer's representative. Dressed in shorts and a T-shirt, the soldier was placed in a supine posture on a DEXA scanner table. She was carefully positioned so that her head, trunk, and pelvis were aligned. Her hands were pronated. Approximately 45° of femoral external rotation was maintained through the placement of separate Velcro straps around the knees and around the forefeet. Beginning with the scanner positioned at the soldier's head, each soldier was scanned in progressive 1 cm horizontal slices with the machine set to the "fast" 10 minute scanning speed. For each soldier, approximately 6000 pixels of data were analyzed using the LUNAR® 3.6 version software (LUNAR Corp., Madison, WI), which produced measurements of body fat, total fat-free mass, and bone density.

Bioelectrical Impedance Spectroscopy

Bioelectrical impedance spectroscopy (BIS) was measured pre- and post-BCT. Four gel-backed electrodes were applied to the dorsal surface of the right hand and foot (two to each). An electrical current of 200 µA was applied to each soldier using a Model 4000B Complex Bio-impedance Spectrum Analyzer (Xitron Technologies). The length of the cables used to carry this current was less than 2.5 m, in order to minimize the equipment-induced phase offset. Measurements were begun within 2 minutes after the soldier assumed a supine position on a nonconductive pad. Maintenance of this posture did not exceed 5 minutes. To prevent possible confounding of the data, collection of BIS data never immediately followed the DEXA measurements (i.e., after 10 minutes in a recumbent posture). Resistance, reactance, impedance, and phase measurements were automatically recorded for 25 frequencies between 3 KHz and 1.35 MHZ. Analyses of the data were performed using predictive equations for fluid compartments derived for single, dual, and multiple frequency measurements.

Stature and Other Linear Measurements

Stature and other linear measurements were measured only once, pre-BCT. Measurements of standing height, sitting height, and arm span were measured by standard U.S. Army methods (Gordon et al., 1989).

Body Weight

The body weight of each soldier was documented pre- and post-BCT, as well as on a daily basis during BCT. These daily measurements were done throughout BCT, with the exception of Sundays and days when training precluded availability of soldiers (i.e., bivouac, FTX, kitchen patrol). Calibrated scales and data clipboards were maintained within each platoon area, where each soldier weighed herself while wearing PT shorts and T-shirt immediately after the evening meal. Recording of the weights was done under the supervision of one of the study investigators or the platoon sergeant. The weight data sheets were collected and reviewed by a study investigator on a daily basis.

Anthropometric Measurements

Anthropometric measurements were performed pre- and post-BCT. These measurements included 15 circumferences (neck, shoulder, chest, natural waist, abdomen at the navel, iliac crest, hips, thigh, biceps flexed, biceps, forearm, wrist, knee, calf, and ankle) and 9 skinfold thicknesses (chest, subscapular, triceps, biceps, midaxillary, supra iliac, abdominal, thigh, and calf). Circumference measurements were done in duplicate using a fiberglass tape measure, while skinfold thicknesses were made in triplicate using Harpenden calipers. All measurements were made on the right side of the body. These data were used to estimate body fat through the use of the seven commonly used "generalized" female equations (Vogel & Friedl, 1992), and to estimate changes in the primary sites of subcutaneous adiposity (thighs, buttocks, abdomen, upper trunk, and upper arm).

STRENGTH AND PERFORMANCE TASK TESTS

Maximal Lifting Strength

Maximal lifting strength was measured pre- and post-BCT. The test simulated lifting a box with handles from ground level onto a 2-1/2 ton truck. Soldiers lifted handles attached to the carriage of a weight stack machine vertically from 20 cm to 152 cm. The soldier began the lift in a bent-knee position with her head up and back straight. The load was accelerated upward by straightening the legs and pulling up on the handles of the load carriage, which were held in an overhand grip. The wrists were rotated under the handles, and the load was pressed up to the 152 cm mark on the vertical guides. The initial load of 18.2 kg was increased in 4.5 kg increments until the soldier began to exhibit difficulty (Sharp & Vogel, 1992; McDaniels et al., 1983). Subsequent increases were 2.3 kg, until the soldier was unable to complete the lift (Stevenson et al., 1995). Unlike previous studies, soldiers were allowed to rest between lift attempts and were provided with detailed instructions on lifting technique.

Bench Press and Military Press

Bench press and military press were conducted using a Calgym weight stack machine pre- and post-BCT. For the bench press, the soldier was supine on a padded bench, grasped the machine handles and straightened her arms vertically. To perform the military press, the soldier was seated on a padded chair with a back support. She grasped the handles of the machine at shoulder height in an overhand grip and pushed the handle upwards fully extending the elbows. For both of these tests, soldiers began with a load of 5 to 10 kg. Subsequent lifts were increased by increments of 2 to 4 kg, until the soldier was unable to complete the lift.

Vertical Jump

Vertical jump was measured pre- and post-BCT. For the performance of this test, the soldier's right fingertips were marked with chalk. She stood next to a wall marked with a metric scale, and reached as high as possible with her right hand while keeping her heels on the floor and her left arm at her side. The highest point reached was recorded as the standing reach height. The soldier swung her arms down while assuming a shallow squatting position, then swung her arms upward, jumped as high as possible, and touched the wall at the peak of the jump. The chalk mark made at the peak of the jump was recorded. The vertical jump score was the difference in centimeters between the two chalk marks. Several practice jumps were allowed, followed by three trial jumps. The vertical jump score was used to calculate peak power (PP) (Harman et al., 1991):

$$PP(W) = 61.9 \times \text{jump height(cm)} + 36.0 \times \text{body mass(kg)} - 1822 \qquad (1)$$

Load Carriage Task

Load carriage task capability was assessed pre- and post-BCT by having the soldier carry an 18.2 kg (40 lb) metal box along a 91.4 m (100 yd) course as quickly as possible. The soldier assumed a self-selected starting position behind the starting line. The box was held in both arms in front of the body. The soldier carried the box from the starting line, around a cone, back to the starting line and placed the box on a table. A stop watch was started at the end of the starting instruction "three, two, one, go," and was stopped when the soldier replaced the box on the table. The soldier was verbally encouraged to move as quickly as possible. The time to complete the course was recorded in seconds and converted to velocity in meters per second ($m \cdot s^{-1}$) by dividing 91.4 m by the time to complete the task (sec).

Torque Task

The torque task was conducted pre- and post-BCT using a calibrated 350 ft-lb capacity torque wrench placed on a stationary 1-1/16 inch bolt mounted 10 inches from the edge of a large wooden box. The soldier stood in front of the box, and square pieces of ½ inch plywood were placed under her feet to raise her to axillary level with the top of the box. One-inch pads were placed between the soldier and the box so that the dominant arm of the soldier was straight when gripping the handle of the torque wrench. The torque wrench was placed at a right angle to the soldier, extending outward on the dominant side. (The soldier's dominant side was determined by asking her if she was right- or left-handed. If the soldier stated that she was ambidextrous, the preferred side was used.) The soldier gripped the torque wrench with the dominant hand at a point 12 inches away from the center of rotation. The non-dominant hand was placed on the wrench at the center of rotation. In response to the cadence "3-2-1, pull," the soldier pulled maximally on the handle of the torque wrench while maintaining contact against the box with her knees and hips. Soldiers were instructed to build to maximum within two seconds and then hold this position briefly. A follow-up arm maintained the maximum reading on the torque wrench. Soldiers completed three trials with a minimum of one minute rest between trials. The two highest trials within 10% of one another were averaged for the final score. Additional trials were conducted if two trials were not within 10% of one another.

CLINICAL BIOCHEMISTRY

Blood samples were collected at three points during the study (Figure 1; pre-BCT, mid-BCT, and post-BCT) for the biochemical assessment of nutritional status. The day prior to each collection of blood samples, soldiers were reminded that no food or fluid (except plain water) was permitted after 2100 hours on each of the evenings preceding the blood draws. Three separate 15 ml samples were collected into vacutainers: one 15 ml blood sample was taken to provide serum, and two 15 ml blood samples (EDTA and heparin as anticoagulants) were taken to provide unclotted whole blood, plasma, and erythrocytes. Following collection, blood samples were kept cool until processing (completed within 4 - 5 hours). Serum (or plasma) and cells were separated and the different blood fractions frozen (-20° C) until analysis.

Stored blood fractions were analyzed for nutrients and indicators of metabolic status, serum lipids, hematological status, clinical liver function tests, and vitamin and mineral status. Most of these tests were performed on a Beckman Synchron CX5 using colorimetric tests according to the manufacturers' recommendations (Beckman Instruments, La Brea, CA). Short-term indicators of metabolic status included uric acid, total proteins, albumin, glycerol, and nonesterified fatty acids. Serum cholesterol was measured using a cholesterol oxidase method and HDL-cholesterol was measured by the same method following precipitation of VLDL- and LDL-cholesterol with dextran sulfate. LDL-cholesterol was calculated using the Friedewald equation. Hematological parameters were measured using a field-portable Coulter counter (COULTER® Electronics, Inc., Hialeah, FL). Iron was measured in serum using ferroZine iron reagent after release from transferrin with acetic acid and reduction with hydroxylamine and thioglycolate. TIBC was assessed by measurement of total bound ferric iron by the same method following saturation of transferrin with ferric chloride and removal of excess iron with an alumina column. Ferritin was measured by enzyme immunoassay (Abbott Laboratories, Abbott Park, IL). Haptoglobin was measured in serum by rate nephelometry using Beckman specific protein analyzers. Liver function tests included total bilirubin, lactate dehydrogenase (LDH), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and gamma glutamyl transferase (GGT). Serum electrolytes were measured with ion selective electrodes (sodium, potassium, and chloride). Serum minerals were measured by colorimetric tests (calcium by Arsenazo III method, magnesium by calmagite method, phosphorus by phosphomolybdate method) on the Synchron CX5. Routine chemistries were verified daily with standard quality control procedures and standardization was confirmed by participation in the College of American Pathologists Survey.

Vitamin status was measured by direct assay or by biochemical indices summarized in Table 6. Retinol was extracted in hexane and measured by HPLC uv detection. Thiamin, riboflavin, and vitamin B_6 were assessed by sensitive _in vitro_ erythrocyte assays, where the addition of vitamin to the erythrocytes produces a stimulation of specific vitamin-dependent enzymes, with the level of enzyme stimulation corresponding to the vitamin status; the methods used were adapted from Bayoumi &

Rosalki (1976) and Vuilleumier et al. (1990). Vitamin B_{12} and folic acid were measured using radiolabelled ligand assays (BioRad); vitamin B_{12} and folic acid were measured in serum.. To measure whole blood and red cell folate, whole blood (previously diluted 1:11 with 0.4% [w/v] ascorbic acid) was mixed 1:2 with a protein diluent; endogenous binding proteins were inactivated with diothreitol and cyanide, and folic acid was measured by competition in a radio assay using folate binding protein-coated beads (BioRad Quantaphase IIB-12/folate radio assay). Red cell folate was calculated from the whole blood values, divided by hematocrit/100. Ascorbic acid was measured by colorimetric assay using o-phenylenediamine and ascorbate oxidase; plasma samples were stabilized at the time of collection using metaphosphoric acid and dithiothreitol. Unusually low baseline values were obtained for ascorbic acid in this study due to an unidentified problem in the preservation and/or assay of these samples which yielded undetectable levels. Vitamin 25-hydroxy-D was measured by a double antibody radioimmunoassay procedure after serum extraction with acetonitrile (Incstar Corporation, Stillwater, MN). Other markers of vitamin D status (calcium and phosphorus) were measured as described above. Some of these methods have been reported in more detail in Moore et al. (1992).

Serum estradiol, progesterone, and 17α-hydroxyprogesterone were measured in direct radioimmunoassay procedures with commercially available kits (DPC, Los Angeles, CA). Sex hormone binding globulin was measured in baseline samples of all women using a double-antibody radioimmunoassay (Farmos, Oulunsalo, Finland). Osteocalcin levels were measured in a randomly drawn subsample of women and in all women with suspected stress fractures using a direct radioimmunoassay procedure (IncStar Corporation, Stillwater, MN).

Table 6. Biochemical indicators used to assess vitamin and mineral status.

Vitamin/Mineral	Biochemical Indicators
Vitamin A (retinol)	Serum retinol concentration
Thiamin	Functional test: *in vitro* stimulation of erythrocyte transketolase by thiamin pyrophosphate
Riboflavin	Functional test: *in vitro* stimulation of erythrocyte glutathione reductase by flavin adenine dinucleotide
Vitamin B_6 (Pyridoxal phosphate	Functional test: *in vitro* stimulation of erythrocyte aspartate aminotransferase by pyridoxal-5'-phosphate
Vitamin B_{12} (cobalamin)	Serum cobalamin concentration
Folacin	Erythrocyte folate Serum folate
Vitamin C (ascorbic acid)	Plasma ascorbic acid concentration
Vitamin D (25-hydroxy cholecalciferol)	Serum Vitamin-25-hydroxy-D_3 Serum ionized calcium Serum total phosphorus
Magnesium	Serum total magnesium
Iron	Serum total iron Serum total iron binding capacity (TIBC) Serum ferritin

PREPARATION OF T-LYMPHOCYTE ACTIVATION CULTURES

At each collection point, an additional 7 ml of blood was drawn for immune studies from the same 49 soldiers who were randomly selected to participate in the nutrition dietary data collection. The blood was collected in a sodium heparinized (143 USP units) VACUTAINER® (Becton Dickinson VACUTAINER® Systems, Rutherford, NJ; No. 6527, Lot No. 2Z025) tube and maintained at ambient temperature (18-27° C) for approximately 20 h prior to preparation for *in vitro* cell culture. Delayed processing was necessary to allow time for transport of the blood from Fort Jackson to the Immunology Laboratory in Beltsville, MD. Plasma for interleukin-6 (IL-6) quantitation was removed from packed cells at approximately 30 h post collection. The plasma was stored at -70° C until analysis.

The blood was diluted 1:4 with RPMI-1640 tissue culture media (Sigma Chemical Co., St. Louis, MO, Cat. No. R-8758) in polystyrene tubes (FALCON[R], No. 2003, Becton Dickinson Labware) for preparation of lymphocyte proliferation cultures. The RPMI-1640 contained L-glutamine at 2.0 mmol/L and penicillin-streptomycin at 100,000 U/L and 0.1 mg/L, respectively; referred to hereon as RPMI-1640. The *in vitro* culture for T-lymphocyte proliferation responsiveness received in order: 50 μL of 1:4 diluted blood per well of round bottom 96-well tissue culture plates (Corning Glass Works, Corning, NY, Cat. No. 258550); 50 μL of RPMI-1640 alone (unstimulated background) or with designated amounts of phytohemagglutinin-P (PHA-P; Sigma Chemical Co., St. Louis, MO, Cat. No. L-8754, Lot No. 92H-9565-1) or tetanus toxoid (TT; Connaught Laboratories International, Willowdale, Ontario, Canada, Lot No. TAS303); and 100 μL of RPMI-1640. The cultures contained a final volume of 200 μL, with the blood dilution at 1:16.

T-lymphocyte proliferative activity *in vitro* was based on median DNA incorporation of tritiated thymidine (methyl-^{3}H; specific activity 6.7 μCi, 248 GBeq/mmol, DuPont, New England Nuclear, Boston, MA) by cells in triplicate cultures without (unstimulated background) and with stimulant. PHA-P was added to the cultures at 0.5, 2 and 4 μg per culture. TT was added at 3.2, 6.4, and 12.8 Lf per culture. Cultures stimulated with PHA-P were incubated for 72 h, and those with TT for 144 h, at 37°C in a 5% CO_2, 95% humidified air incubator. ^{3}H-thymidine (1.0 μCi; 37 KBeq) was added to each culture 24 h prior to termination of incubation. The cell cultures were harvested onto 12-well filtermats (Skatron Inc., Sterling, VA., Cat. No. 11731). The filter discs with 4.5 ml of scintillation fluid (READY-SAFE[R], Cat. No. 158735, Beckman, Columbia, MD) were counted in a beta scintillation counter (Beckman LS 3801). Proliferative activity of T-lymphocytes is expressed as mean DPM plus standard error.

Cells for release of soluble interleukin-2 receptor (sIL-2R) were cultured in 4.0 ml polystyrene culture tubes (FALCON, Cat. No. 2003) with 200 μL of blood per tube. The unstimulated cultures (control cultures) received 200 μL of RPMI-1640 alone, and the stimulated cultures received 150 μL of RPMI-1640 plus 50 μL of RPMI-1640 containing 16 μg of PHA-P. The cultures were incubated for 48 h, at which time the supernatants were removed and stored at -70 C. The budget has not permitted analysis of the culture supernatants for sIL-2R.

Interleukin-6 (IL-6) present in the plasma was quantitated by the Quantikine Immunoassay (R & D SYSTEMS, Minneapolis, MN; Cat. No. D6050, Lot No. 9332118).

INJURY AND ILLNESS DATA

Documentation of injuries and illnesses was performed by the same physician on two different occasions. The initial documentation was done during the third week of training, while the second one was performed during the last full week of the training cycle. At the completion of these two documentation periods, 165 of 174 (94.8%) medical records had been reviewed. For each visit, the following information was recorded: (1) date of visit, (2) verbatim diagnosis, (3) body system involved, (4) body part and affected side, and (5) disposition and total limited duty days resulting from the injury or illness.

Definition of specific terms was done prior to data collection. An *injury* or *illness* was defined as any medical complaint that was reported during BCT and resulted in at least one visit to a medical treatment facility. *Traumatic injuries* were specified as injuries resulting from a single event (e.g., twisting an ankle while on a road march). *Overuse injuries* were defined as neuromusculoskeletal complaints of an insidious onset caused by cumulative trauma (which included stress fractures, stress reactions, tendonitis, fascitis, etc.). A *time-loss* injury or illness was defined as a complaint that resulted in at least a 24-hour period of medically restricted activity that was prescribed by a credentialed health care provider.

STATISTICAL ANALYSIS

Means, standard deviations, and ranges were calculated for all variables. Quartiles and quintiles were used to develop categorical measures from continuous effects and covariates.

Personnel from the Boston Biostatistics Research Foundation, Inc. (Phillip T. Lavin, Ph.D. and Karen S. Fung, M.A.) assisted in the statistical analysis of the investigation of the effects of various measurements on certain outcomes of interest. When necessary, principal component analysis was performed to identify similar groups of variables. Forward and backward regression was then performed to determine the strength of relationships.

The cumulative incidence (percentage) of individuals experiencing injuries or illnesses was calculated by dividing the number of soldiers with one or more injuries or illnesses by total number of soldiers with available medical records. Cumulative incidence was also calculated and reported for specific types of injuries and illnesses and body parts.

For risk factor analysis, risk ratios for injury were calculated by dividing the percentage of individuals with one or more injuries in a risk group by the percentage in a reference group. For continuous variables such as number of pushups and two-mile run times, soldiers were divided into three groups from low to high, slow to fast, etc., in the following way: the mean for each variable was calculated, and the individuals who were one or more standard deviations above or below the mean formed the high and low groups, respectively. This roughly equated to 18% at each extreme. Where concordant scores prevented an exact 18% cutoff, the closest discordant score was chosen as the cut point.

Chi-square tests were used to compare risk groups and test for significance of differences in injury incidence. Confidence intervals (95%) for risk ratios were also calculated, and ratios significant at 0.05 level were footnoted.

RESULTS AND DISCUSSION

DIETARY ASSESSMENT

Menu Nutritional Analysis

Table 7 shows the mean daily nutrient content (over the 7 days), nutrient density, and percent of the MRDA supplied by this menu. Since the dining facility offered the same menu for both male and female soldiers, the daily mean energy content of the menu was very high, especially for the female soldier. However, the nutrient density of the menu provided suboptimal levels of some nutrients. In particular, the menu did not provide sufficient amounts of vitamin B_6, folic acid, calcium, iron, magnesium, and zinc, according to the standards in AR 40-25 (1985). A menu of this nutrient density would require a female soldier to consume more than her energy requirement (which ranges from 2000 to 2800 kcal) in order to achieve optimal intake of all required nutrients. However, it would be difficult for most female soldiers to consume that amount of energy without gaining weight.

Analysis of the menu macronutrient distribution revealed that 12.8% of the energy was provided by protein, 33.4% by fat, and 56.1% by carbohydrate. In the 1988 study, the menu macronutrient distribution was 14.3% protein, 37.9% fat, and 50.1% carbohydrate (Rose et al., 1989a). The menu cholesterol content decreased from 1299 mg in 1988 to 928 mg in 1993. The sodium content was reduced from 1731 mg/1000 kcal in 1988 to 1640 mg/1000 kcal in 1993.

These favorable menu changes in fat, cholesterol, and sodium content suggest that the Department of the Army Military Nutrition Initiatives, which are consistent with national health objectives, may be having a positive influence (CMNR, 1991). These initiatives were first introduced into the Armed Forces Recipe Service, the Army Master Menu, and the Army Food Service Program in 1985 in an attempt to provide soldiers with diets lower in fat, cholesterol, and sodium.

Table 7. Mean daily menu nutrient content, nutrient density, and percent of Military Recommended Dietary Allowances[1].

Nutrients	Amount (Mean)	Nutrient Density (per 1000 kcal)		% of MRDA
		Study Menu	Recommended[2]	
Energy, kcal	5344	--	--	223
Protein, g	170.8	32	33	214
Fat, g	198	37	--[3]	--
Carbohydrate, g	749	140	--	--
Vitamin C, mg	244	46	25	407
Thiamin, mg	2.7	0.5	0.5	223
Riboflavin, mg	3.2	0.6	0.6	228
Niacin, mg	37.9	7.1	6.7	237
Vitamin B_6, mg	2.3	0.4	0.8	116
Folic Acid, mcg	564	106	167	141
Vitamin B_{12}, mcg	11.2	2.1	1.3	372
Vitamin A, IU	20379	3814	1665	509
Calcium, mg	1759	329	417	220
Phosphorous, mg	2785	521	417	348
Magnesium, mg	616	115	125	205
Iron, mg	32.9	6.2	7.5	183
Zinc, mg	22.7	4.2	6.3	151
Potassium, mg	6498	1516	--	--
Sodium, mg	8765[4]	1640	--	--
Cholesterol, mg	928	174	--	--

[1]Military Recommended Dietary Allowances (MRDA) for female soldiers aged 17-50 years (AR 40-25, 1985). [2]Nutrient Density Index (AR 40-25, 1985). [3]No MRDA established denoted by "--." [4]Discretionary items, such as table salt, were not included on the menu analysis.

The most noticeable difference between the 1988 and 1993 menus was a change in the fat content of the milk provided in the bulk containers (2% low-fat milk in 1988 versus 1% low-fat milk in 1993).

Nutritional Intake

The wide range in nutritional intakes during this study suggests that the mean intake of certain nutrients by some individuals was suboptimal (Table 8).

Table 9 depicts how well the various nutrients analyzed in the 1988 and the 1993 studies met MRDA standards (as established for female soldiers). It also suggests that the macronutrient distribution was more closely aligned with the Military Nutrition Initiatives in 1993. It is particularly important to note that differences between the 1988 and 1993 data bases may preclude strict comparisons. For example, the limitations in the 1988 nutrient data base that prevented analysis of nutrients such as vitamin B_6, folic acid, magnesium, zinc, and potassium were rectified in the 1993 data base. Because of these differences, the mean nutritional intakes that appear to be less in 1993 cannot be substantiated. For instance, the lowest mean intake in 1988 was 91% for calcium, while in 1993 it was 65% for folic acid. Although the mean energy intake in 1993 was 108% of the MRDA, these soldiers did not consume enough food to meet their MRDA for vitamin B_6, folic acid, calcium, magnesium, iron, and zinc, which were 76%, 65%, 73%, 89%, 90%, and 73% of their respective MRDA.

The Military Nutrition Initiatives include recommendations for a reduction in fat intake to 30% or less of total energy by 1998, a reduction in cholesterol intake to less than 300 mg/day by 1993, and a reduction in sodium consumption to no more than 1400-1700 mg/1000 kcal. In spite of a reduction in fat energy contribution from 34% in 1988 to 32% in 1993, mean dietary cholesterol intake was approximately 12% higher in 1993 (466 mg/d, or an additional 48 mg/soldier/day). This increase in cholesterol intake was actually worse than these numbers suggest when one further considers the changes made by the USDA when the cholesterol value of eggs was lowered from 548 mg/100 g to 422 mg/100 g in 1989. Consideration of these differences in cholesterol values would mean that the 466 mg observed in 1993 would have been equivalent

Table 8. Mean and range of daily nutrient intakes of female soldiers during BCT (n=49).

Nutrients	Mean ± SD	Minimum	Maximum
Energy, kcal	2592 ± 500	1294	4388
Protein, g	82.1 ± 18.3	29.9	131.8
Fat, g	94 ± 25	43	190
Carbohydrate, g	365 ± 69	166	568
Vitamin C, mg	89 ± 38	10	208
Thiamin, mg	1.8 ± 0.4	0.7	2.9
Riboflavin, mg	2.0 ± 0.6	0.9	3.6
Niacin, mg	20 ± 5	6	43
Vitamin B_6, mg	1.5 ± 0.5	0.4	3.1
Folic Acid, mcg	261 ± 74	88	425
Vitamin B_{12}, mcg	5.6 ± 4.9	1.3	23.8
Vitamin A, IU	6951 ± 6214	2271	35919
Calcium, mg	728 ± 321	380	1763
Phosphorous, mg	1296 ± 339	602	2227
Magnesium, mg	267 ± 69	106	506
Iron, mg	16.2 ± 3.5	6.5	27.0
Zinc, mg	10.9 ± 2.6	3.3	17.5
Potassium, mg	2681 ± 670	1066	4547
Sodium, mg	3994 ± 819	2055	6630
Saturated Fat, g	30 ± 7	16	51
Monounsat Fat, g	34 ± 10	16	71
Polyunsat Fat, g	17 ± 7	7	49
Cholesterol, mg	466 ± 169	145	763

Table 9. Comparison of mean daily nutritional intakes and %MRDA of female soldiers during BCT in 1988 (n=40) and in 1993 (n=49).

Nutrients	MRDA[2]	1988 (Mean ± SD)	%MRDA	1993 (Mean ± SD)	%MRDA
Energy, kcal	2000-2800	2467 ± 560	103	2592 ± 500	108
Protein, g	80	96 ± 22	120	82.1 ± 18.3	103
Fat, g	--[2]	94 ± 34	--	94 ± 25	--
Carbohydrate, g	--	318 ± 74	--	365 ± 69	--
Vitamin C, mg	60	165 ± 117	275	89 ± 38	148
Thiamin, mg	1.2	2 ± 0.6	167	1.8 ± 0.4	148
Riboflavin, mg	1.4	2.2 ± 0.7	157	2.0 ± 0.6	144
Niacin, mg	16	27 ± 7.4	169	20 ± 5	128
Vitamin B_6, mg	2.0	-[3]	-	1.5 ± 0.5	76
Folic Acid, mcg	400	-	-	261 ± 74	65
Vitamin B_{12}, mcg	3.0	3.7 ± 1.5	123	5.6 ± 4.9	187
Vitamin A, IU	4000	8450 ± 6690	211	6951 ± 6214	174
Calcium, mg	800-1200	907 ± 428	91	728 ± 321	73
Phosphorous, mg	800-1200	1600 ± 392	160	1296 ± 339	130
Magnesium, mg	300	-	-	267 ± 69	89
Iron, mg	18	18.4 ± 7	102	16.2 ± 3.5	90
Zinc, mg	15	-	-	10.9 ± 2.6	73
Potassium, mg	--[4]	-	-	2681 ± 670	-
Sodium, mg	--[5]	4420 ± 1158	--	3994 ± 819	--
Cholesterol, mg	--[6]	418 ± 219	--	466 ± 169	--
% Protein[7]	--	16	--	12	--
% Fat[7]	--	34	--	32	--
% Carbohydrate[7]	--	52	--	56	--

[1]Military Recommended Dietary Allowances for female soldiers aged 17-50 years (AR 40-25, 1985). [2]No MRDA established denoted by "--." [3]Data not recorded denoted by "-." [4]Estimated safe and adequate potassium intake is 1875-5625 mg. [5]Target for sodium is 1700 mg/1000 kcal. [6]Suggested cholesterol maximum intake is 300 mg (CMNR, 1991). [7]Military feeding suggests 11%-16% protein, 50%-55% carbohydrate (AR 40-25, 1985) and ≤30% fat (CMNR, 1991).

to 504 mg using the 1988 standards. This increase in dietary cholesterol appeared to be primarily attributed to the increased consumption of visible eggs, which suggests that nutrition education programs need to stress moderation in egg consumption as well as emphasize low cholesterol breakfast alternatives.

The decreased consumption of dairy cholesterol (11% in 1988 versus 5% in 1993) was offset by the cholesterol from the increased egg consumption. The decrease in dairy cholesterol intake can be attributed to the intake of milk with less fat, and/or to a decreased intake of dairy foods. This difference may have contributed to the reductions in fat and cholesterol intake.

Mean sodium intake decreased from 1792 mg/1000 kcal in 1988 to 1541 mg/1000 kcal in 1993, which is well within the guidelines of 1700 mg/1000 kcal. This decrease was mainly due to a decrease in table salt usage (4% in 1988 versus 1.7% in 1993). More than half of the soldiers (65.3%) reported following a low salt diet.

Total fat intake was less in 1993 than in 1988. Table 10 divides the soldiers for the two studies by absolute and relative numbers into groups based upon food energy fat intake. In 1988, most of the soldiers (40%) had a fat intake of 35% to 39% of total energy from fat, while in 1993 most of the soldiers (46.9%) had a fat intake of 30% to 34%.

Table 10. Absolute and relative number of soldiers obtaining specified percentages of food energy from fat.

Percentage of total energy from fat	1988 (n=40)	1993 (n=49)
<25%	0	3 (6.1%)
25-29%	9 (23%)	11 (22.4%)
30-34%	12 (30%)	23 (46.9%)
35-39%	16 (40%)	9 (18.4%)
40-44%	3 (7%)	3 (6.1%)
≥45%	0	0

For those nutrients for which inadequate intake was noted, determination was made of the numbers of soldiers with intakes less than selected levels of the MRDA (Table 11). Even though study mean nutrient intakes were marginal at worst, some soldiers had mean intakes less than 60% of the MRDA, which could potentially put them at nutritional risk. These data underscore the importance of apportioning data into MRDA levels in order to best detect individuals who may be at higher risk of developing nutritional deficiencies.

The large number of soldiers with inadequate folic acid intake is of concern since this nutritional deficiency has been associated with neural tube defects. This makes folic acid of particular concern to pregnant women (Scott et al., 1990). It has been suggested that adequate folic acid intake is essential from at least four weeks before conception through the first three months of pregnancy (Rush & Rosenberg, 1992). Although it is unlikely that U.S. Army female soldiers would become pregnant during BCT, nutritional intake during BCT could potentially have an impact upon embryonic development during the weeks subsequent to BCT.

Inadequate calcium intake during the first three decades of life has been associated with an increased risk of osteoporosis later in life (Heaney, 1988). Mean calcium intake decreased from 907 mg in 1988 to 728 mg in 1993. This was probably due to a decrease in consumption of dairy products (energy provided by the dairy group was 9% in 1988, but only 5% in 1993).

Suboptimal intakes of dietary iron are of concern to military women because negative iron balance has been associated with decrements in physical performance (Gardner et al., 1977; Lukaski et al., 1991). Mean iron intakes decreased from 18.4 mg in 1988 to 16.2 mg in 1993. In 1988, none of the soldiers consumed <70% of the MRDA for iron, but 10% of the soldiers consumed <70% in 1993. Since the percentage of energy contributed from meat group/combination dishes and grains was similar between 1993 and 1988, the reason for the lower mean iron intake in 1993 is not evident.

Table 11. Number of soldiers with mean daily intake at selected levels of the Military Recommended Dietary Allowances[1].

Nutrient	1988[2] (n=40)						1993 (n=49)					
	Percent of MRDA						Percent of MRDA					
	<60	60-69	70-79	80-89	90-99	≥100	<60	60-69	70-79	80-89	90-99	≥100
Kilocalories	-	-	-	-	-	-	1	0	4	3	7	34
Protein	-	-	-	-	-	-	2	1	1	8	15	22
Vitamin C	0	1	0	0	0	39	4	1	1	5	1	37
Thiamin	-	-	-	-	-	-	1	0	0	1	0	47
Riboflavin	-	-	-	-	-	-	0	1	1	0	4	43
Niacin	0	0	0	0	1	39	1	0	0	1	6	41
Vitamin B_6	-	-	-	-	-	-	9	11	11	5	9	4
Folic Acid	-	-	-	-	-	-	20	12	6	7	2	2
Vitamin B_{12}	0	0	3	4	5	28	1	2	1	1	5	39
Vitamin A	0	1	1	0	0	38	3	0	3	5	5	33
Calcium	4	8	7	[3]	[3]	21	22	9	4	5	2	7
Phosphorus	-	-	-	-	-	-	0	1	1	2	2	43
Magnesium	-	-	-	-	-	-	4	3	7	15	6	14
Iron	0	0	5	10	5	20	2	3	7	12	10	15
Zinc	-	-	-	-	-	-	9	13	13	6	5	3

[1]Military Recommended Dietary Allowances for female soldiers aged 17-50 years (AR 40-25, 1985); an average was used for those nutrients in which the MRDA is a range.
[2]Inadequate nutrient intakes noted only for vitamin C, niacin, vitamin B_{12}, vitamin A, and iron were reported in this format; vitamin B_6, folic acid, magnesium, and zinc were not assessed in 1988.
[3]Calcium intakes were grouped differently by Rose et al. (1989b); therefore, their >1200 mg and 800-1200 mg groups are included within the ≥ 100% column in this table.

Reasons for Not Eating

The reasons for not eating are shown in Table 12. Of the 8,012 food items selected by the soldiers, 569 were returned with 50% or more of the portion not being consumed. The reasons most commonly given were "not hungry" and being "full."

Table 12. Reasons given for not eating the entire portion of food.

Reason for not eating	Frequency
Not hungry	150
Full	148
Not enough time	129
Do not like	119
Food was cold	12
Sickness	11
Saved food for later	0
Dieting	0

Food Attitudes

Table 13 shows the pre-BCT and post-BCT mean scores for eight measured scales. The results indicated that the 1993 soldiers were neither preoccupied with weight, or possessed tendencies toward eating disorders. Seven of the eight scales were significantly ($p \leq 0.05$) different, with the post-BCT scores consistently lower than the pre-BCT scores. Since the scores were well below the mean scores for known anorexics, these changes appear to be of no clinical significance, but do suggest that the soldiers altered their attitudes toward food and eating over BCT. Specifically, the data suggest the soldiers were less concerned with thinness and body appearance (weight) post-BCT.

Figure 4 depicts each survey scale score frequency distribution for the pre- and post-BCT assessments. This figure shows that, even though the mean scores were well below the mean scores of known anorexics, several soldiers were at, or above,

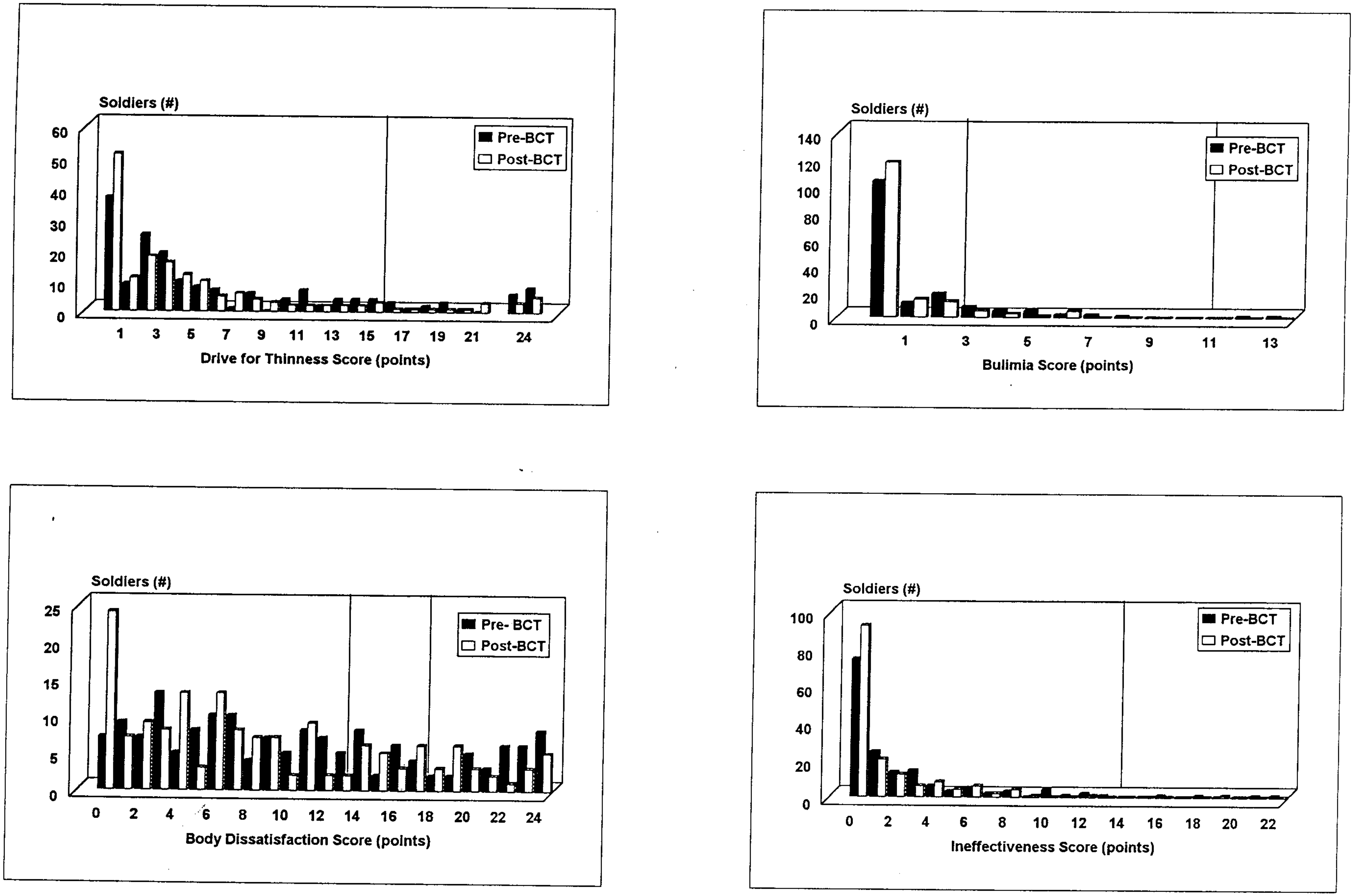
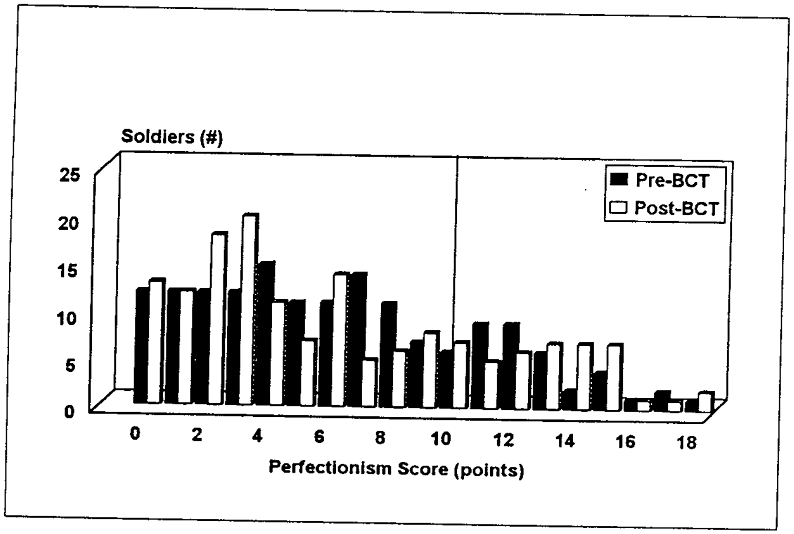
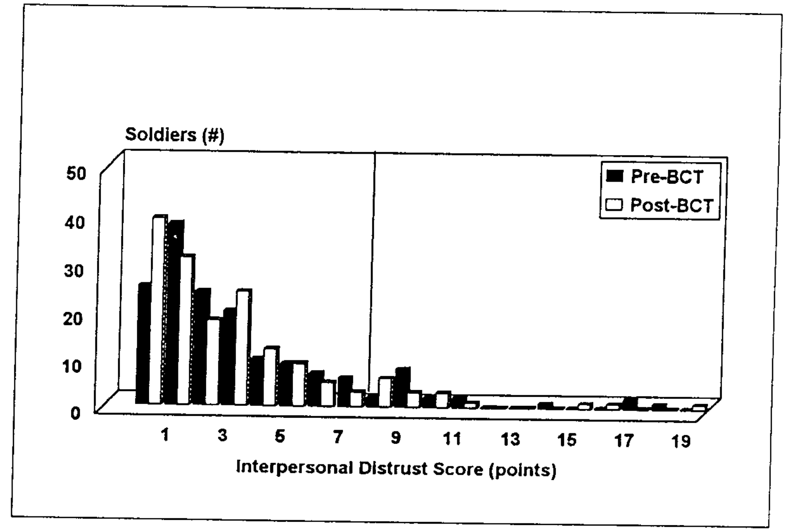
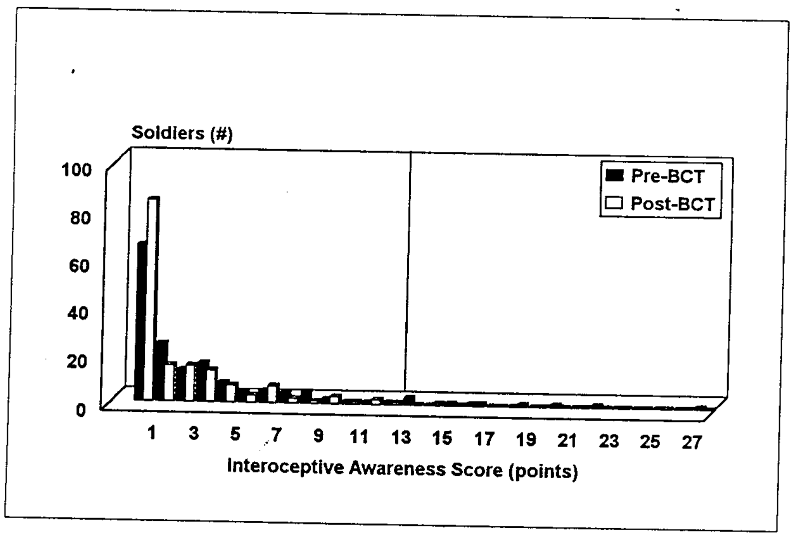


Figure 4. Frequency distributions for eight scales of a food attitude survey assessed pre- and post BCT. Vertical line represents reference score for diagnosed anorexics.







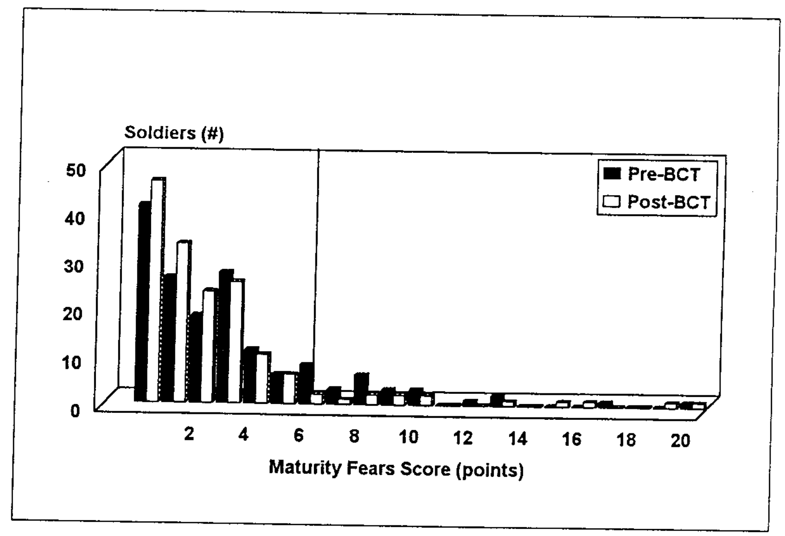


Figure 4 (continued). Frequency distributions for eight scales of a food attitude survey assessed pre- and post-BCT. Vertical line represents reference score for diagnosed anorexics.

these scores. This suggests the possibility that these individual soldiers may have been excessively preoccupied with their weight, or that they may have had a tendency toward an eating disorder.

Table 13. Comparison of scores for eight scales of 1993 pre-BCT and post-BCT food attitudes survey.

	Mean Scores ± SD (n = 157)	
Scale	Pre-BCT	Post-BCT
Drive for Thinness	5.0 ± 5.4	4.1 ± 5.1*
Bulimia	1.1 ± 2.1	0.6 ± 1.4*
Body Dissatisfaction	10.4 ± 7.3	8.5 ± 7.1*
Ineffectiveness	2.5 ± 4.5	1.5 ± 2.7*
Perfectionism	6.4 ± 4.4	6.3 ± 4.9
Interpersonal Distrust	3.3 ± 3.5	2.9 ± 3.3*
Interoceptive Awareness	2.8 ± 4.4	2.0 ± 3.3*
Maturity Fears	3.0 ± 3.4	2.4 ± 3.4*

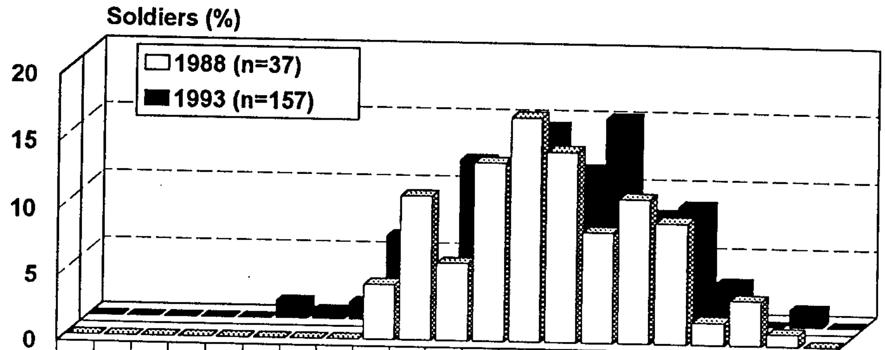
* Significant difference pre- to post-BCT ($p \leq 0.05$).

NUTRITION KNOWLEDGE AND BELIEFS

<u>Comparison of 1988 and 1993 Nutrition Knowledge and Beliefs</u>

Nutrition knowledge was not significantly different between the female soldiers that entered BCT in 1988 (n = 37) and those that entered BCT in 1993 (n = 157). From the 21 nutrition knowledge questions, the total mean scores were 13.9 ± 2.5 and 13.4 ± 2.7 (mean ± SD) for the 1988 and 1993 groups, respectively. This represents a mean percentage of correct response of 66.0 ± 12.0% and 63.6 ± 12.9%, respectively. Figure 5 depicts the distribution of nutrition scores for the 1988 and the 1993 assessments. The 1988 mode was a score of 13, while in 1993 the mode was 15.

No soldier obtained extremely low scores (1 to 5) or a maximum score (21) in either of the assessments. The highest score in both assessments was 20 out of a possible 21. The lowest score in 1988 was 9, while the lowest score in 1993 was 6.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1988 (n=37)	0	0	0	0	0	0	0	0	4.2	10.9	5.9	13.4	16.8	14.3	8.4	10.9	9.2	1.7	3.4	0.9	0
1993 (n=157)	0	0	0	0	0	1.3	0.6	1.3	6.4	3.8	12.1	11.5	14.6	11.5	15.3	8.3	8.9	3.2	0	1.3	0

Nutrition Knowledge Scores (points)

Figure 5. Frequency distributions of nutrition knowledge scores for female soldiers assessed in 1988 (n=37) and in 1993 (n=157).

Table 14 compares the percentage of correct responses from the 1988 and the 1993 assessments. Questions 1 through 14 were multiple choice; questions 15 through 21 were true or false.

Table 15 compares the nutrition beliefs for the 1988 and the 1993 assessments. In general, when deciding which foods to choose to help them practice good nutrition or to lose weight, the percentage of soldiers making the correct choice on the nutrition belief questions was similar between the 1988 and the 1993 groups.

Table 14. Comparison of the 1988 and the 1993 nutrition knowledge scores.

Question	Percent of soldiers with correct response 1988 (n=37)	1993 (n=157)
Q1 Fast foods are high in salt/fat	72	64
Q2 Calcium helps build bones/teeth	96	99
Q3 Protein is found in meat/fish/poultry	87	89
Q4 Carbohydrates are found in grains	37	41
Q5 Lean meats are good source of B vitamins	35	28
Q6 Iron is found in whole grains/red meats	41	46
Q7 Low-fat milk has...	57	54
Q8 Nutrient giving most energy	8	12
Q9 Food in same group as chicken	98	90
Q10 Best choice for a reducing diet	90	90
Q11 Food lowest in salt	65	53
Q12 Daily caloric needs of young females	61	46
Q13 Steak is not a good source of fiber	40	54
Q14 Four major food groups	83	79
Q15 Water is essential	97	98
Q16 Comparison of fat and carbohydrate calories	61	76
Q17 Necessity of vitamin pills	96	88
Q18 Order of ingredients listed on food labels	66	63
Q19 Energy requirement of physical activity	77	82
Q20 Calcium in ice cream	66	59
Q21 Comparison of margarine and butter calories	28	26

Table 15. Comparison of the 1988 and the 1993 nutrition beliefs and food choices.

Question	Percent of soldiers with correct response 1988 (n=37)	1993 (n=157)
Foods to practice better nutrition		
Butter vs. margarine	73.1	81.5
Whole vs. low-fat milk	89.9	90.4
Sodas vs. unsweetened juice	94.1	98.7
Fried vs. baked foods	91.6	96.2
Salt vs. herbal seasoning	92.4	91.7
Pastries vs. fresh fruits	96.6	96.8
Chicken with or without skin	87.4	93.6
Foods to lose weight		
Regular vs. low calorie menu	94.1	93.6
Pastries vs. fresh fruits	93.3	98.1
Regular vs. low calorie dressing	92.4	98.7
Whole vs. low-fat milk	89.1	93.6
Fried vs. baked foods	91.6	96.2
Regular vs. reduced portions	84.9	91.1
Potatoes with or without gravy	91.6	93.0
Frosted flakes vs. shredded wheat	89.9	94.3
Chicken with or without skin	89.9	94.3
Hypothetical consumption choices		
Fried vs. baked chicken	47.1	66.2
High vs. low calorie food	59.7	67.5
Whole vs. low-fat milk	58.0	62.4
Buttered vs. nonbuttered vegetables	46.2	44.6
Cakes/pies vs. fresh fruits	57.1	72.0
Potatoes with or without gravy	32.8	45.2

The percent of soldiers who chose the correct answer to the first two questions was high, ranging from 73.1% to 96.6% for the 1988 group and from 81.5% to 98.7% for the 1993 group. The mean percentage of soldiers responding with the correct answer regarding the foods to practice better nutrition was 89.3 ± 7.7% and 92.7 ± 5.7% (mean ± SD) for 1988 and 1993 groups, respectively. The mean percentage of soldiers responding correctly to the question pertaining to foods to lose weight was significantly ($p \leq 0.05$) different between 1988 and 1993, 90.8 ± 2.7% and 94.8 ± 2.5%, respectively. In spite of the high percentage of correct responses for these two questions, when the soldiers were asked to make a choice ("If given a choice between the food in column A or the food in column B, which would you choose?"), the percentage of soldiers who chose the more nutritious answer was much lower, ranging from 32.8% to 59.7% for the 1988 group and from 44.6% to 72.0% for the 1993 group. These results confirm that nutrition knowledge may not reliably predict dietary behavior.

Overall, a higher percentage of the 1993 soldiers chose the more nutritious food compared to those made by soldiers five years ago. The mean percentage of soldiers choosing the more nutritious answer was 50.2 ± 10.3% and 59.7 ± 11.8% for the 1988 and the 1993 soldiers, respectively.

Table 16 has the 1988 and the 1993 responses to the four nutrition belief questions that required the soldier to agree or disagree using a 5-point scale (1 = "strongly disagree," 3 = "neutral or undecided," and 5 = "strongly agree"). The 1988 and the 1993 responses were very similar, except for the question regarding the use of additional salt on hot days for which the 1988 soldiers tended to be indecisive.

<u>Comparison of 1993 Pre- and Post- BCT Nutrition Knowledge and Beliefs</u>

Nutrition knowledge scores (n = 157) significantly ($p \leq 0.05$) increased between pre- and post-BCT (mean ± SD: 13.4 ± 2.7 and 14.4 ± 2.6 out of 21, respectively). These scores translated to 63.6 ± 12.9% and 68.6 ± 12.1%, respectively. Table 17 shows the percentage of soldiers with correct responses pre-BCT and post-BCT.

Table 16. Comparison of 1988 and the 1993 nutrition beliefs.

Question	Mean rating[1] 1988 (n=37)	1993 (n=157)
Additional salt is important on hot humid days when you're active and perspiring	2.7	3.6
To lose weight, it's best to eat fewer carbohydrate foods like bread and pasta	3.2	3.1
Nutrition information prior to joining military service:		
Influenced my food choices at restaurants and at home	3.2	3.4
Increased my awareness of proper nutrition	3.5	3.7
Improved my attitude toward proper nutrition	3.6	3.7
Proper nutrition:		
Is important to overall health	4.6	4.8
Is important to overall fitness	4.5	4.7

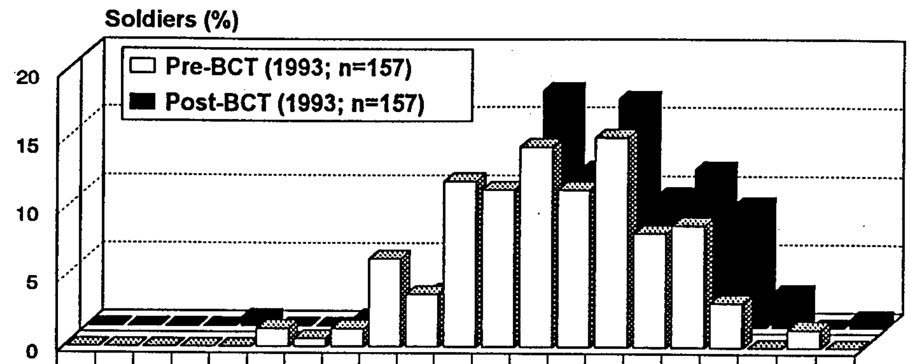
[1]Questions were answered on a 5-point scale where 1 = "strongly disagree," 3 = "neutral or undecided," and 5 = "strongly agree."

Figure 6 depicts the distribution of the 1993 pre- and post-BCT nutrition scores. Although one soldier (0.6%) had a perfect post-BCT score of 21, the mode decreased from 15 pre-BCT to 13 post-BCT. Furthermore, the lowest pre-BCT score was 6 while the lowest post-BCT score was 5.

Table 18 shows the percentage of soldiers who, when answering the nutrition knowledge questions pre- to post-BCT, went from "wrong to right," "right to right," "right to wrong," and "wrong to wrong." These data indicate that the amount of nutrition learning that occurred was minimal with only 13.1% changing their responses from wrong to right. On the other hand, there were 8.2% that went from right to wrong and 23.3% that remained wrong.

Table 17. Comparison of 1993 pre- and post-BCT nutrition knowledge.

Question	Percent of soldiers with correct responses (n = 157) Pre-BCT	Post-BCT
Q1 Fast foods are high in salt/fat	63.7	72.0
Q2 Calcium helps build bones/teeth	98.7	96.2
Q3 Protein is found in meat/fish/poultry	89.2	93.0
Q4 Carbohydrates are found in grains	40.8	45.9
Q5 Lean meats are good source of B vitamins	28.0	29.9
Q6 Iron is found in whole grains/red meats	45.9	56.7
Q7 Low-fat milk has...	53.5	52.2
Q8 Nutrient giving most energy	11.5	10.8
Q9 Food in same group as chicken	90.4	96.8
Q10 Best choice for a reducing diet	90.4	96.2
Q11 Food lowest in salt	52.9	63.1
Q12 Daily caloric needs of young females	45.9	56.7
Q13 Steak is not a good source of fiber	53.5	58.0
Q14 Four major food groups	79.0	84.7
Q15 Water is essential	98.1	100.0
Q16 Comparison of fat and carbohydrate calories	75.8	80.9
Q17 Necessity of vitamin pills	87.9	90.4
Q18 Order of ingredients listed on food labels	63.1	74.5
Q19 Energy requirement of physical activity	82.2	91.1
Q20 Calcium in ice cream	59.2	68.2
Q21 Comparison of margarine and butter calories	26.1	22.3



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pre-BCT (1993; n=157)	0	0	0	0	0	1.3	0.6	1.3	6.4	3.8	12.1	11.5	14.6	11.5	15.3	8.3	8.9	3.2	0	1.3	0
Post-BCT (1993; n=157)	0	0	0	0	0.6	0	0	0.6	1.3	2.5	7	9.6	17.2	11.5	16.6	9.6	11.5	8.9	2.5	0	0.6

Nutrition Knowledge Scores (points)

Figure 6. Frequency distributions of 1993 nutrition knowledge scores assessed pre- and post-BCT.

Table 18. Changes in 1993 nutrition knowledge (pre-BCT→post-BCT).

Pre-BCT → Post-BCT Response	Percent of soldiers n = 157 (Mean ± SD)
Wrong → Right	13.1 ± 7.8
Right → Right	55.4 ± 14.6
Right → Wrong	8.2 ± 6.5
Wrong → Wrong	23.3 ± 10.5

The percentage of soldiers making the correct choice on the nutrition belief questions were similar between the pre- and the post-BCT administration of the questionnaire. These results are shown in Table 19. The percentage of soldiers who chose the correct answer for the questions that asked about food items that would help with the practice of good nutrition, or that would help with weight loss was high, ranging from 81.5% to 98.7% for the pre-BCT and 99.4% to 84.7% for the post-BCT assessment. In spite of the high percentage of correct responses for these two questions, when the soldiers were asked to make a choice ("If given a choice between the food in column A or the food in column B, which would you choose?"), the percentage of soldiers who chose the more nutritious food was much lower, ranging from 44.6% to 72.0% for the pre- and 65.0% to 46.5% for the post- BCT assessments.

The mean percent of soldiers choosing a nutritional food was 59.7 ± 11.8% and 57.7 ± 8.5% for the pre- and post-BCT assessments, respectively. This difference was not statistically significant. These results suggest that nutrition knowledge cannot be used to predict dietary behavior.

Field Feeding Issues

During BCT, the soldiers participated in a 4-day FTX, where the soldiers received two A-Rations and one Meal, Ready-To-Eat (MRE) per day, but nutrient intake data were not collected during the FTX. The A-Ration meals were prepared in the garrison kitchen facility and transported to the field in insulated food containers. Upon return from the field, the Field Feeding Questionnaire was administered to all of the soldiers in the training unit. Table 20 contains the soldiers' responses. Approximately 86% of the soldiers reported eating less in the field than in the dining facility. The main reason (62.7% of soldiers) provided for this change in eating habits during the FTX was "the food did not look good."

Table 19. Comparison of the 1993 pre-BCT and post-BCT nutrition beliefs and food choices.

Question	Percent of soldiers choosing correct answer (n=157) Pre-BCT	Post-BCT
FOODS TO PRACTICE BETTER NUTRITION		
Butter vs. margarine	81.5	84.7
Whole vs. low-fat milk	90.4	93.0
Sodas vs. unsweetened juice	98.7	94.3
Fried vs. baked foods	96.2	95.5
Salt vs. herbal seasoning	91.7	93.0
Pastries vs. fresh fruits	96.8	96.2
Chicken with or without skin	93.6	95.5
FOODS TO LOSE WEIGHT		
Regular vs. low calorie menu	93.6	94.9
Pastries vs. fresh fruits	98.1	99.4
Regular vs. low calorie dressing	98.7	95.5
Whole vs. low-fat milk	93.6	96.2
Fried vs. baked foods	96.2	95.5
Regular vs. reduced portions	91.1	92.4
Potatoes with or without gravy	93.0	95.5
Frosted flakes vs. shredded wheat	94.3	94.9
Chicken with or without skin	94.3	96.2
HYPOTHETICAL CONSUMPTION CHOICES		
Fried vs. baked chicken	66.2	63.1
High vs. low calorie food	67.5	62.4
Whole vs. low-fat milk	62.4	61.8
Buttered vs. nonbuttered vegetables	44.6	46.5
Cakes/pies vs. fresh fruits	72.0	65.0
Potatoes with or without gravy	45.2	47.1

Table 20. Field feeding issues during BCT Field Training Exercise.

Question	Percentage of soldiers (n = 153)
Compare field intake with dining hall intake[1]:	
Ate less	85.5
Ate the same	7.2
Ate more	5.9
I do not know	1.3
Field intake was less because:	
The food did not look good.	62.7
I was not hungry.	49.7
The food's temperature was not right.	38.6
I was not feeling well.	32.7
My hands were not clean.	24.8
I wanted to lose weight.	16.3
I was not given enough time to eat.	15.7
I do not like to be told what to eat.	13.7
I did not want to have to go to the bathroom.	11.8
The weather was bad.	11.8
It was not my usual meal time.	5.9
I had menstrual cramps.	5.2
I was not eating with my friends.	0.7

[1]One soldier (0.7%) did not answer this question.

BODY COMPOSITION

Body weight at the start of BCT was 62.1±8.7 kg. This is comparable to the weight average of the females measured in the 1988 Army Anthropmeteric Survey (62.0±8.4 kg) (Gordon et al., 1989). For basic trainees in the current study, body weight increased by 0.8 kg over the eight weeks of training. DEXA analysis indicated that this weight change reflected an average loss 1.2 kg of fat, but a gain of 2.0 kg of fat-free tissue. This apparent increase in fat-free tissue was corroborated by an increase of 2.1±2.7 kg in total body water, as estimated by bioelectrical impedance spectroscopy (start: 31.5±4.5 kg, end: 33.8±4.2 kg, $p<0.01$).

Table 21. Body weight and percent changes analyzed by body composition components and body regions at the start and end of BCT (all values in Kilograms; n=150 soldiers)

	Start	End	Change
Body weight	62.1±8.7	62.9±8.1	0.8±3.1
Bone mineral (kg)	2.63±0.37	2.65±0.51	0.01±0.38
Fat (kg)	19.5±6.0	18.2±5.2	-1.2±2.6
Fat-free mass (kg)	42.7±4.5	44.6±4.6	+2.0±1.5
Composition of arms, legs and trunk regions			
Arms			
Bone mineral	0.31±0.05	0.31±0.05	0.00±0.02
Fat	2.17±1.00	1.85±5.2	-0.31±0.77
Fat-free tissue	4.19±0.66	4.41±0.69	0.24±0.35
Legs			
Bone mineral	0.92±0.17	0.93±0.17	0.008±0.07
Fat	7.40±2.29	7.20±2.1	0.18±1.27
Fat-free tissue	13.64±1.837	14.49±1.95	0.85±0.89
Trunk			
Bone mineral	0.89±0.15	0.88±0.16	-0.01±0.11
Fat	8.62±2.96	8.16±2.68	-0.46±1.54
Fat-free tissue	18.93±2.10	20.05±2.74	1.12±2.17

There was no change in bone mineral content for the group. A small but statistically significant reduction in bone mineral density was observed (pre-BCT: 1.204±0.079 g/cm^2; post-BCT: 1.193±0.082 g/cm^2; change: -0.011±0.035 g/cm^2; $p<0.01$). This either reflects a true reduction in bone mineral when the group variance is reduced with adjustment for body size, or it may reflect an artifact of the measurement technique. The latter explanation cannot be excluded, since the net change approximates the precision of the measurement.

Regional changes based solely on DEXA-assessed tissue mass indicated a loss of fat from each of three assessed regions (arms, legs, trunk). The greatest relative losses of fat were from the arms (-0.3 kg, 14.7%), the greatest absolute losses were from the trunk (-0.5 kg, 5.3%), and the least loss of fat was from the legs (-0.2 kg, 2.8%). Fat-free soft tissue increased in all three regions, with the greatest absolute gain on the trunk (+1.1 kg, 5.9%), while the greatest relative gain was on the legs (+0.9 kg, 6.2%). The increases on the arms and legs can be assumed to represent changes in muscle tissue. The changes in trunk fat-free soft tissue mass may include changes in other tissues besides muscle.

A correlation was observed when changes in body fat$_{DEXA}$ were compared with pre-BCT body fat$_{DEXA}$ status ($r=0.47$) (Figure 7). This analysis predicted a loss of fat for those individuals who were assessed to have more than 25% pre-BCT body fat$_{DEXA}$. The regression analysis suggested an approximate 0.2 kg loss of fat over the period of BCT for every additional percent body fat above 25% (i.e., soldiers beginning BCT at 30% body fat$_{DEXA}$ could be expected to lose approximately 1.0 kg of fat by the completion of training). Soldiers who began BCT with less than 25% body fat$_{DEXA}$ could be predicted to gain fat weight.

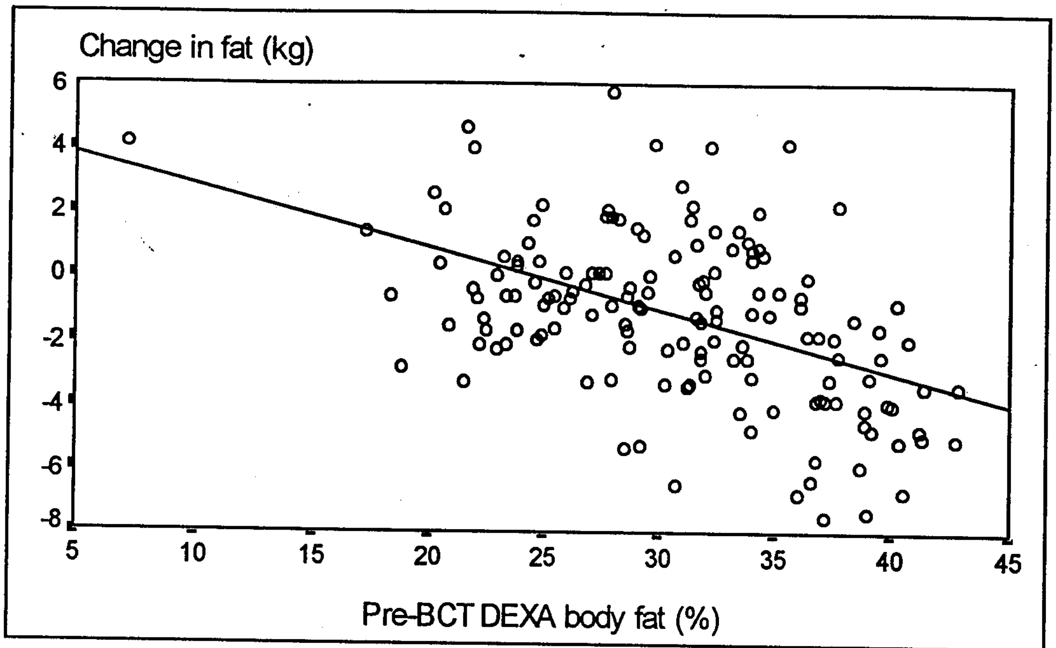


Figure 7. Relationship between pre-BCT body fat-$_{DEXA}$ and changes in body fat-$_{DEXA}$ during BCT (r=0.47).

ANOVA comparisons of regional fat changes over the period of BCT between those subjects with a pre-BCT body fat$_{DEXA}$ less than 25% and those with a pre-BCT body fat$_{DEXA}$ greater than 25% are shown in Figure 8. Both groups lost a similar amount of fat from their arms, but a significant difference was observed in the leg and trunk fat mass change ($p<0.05$). The leaner group (body fat$_{DEXA}$ less than 25%) tended to gain fat in both of these regions, while those with an initial body fat$_{DEXA}$ greater than 25% lost fat from these areas. Further analysis revealed no differences in the regional fat-free mass changes over the period of BCT between these same two groups (Figure 9).

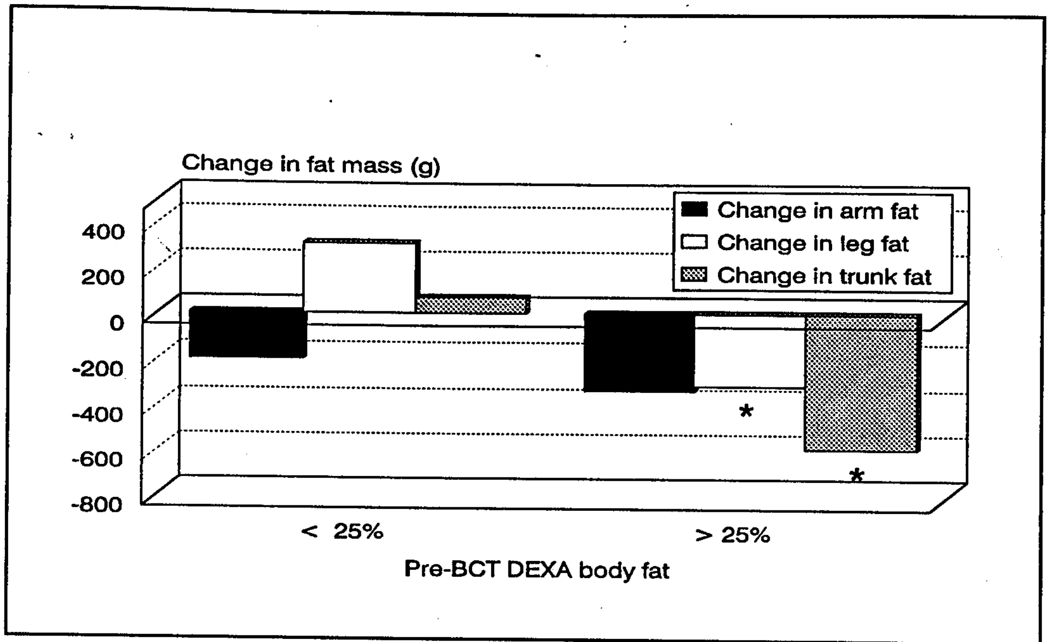


Figure 8. Regional changes in fat mass between soldiers with a pre-BCT body $fat_{DEXA} \leq 25\%$ (n=34) and a pre-BCT body $fat_{Dexa} > 25\%$ (n=123) ($p^* < 0.05$).

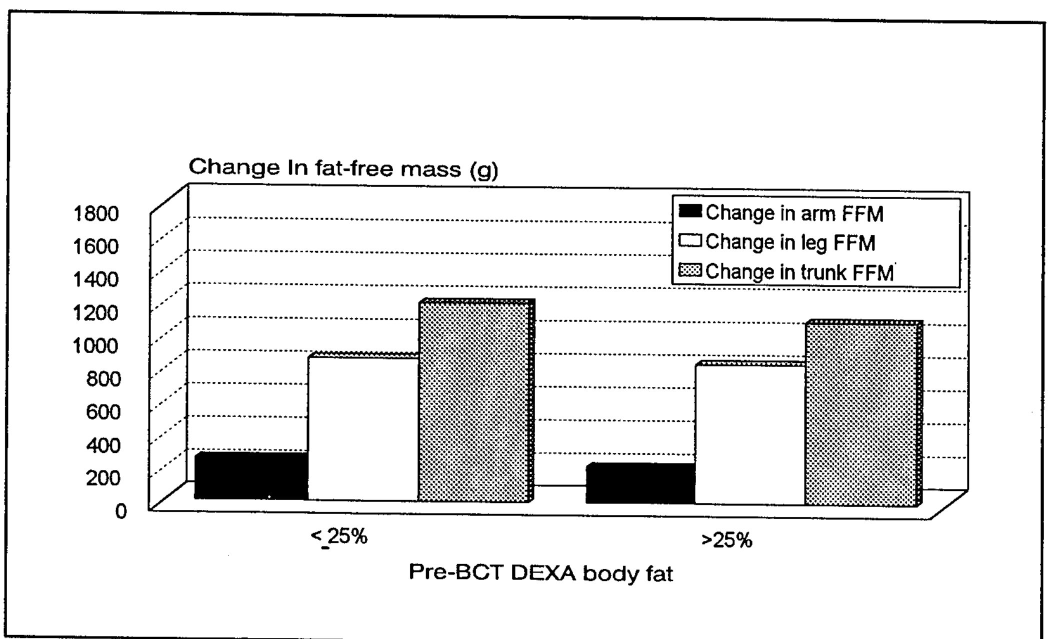


Figure 9. Regional changes in fat-free mass (FFM) between soldiers with a pre-BCT body $fat_{DEXA} \leq 25\%$ (n=34) and a pre-BCT body $fat_{DEXA} > 25\%$ (n=123).

ANOVA comparisons of fat mass changes between groups of subjects based upon quartiles of body fat_{DEXA} are shown in Figure 10. Significant differences in fat mass changes were observed between the fattest group (quartile 4) and all of the other three quartiles ($p<0.05$). Differences in fat mass change among the first three quartiles were not significant.

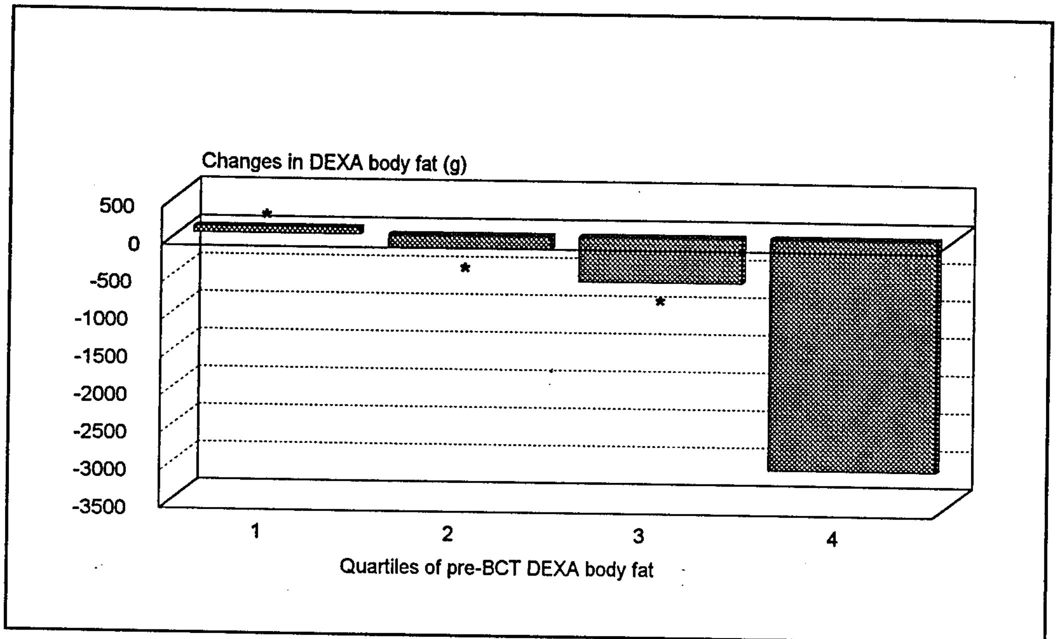


Figure 10. Comparison of mean BCT fat mass changes based upon quartiles of pre-BCT body fat_{DEXA} (*sinificantly different from quartile 4, $p<0.05$).

Pre-BCT body fat_{DEXA} status was also correlated with body weight loss (Figure 11) ($r=0.39$). However, <u>weight loss</u> was predicted only for soldiers exceeding 35% body fat_{DEXA}, as compared to a prediction of <u>fat loss</u> for those soldiers exceeding 25% body fat_{DEXA}. In this zone between 25% and 35% body fat, successful losses of body fat (0.2 kg/body fat unit) were offset by an average 2 kg gain in fat-free mass, so no net weight loss was observed. But for those soldiers who exceeded 35% body fat_{DEXA}, the higher fat loss resulted in a measurable reduction in weight.

There was no relationship between pre-BCT fatness and change in fat-free mass during BCT (Figure 12).

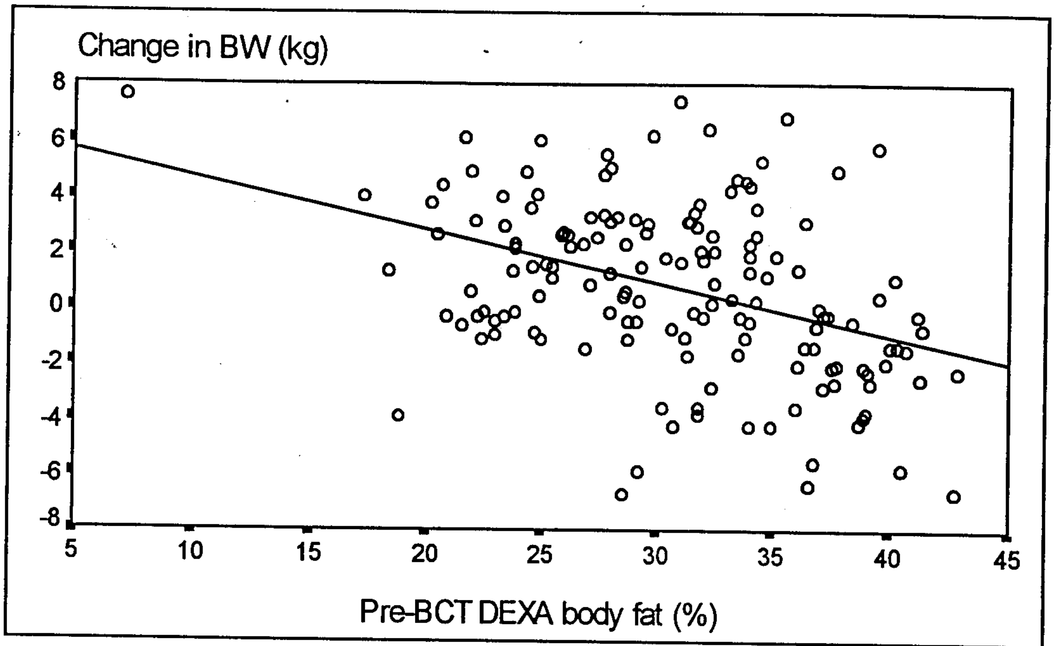


Figure 11. Relationship between pre-BCT body fat$_{DEXA}$ and change in body weight (BW) during BCT (r=0.39).

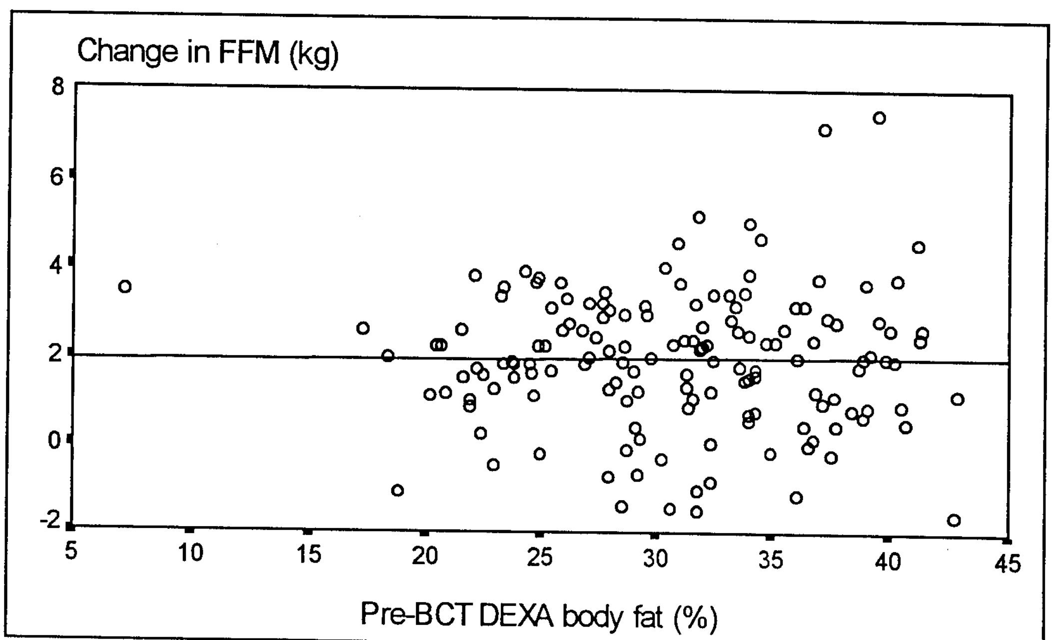


Figure 12. Relationship between pre-BCT body fat$_{DEXA}$ and change in fat-free mass (FFM) during BCT (r=0.01).

Anthropometric Measurement Changes Pre- to Post-BCT

Circumference measurements that can be compared to the 1988 Army Anthropometric Survey (Gordon et al., 1989) were very similar (neck, chest, waist, hips, upper thigh, calf, flexed biceps, and wrist) (Table 22). Only the abdominal measurement at the navel appeared remarkably different (1989 survey: 79.2±8.3 cm; present study: 76.7±7.1 cm). Since this measurement is a primary discriminator of female obesity (Vogel and Friedl, 1992), the difference suggests that the 1993 basic trainees were leaner than the active duty females represented by the 1989 survey. It is important to note that the measurements of the knee and ankle were not performed in a comparable manner between the 1989 survey and the present study; in this study, the knee was measured at the point of flexion instead of the plane bisecting the patella, and the ankle was measured at the dorsal juncture of the foot and leg instead of at the minimum.

Statistically significant circumference changes for the group occurred exclusively in the extremities and not in the trunk region, with the most notable changes being increases in the leg region (hips to ankle) (Table 22). This is consistent with the DEXA regional changes, which indicated increases in fat-free mass but no reduction in fat in the legs (Table 21).

Skinfold thicknesses increased in the legs (thigh and calf skinfolds) but decreased in the abdominal region (abdominal and suprailiac skinfolds), and in some portions (chest skinfold) but not all portions (subscapular and midaxillary skinfolds) of the upper trunk (Table 23). Changes in arm fat were indicated by a reduction in biceps skinfold thickness, but there was not a significant change in the triceps skinfold. The changes in trunk and arm subcutaneous fat as assessed by skinfold thicknesses roughly corresponded to the changes in regional fat assessed by DEXA (Table 21). DEXA measurements and skinfold thicknesses both indicated the largest fat losses in the trunk region, with smaller decreases in the arms.

Evaluation of pre-BCT measures revealed that every circumference and skinfold (with the exception of the neck circumference measurement) was significantly larger

Table 22. Pre- and post-BCT circumference measurements (n=158).

Measurement	pre-BCT	post-BCT	Absolute change	% change	Average female soldier[1]
Circumferences (cm)					
Neck	31.8±1.6	32.1±1.4	0.3±.98	+0.9	31.6±1.5
Chest	91.9±6.0	92.2±6.1	0.3±.3.5	+0.3	90.7±6.4
Abdomen (waist)	72.5±6.0	72.8±5.6	0.2±.3.7	+0.4	72.6±6.3
Abdomen (navel)	76.7±7.1	77.0±6.7	0.3±.4.8	+0.4	79.2±8.3
Abdomen (iliac crest)	81.4±7.9	81.1±7.1	-0.3±.4.8	-0.4	----
Hips	96.8±5.7	97.6±5.6	0.8±.2.9	+0.8**	----
Thigh (gluteal fold)	57.5±4.5	58.8±6.1	1.25±.5.3	+2.3*	----
Thigh (mid)	50.2±4.2	51.3±3.9	1.2±.2.9	+2.2**	----
Knee	34.8±2.3	35.5±2.1	0.7±.1.3	+2.0**	36.5±2.3
Calf	35.3±2.7	36.6±2.4	1.3±.1.5	+3.7**	35.2±2.3
Ankle	21.1±1.2	21.3±1.1	0.2±.0.6	+0.9**	20.5±1.2
Biceps (flexed)	28.3±2.3	29.2±2.2	0.9±.1.1	+3.2	28.1±2.3
Biceps (relaxed)	26.4±2.4	27.1±2.2	0.7±.1.2	+2.7**	----
Forearm	23.8±1.5	24.3±1.4	0.5±.1.0	+2.1**	25.4±1.5
Wrist	15.0±0.8	15.3±0.8	0.3±.0.4	+2.0**	15.1±0.7

Significant difference pre- to post-BCT using paired-t comparisons (*p<0.01; **p<0.001).

[1] Gordon et al., 1989.

---- data not available.

Table 23. Pre- and post-BCT skinfold measurements (n=158).

Measurement	pre-BCT	post-BCT	Absolute change	% change	Average female soldier
Skinfold thicknesses (mm)					
Chest	12.0±4.3	10.4±3.6	-1.5±3.1	-13.3**	----
Subscapular	16.3±5.5	16.5±5.5	0.2±3.7	+1.2	----
Biceps	8.2±3.3	7.6±2.6	-0.6±2.6	-7.3*	----
Triceps	17.5±5.2	17.6±5.1	0.2±3.5	+0.6	----
Midaxillary	12.2±5.0	12.0±4.8	-0.2±3.5	-1.6	----
Suprailiac	21.9±8.4	19.0±8.2	-2.9±5.9	-13.2**	----
Abdominal	22.0±5.3	20.7±6.2	-1.3±4.8	-5.9**	----
Thigh	29.1±8.5	31.6±8.7	2.6±7.3	+8.6**	----
Calf	16.0±4.8	18.2±5.5	2.1±4.1	+13.8**	----

note: statistical significance for paired t-test comparisons: *$p<0.01$; **$p<0.001$.

---- data not available.

for soldiers classified as overfat by Army standards (n=53) (Department of the Army, 1990b) when compared with those soldiers determined to be in compliance with body fat standards (n=120) (Tables 24 and 25). While the largest differences in circumferences were reflected in the abdominal and thigh measurements, these same areas accounted for the smallest differences among the nine skinfold measurements.

Comparison of Body Fat Assessments Among DEXA and Field Expedient Equations

For the soldiers completing all study measurements, percent body fat_{DEXA} decreased from 30.8% (range: 7.2% - 42.8%) pre-BCT to 28.6% post-BCT (range: 13.7% - 39.6%).

Percent body fat by the Army female equation (body fat_{Army}) underestimated pre-BCT percent body fat ($28.3\%_{Army}$ vs $30.8\%_{DEXA}$ pre-BCT), but was in closer accordance with post-BCT values (Table 26). Four of the other five equations that were examined also underestimated body fat percentage when compared with the DEXA calculated value. Three of the five equations (Army, Navy, USMC) yielded no significant change in percent body fat over BCT (paired t-test). However, this, and several other equations, predicted body fat losses for the group of soldiers classified as overfat by Army standards.

The pre-BCT distribution of individuals based on percent body fat as estimated by the Army female circumference equation is shown in Figure 13. Figure 14 is the pre-BCT percent body fat distribution based on DEXA measurements for these same individuals. The soldiers who were determined to be overfat AR 600-9 (Department of the Army, 1990b) are highlighted on both distribution graphs; it should be noted that new soldiers are not held to these standards until after basic training. The DEXA measurements confirm that soldiers identified as overfat through the procedures in AR 600-9 were appropriately categorized (Figure 13). It is also apparent from comparison of the two graphs that the Army female circumference equation errs on the side of the soldier and tends to underestimate body fat in the upper range. Three of the eight soldiers exceeding 30% body fat in Figure 13 exceeded Army fat standards for their age IAW AR 600-9, but were not identified as overfat because they did not exceed initial weight-for-height screening tables (3/170 soldiers).

Table 24. Differences in pre-BCT circumference measurements between soldiers classified as overfat (Fail AR 600-9; n=53) and soldiers classified as within body fat standards (Pass AR 600-9; n=120).

Measurement	Pass AR 600-9[1]	Fail AR 600-9[1]	% difference	95% confidence interval	p-value
Circumferences (cm)					
Neck	31.6±1.6	32.0±1.7	1.3%	(-0.93, 0.11)	0.121
Chest	90.0±5.7	96.5±4.7	6.8%	(-8.31, -4.80)	0.000
Abdomen (waist)	71.1±6.1	76.6±4.8	7.2%	(-7.37, -3.64)	0.000
Abdomen (navel)	74.9±6.9	81.7±5.5	8.3%	(-8.92, -4.67)	0.000
Abdomen (iliac crest)	78.9±7.2	87.5±6.5	9.8%	(10.85, -6.32)	0.000
Hips	94.9±5.3	101.6±4.0	6.6%	(-8.34, -5.11)	0.000
Thigh (gluteal fold)	55.8±4.0	61.5±3.4	9.2%	(-6.91, -4.41)	0.000
Thigh (mid)	48.8±3.8	53.5±3.1	8.7%	(-5.80, -3.47)	0.000
Knee	34.2±2.2	36.2±2.0	5.5%	(-2.68, -1.30)	0.000
Calf	34.4±2.7	37.1±2.3	7.1%	(-3.46, -1.79)	0.000
Ankle	20.8±1.1	21.8±1.3	4.4%	(-1.35, -0.58)	0.000
Biceps (flexed)	27.6±2.2	29.9±2.0	7.6%	(-2.94, -1.61)	0.000
Biceps (relaxed)	25.8±2.3	27.9±1.9	7.6%	(-2.83, -1.43)	0.000
Forearm	23.6±1.6	24.2±1.4	2.6%	(-1.12, -0.15)	0.010
Wrist	14.9±0.7	15.2±0.8	1.7%	(-0.50, -0.01)	0.040

[1] Department of the Army, 1990b.

Table 25. Differences in pre-BCT skinfold measurements between soldiers classified as overfat (Fail AR 600-9; n=53) and soldiers classified as within body fat standards (Pass AR 600-9; n=120).

Measurement	Pass AR 600-9[1]	Fail AR 600-9[1]	% difference	95% confidence interval	p-value
Skinfold thicknesses (mm)					
Chest	11.1±4.1	14.1±3.4	21.0%	(-4.25, -1.65)	0.000
Subscapular	14.9±5.3	19.7±4.4	24.3%	(-6.43, -3.15)	0.000
Biceps	7.4±2.9	10.1±3.4	26.3%	(-3.65, -1.66)	0.000
Triceps	16.3±5.0	20.5±4.3	20.2%	(-5.70, -2.58)	0.000
Midaxillary	10.8±4.4	16.0±4.2	32.5%	(-6.61, -3.76)	0.000
Suprailiac	19.8±7.7	27.6±7.0	28.1%	(-10.19, -5.30)	0.000
Abdominal	21.1±5.4	24.3±4.5	13.1%	(-4.84, -1.52)	0.000
Thigh	27.3±8.1	33.9±7.3	19.5%	(-9.16, -4.05)	0.000
Calf	14.9±4.3	19.4±4.9	23.3%	(-6.00, -3.06)	0.000

[1] Department of the Army, 1990b.

Table 26. Pre- and post-BCT body composition measurements and net changes (n=150).

	Pre-BCT	Post-BCT	Change	p value
Body weight (kg)	62.1±8.7	62.9±8.1	0.8±3.1	0.002
Fat (kg)	19.4±6.0	19.2±8.7	-0.2±7.3	0.704
FFM (kg)	39.4±4.3	41.8±4.4	2.5±1.5	0.000
Body fat_{DEXA}(%)	30.8±6.3	28.6±5.7	-2.2±2.8	0.000
Body fat_{Army}(%)	28.3±4.2	28.1±3.7	-0.2±2.2	0.228
Body fat_{Navy}(%)	29.8±5.2	30.3±4.7	-0.4±3.1	0.082
Body fat_{USMC}(%)	23.7±4.6	24.2±5.1	-0.5±3.8	0.083
Body fat_{sknfld}(%)	31.3±4.5	30.6±4.5	-0.7±2.7	0.001
Body fat_{imped}*(%)	30.4±6.0	26.3±5.4	-4.1±5.9	0.000

* n = 138

Note: p values reflect significance level for paired-t test comparisons.

In addition, Figure 14 demonstrates that a relatively large number of soldiers (92/170 soldiers) were overfat when AR 600-9 standards were applied to the calculated DEXA body fat values, but 38 of these 92 soldiers were not identified as overfat by the Army circumference equation. This discrepancy may be explained by the considerable variability in the location of fat deposition sites in women (Vogel and Friedl, 1992).

Pre-BCT, more than one fourth (28.4%) of the soldiers were categorized as overfat by AR 40-501 (Department of the Army, 1989b) (i.e., soldiers within their age category who exceeded weight-for-height tables, and also exceeded body fat allowances as determined by the Army female circumference equation). This was consistent across age categories (Table 27).

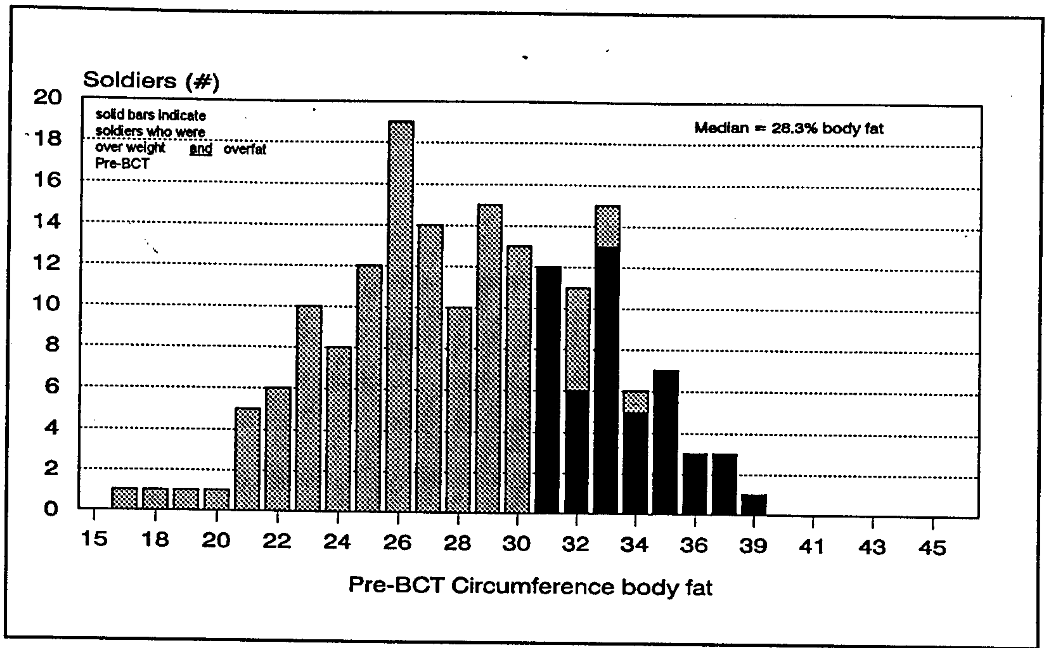


Figure 13. Pre-BCT distribution of soldiers based upon percent body fat as estimated by the U.S. Army female circumference equation (Department of the Army, 1990).

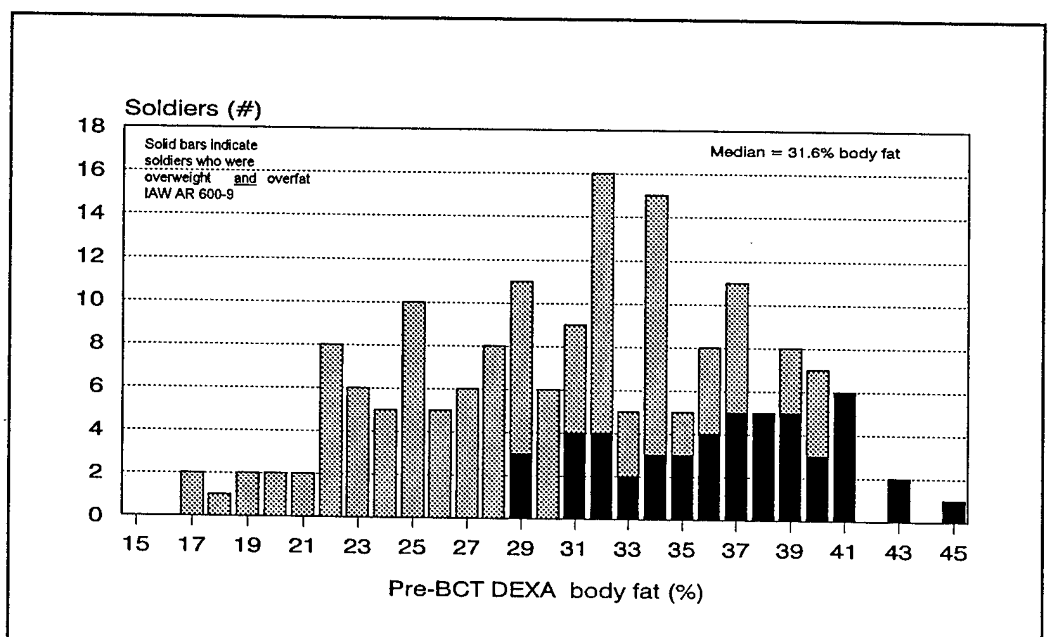


Figure 14. Pre-BCT distribution of soldiers based upon percent body fat$_{DEXA}$.

Table 27. Classification of overfat soldiers by age category. IAW AR 40-501.

Age category	Pre-BCT	Post-BCT
17 - 20 (85)	28.2% (24)	21.2% (15 + 3)
21 - 27 (51)	29.4% (15)	17.6% (9)
27 - 33 (14)	28.6% (4)	0
Total (151)	28.4% (43)	17.9% (24 + 3)

Note: Numbers in parentheses indicate number of soldiers. Under the age category column this represents total subsample size. Under the pre-BCT column, this represents the number of soldiers who were initially overfat. Under the post-BCT column this represents the number of soldiers who were still overfat + number of soldiers who became overfat during BCT.

Anthropometric Predictors of Female Body Fat

Principal component analysis of the skinfold and circumference measurements was performed to reduce these variables into the smallest number of meaningful and relatively independent factors. The first principal component represents a weighted average of all of the variables. Subsequent principal components are linear combinations that are not correlated with previous principal components. Thus, when pre-BCT circumference measures were compared to % body fat_{DEXA} (Table 28), the wrist circumference was the best independent correlate of % body fat (after the mean of all circumferences). The abdominal measurement was a third principal component. Post-BCT principal component analysis of the circumferences yielded similar results, with the wrist as the second component, followed by the ankle and waist (Table 29).

The same analysis performed with the nine skinfold measurements against % body fat_{DEXA} yielded only the triceps skinfold for the pre-BCT data (Table 30), and only the calf skinfold for the post-BCT data (Table 31). In combined analyses involving skinfolds and circumferences, the triceps skinfold and wrist circumference emerged as principal components in both the pre- and post-BCT measurements (Tables 32 and 33). This is consistent with previous studies where the triceps skinfold is the best anthropometric predictor of female fatness, and this single skinfold has been used

Table 28. Summary of stepwise regression to determine pre-BCT circumference measures that best model pre-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all circumferences	0.567	0.567	201.86	0.0001
Wrist	0.051	0.618	20.45	0.0001
Abdomen (navel)	0.011	0.630	4.66	0.0324

Table 29. Summary of stepwise regression to determine post-BCT circumference measures that best model post-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all circumferences	0.456	0.456	129.31	0.0001
Wrist	0.076	0.532	24.77	0.0001
Ankle	0.023	0.555	7.92	0.0055
Abdomen (waist)	0.012	0.567	4.03	0.0464

Table 30. Summary of stepwise regression to determine pre-BCT skinfold measures that best model pre-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all skinfolds	0.709	0.709	375.81	0.0001
Triceps	0.005	0.714	2.74	0.1000

Table 31. Summary of stepwise regression to determine post-BCT skinfold measures that best model post-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all skinfolds	0.568	0.568	202.29	0.0001
Calf	0.012	0.580	4.46	0.0364

Table 32. Summary of stepwise regression to determine pre-BCT circumference and skinfold measures that best model pre-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all circumferences	0.567	0.567	201.86	0.0001
Triceps skinfold	0.116	0.684	56.24	0.0001
Wrist circumference	0.041	0.724	22.44	0.0001
Chest skinfold	0.015	0.739	8.43	0.0042

Table 33. Summary of stepwise regression to determine post-BCT circumference and skinfold measures that best model post-BCT body fat_{DEXA} values.

Variable	Partial R^2	Model R^2	F	p-value
Mean of all circumferences	0.456	0.456	129.31	0.0001
Triceps skinfold	0.109	0.565	38.19	0.0001
Wrist circumference	0.054	0.619	21.48	0.0001
Ankle circumference	0.016	0.635	6.60	0.0112
Chest skinfold	0.012	0.647	4.94	0.0276

as an index of female fatness for clinicians. Most recently, a triceps circumference has been combined with bioelectrical impedance analysis to improve body fat prediction by expedient methods. Skinfold thicknesses are generally better predictors of fatness than circumferences; however, any gain in prediction is lost to measurement error in the hands of inexperienced caliper users. The military services all use circumference-based body fat equations because of the greater reliability of the measurements.

The association of wrist circumference with female fatness is not an intuitive relationship, but has been previously observed in Army data. A comparison of individual circumferences to "reference female soldier" (based on the average circumferential proportions of a sample of female soldiers rated as having "good" military appearance) showed the largest differences in wrist and abdominal proportions between leanest and fattest soldiers (Vogel and Friedl, 1992). In the derivation of the Army female fat equation by multiple regression analysis of circumference measurements, wrist circumference also emerged as a significant factor (Vogel et al., 1988). For the present study, wrist was also a significant variable in multiple regression against % body fat_{DEXA}.

The three different female fat prediction equations used by the military services each emphasize different fat depots in the choice of measurements: hips and body weight (Army), hips and waist (Navy), and thigh and abdomen (Marine). Each of these, along with variables with negative coefficients that adjust for lean mass and body proportions, have been derived in comparison to body fat estimated by underwater weighing. For the data in this study, after controlling for age, height, prior pregnancy, and ethnicity, hip circumference was the first measurement selected (with the highest correlation coefficient), in stepwise multiple regressions when offered the variables used in the Army equation (Table 34). The next best variable was the wrist circumference (previously observed as the second principal component chosen from circumferences). When offered only the variables present in the Marine Corps equation (which lacks a hip measurement) neck was the first selected variable, followed by abdomen (Table 35). When offered only the variables present in the Navy equation, neck was chosen even before the waist circumference (but after hips) (Table 36). This appears to validate the choice of hips circumference as the key determinant of body fat in the Army female equation.

Table 34. Summary of stepwise regression to determine contribution of four variables included within the Army circumference equation.

Variable	Partial R^2	Model R^2	p-value
Hips	0.566	0.566	0.0000
Wrist	0.040	0.606	0.0000
Forearm	0.021	0.627	0.0004
Neck	0.004	0.631	0.1005

Table 35. Summary of stepwise regression to determine contribution of five variables included within the Marine Corps circumference equation.

Variable	Partial R^2	Model R^2	p-value
Neck	0.549	0.549	0.0000
Abdomen (navel)	0.052	0.600	0.0000
Biceps (relaxed)	0.023	0.624	0.0280
Forearm	0.031	0.655	0.0000
Thigh (gluteal fold)	0.024	0.679	0.0003

Table 36. Summary of stepwise regression to determine contribution of three variables included within the Navy circumference equation.

Variable	Partial R^2	Model R^2	p-value
Hips	0.566	0.566	0.0017
Neck	0.020	0.586	0.0002
Abdomen (waist)	0.021	0.608	0.0000

These analyses suggest that hip and wrist circumferences are key correlates of female fatness, not only as measured by underwater weighing in the original Army equation derivation, but also as measured by DEXA in the current study. Based on the principal components analyses, the abdomen and wrist measurements are also important independent factor(s). This can be readily explained as the factor that accounts for fatness in those women with an upper body fat patterning. These appear to be the most important sites to assess for the circumference measurements taken in this study. These relationships are valid for the moderate range of body fat observed in the subjects most often investigated in Army studies.

Effect of Prior Pregnancy Status on Body Composition

There is a common perception, not well substantiated in any scientific data, that pregnancy has physiological consequences on subsequent weight control. The relationship is partially confused because first-time pregnancy is also frequently associated with lifestyle changes. The data shown in Table 37 indicate that there is no difference in body composition or anthropometry between the one-third of the sample who reported previous pregnancy (n=32) and those who did not (n=105). If anything, thigh girths were slightly less in women who had been pregnant. Thigh fat is suspected as a principal source of energy in lactating women, with mobilization occurring predominantly under the influence of postpartum hormones such as prolactin. Even though this observation fits with speculation in the scientific literature, a sounder interpretation is that these data represent the arbitrary 1 in 20 probability of a false difference for 20 measurements compared in this table.

Table 37. Differences in pre-BCT anthropometric measures between soldiers who reported to have been previously pregnant and those who reported to have never been pregnant.

	Prior Pregnancy Status		% difference	95% confidence interval	p-value
	Yes (n=52)	No (n=105)			
Body weight (kg)	62.0±7.8	62.1±9.3	0.2%	(-3.03, 2.87)	0.955
Body mass index	23.5±2.5	23.3±2.7	0.9%	(-0.69, 1.06)	0.679
Waist-to-hip ratio	0.80±0.1	0.80±0.05	0.0%	(-0.01, 0.03)	0.237
Body fat_{DEXA} (%)	30.6±6.2	30.9±6.4	1.0%	(-2.36, 1.86)	0.817
Total fat-free $mass_{DEXA}$ (kg)	39.6±3.7	39.4±4.5	0.4%	(-1.30, 1.61)	0.834
Bone mineral content (kg)	2.63±3.14	2.63±3.94	0.0%	(-1.27, 1.26)	0.997
Circumference Measures (cm)					
Neck	31.8±1.4	31.8±1.7	0.0%	(-0.50, 0.57)	0.894
Biceps, relaxed	26.5±2.3	26.4±2.4	0.4%	(-0.71, 0.86)	0.854
Biceps, flexed	28.4±2.3	28.3±1.4	0.4%	(-0.68, 0.89)	0.791
Forearm	23.8±1.4	23.8±1.5	0.0%	(-0.48, 0.53)	0.932
Wrist	15.0±0.7	15.0±0.79	0.0%	(-0.21, 0.30)	0.737
Chest	92.3±6.2	91.7±5.8	0.7%	(-1.48, 2.52)	0.610
Waist	73.5±5.2	72.1±6.3	2.0%	(-0.57, 3.43)	0.161
Abdomen	77.4±7.1	76.4±7.1	1.3%	(-1.39, 3.38)	0.410
Iliac crest	81.9±7.5	81.1±8.0	1.0%	(-1.86, 3.40)	0.565
Hip	96.9±5.4	96.8±5.9	1.0%	(-1.81, 2.04)	0.903
Thigh (gluteal fold)	57.7±4.3	57.5±4.6	0.3%	(-1.31, 1.73)	0.786
Thigh (mid)	50.1±3.8	50.2±4.3	0.2%	(-1.49, 1.31)	0.896
Knee	34.8±2.2	34.8±2.3	0.0%	(-0.81, 0.72)	0.908
Calf	35.3±2.1	35.3±3.0	0.0%	(-0.94,0.88)	0.946

Table 37. (continued). Differences in pre-BCT anthropometric measures between soldiers who reported to have been previously pregnant and those who reported to have never been pregnant.

	Prior Pregnancy Status		% difference	95% confidence interval	p-value
	Yes (n=52)	No (n=105)			
Ankle	21.1±1.2	21.1±1.2	0.0%	(-0.43, 0.40)	0.956
Skinfold Measures (mm)					
Chest	11.6±4.0	12.2±4.4	5.2%	(-1.95, 0.90)	0.466
Subscapular	16.1±5.6	16.5±5.4	2.5%	(-2.22, 1.46)	0.683
Biceps	7.9±3.0	8.4±3.5	6.3%	(-1.65, 0.57)	0.337
Triceps	16.8±5.0	17.9±5.2	6.5%	(-2.77, 0.66)	0.228
Midaxillary	11.8±4.4	12.4±5.2	5.1%	(-2.19, 1.15)	0.539
Suprailiac	21.0±8.4	22.5±8.3	7.1%	(-4.30, 1.29)	0.288
Abdomen	21.6±5.4	22.3±5.2	3.2%	(-2.39, 1.14)	0.485
Thigh	27.3±7.6	30.2±8.8	10.6%	(-5.69, -0.03)	0.047
Calf	15.6±4.2	16.5±5.1	5.8%	(-2.47, 0.77)	0.302

Similarly, one difference was obtained at $p<0.05$ for the same comparisons made at the end of BCT, with a smaller waist to hip ratio (WHR) in women who had never been pregnant.

These data suggest that pregnancy does not have a lasting effect on body composition or anthropometry. This is more remarkable when mean age is compared between the two groups, with the previously pregnant women averaging 22.7±1.5 years compared to 20.7±2.9 years for women who have never been pregnant. Weight gain is strongly associated with increasing age in young U.S. women. The data should be carefully interpreted in view of military entry standards for health, fitness, and body fat which select a sample of women not representative of the U.S. population, or perhaps even of women who have had one or more pregnancies.

Alterations in Body Fat Distribution

The weight-to-height ratio utilized in this study was the Quetelet's index (wt/ht^2, also referred to as body mass index [BMI]). This ratio is used by investigators as an indirect measure of obesity. In the present study, a high correlation was observed between BMI and % body fat_{DEXA} ($r=0.81$; $p=0.000$), which emphasizes the positive association between BMI and obesity.

The subjects of the current study were categorized using a BMI classification system developed by Health and Welfare Canada (Health and Welfare Canada, 1988) (Table 38). Based upon this categorization, a relatively large percentage of soldiers fell outside the 'ideal' BMI range. However, it is important to note that the total percentage of soldiers within this category increased pre- to post-BCT. This may be the positive result of several factors, such as adequate nutrition and increased physical activity.

Table 38. Categorization of soldiers based upon body mass index (BMI) classification system (Health and Welfare, Canada, 1988).

BMI	Classification	Pre-BCT % of soldiers	Post-BCT % of soldiers
< 20	May be associated with health problems for some individuals	12	5
20 - 25	'Ideal' index range associated with lowest risk of illness for most people	56	64
25 - 27	May be associated with health problems for some people	26	24
> 27	Associated with increased risk of health problems; i.e., heart disease, high blood pressure, and diabetes	6	7

Though an association did indeed exist between % body fat_{DEXA} and BMI, further measures were interpreted to more accurately determine what contributed to the excess weight that is suggested by a high BMI (i.e., adipose or muscular tissue). This was done through the use of the WHR, which is a measure used to describe the distribution of subcutaneous and intra-abdominal adipose tissue. Greater intra-abdominal adipose tissue, reflected by a high WHR (i.e., greater than 0.80 in females) has been associated with cardiovascular disease, diabetes mellitus, and breast, ovarian, and endometrial cancers (Laws et al., 1990; Wing et al., 1991). In the current study, 43% of the soldiers had a pre-BCT WHR greater than 0.80, but there was no correlation observed between these individuals and pre-BCT biochemical measures of cholesterol, high density lipoprotein, or triglycerides. This finding is not totally unexpected, however, considering the relative young age of the study population. Since many of the factors that contribute to a high WHR are felt to be behavioral, and therefore potentially modifiable (i.e., smoking and alcohol consumption), it may prove more enlightening to longitudinally follow a group of soldiers over an enlistment period in order to resolve the issue of whether an expedient measure such as the WHR could be used to predict certain health risks.

A high WHR has also been suggested to reflect other male-type attributes such as increased upper body strength and greater muscle mass. The relationship between quartiles of WHR and total fat-free $mass_{DEXA}$ is displayed in Figure 15. Considerable similarity is observed in the fat-free mass of those subjects with a WHR<0.82 (quartiles 1, 2, and 3). However, subjects within the fourth quartile (WHR≥0.82) had distinctly more fat-free mass. An independent-t test performed between those subjects with a WHR<0.82 and those with a WHR≥0.82 showed this difference in fat-free mass to be significant (p=0.025; 95%CI, -3305.73, -226.83).

Besides the health concerns associated with increases in fat mass and particular fat patterning, the military services must also address issues regarding the ability to accomplish the mission. For many tasks, this requires a particular strength threshold (though this threshold remains undefined, or unclearly defined, for most tasks). An ANOVA was done to determine the relationship between the post-BCT strength and performance tasks tests, as well as the individual events of the final APFT, and post-BCT BMI (separated into quartiles). (Post-BCT measures were utilized in the analysis

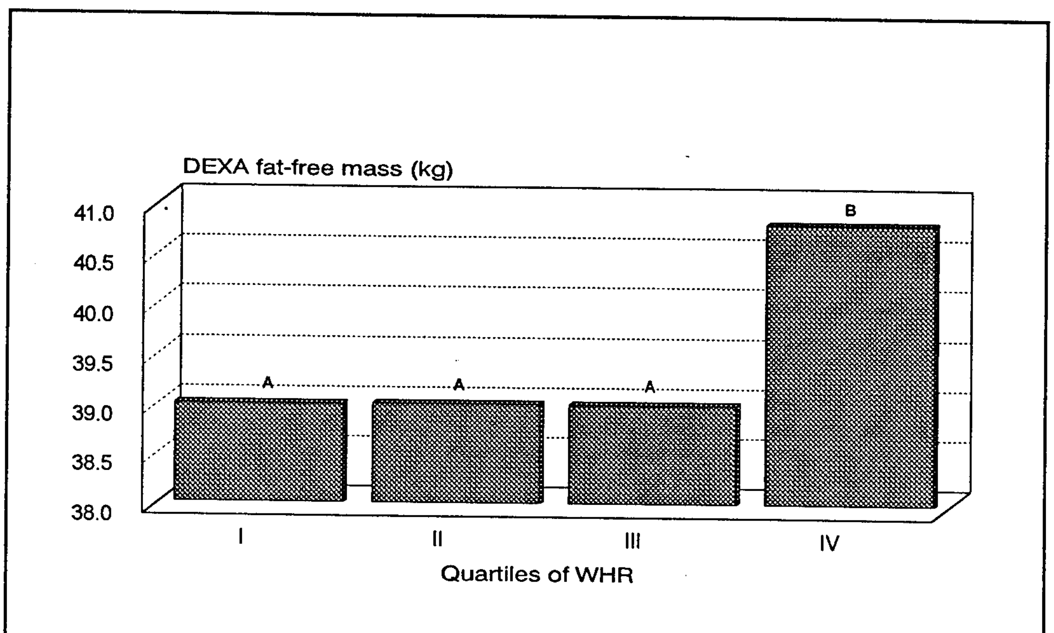


Figure 15. Relationship between fat-free $mass_{DEXA}$ and quartiles of waist-to-hip ratio (WHR) (p<0.05).

to allow comparable training time for all soldiers.) As might be expected, those soldiers with a higher BMI performed significantly better on several of the strength and performance tasks. On none of the strength and performance tasks did soldiers with a lower BMI demonstrate a stronger performance. A different trend was observed when examining the relationship between BMI and the APFT events. The soldiers with the lowest BMI performed the most sit-ups, and obtained the fastest running time. No relationship was observed between BMI and push up performance.

A comparable analysis was also done examining the relationship between post-BCT performance and post-BCT WHR. However, considering the similarity in total fat-free mass$_{DEXA}$ among quartiles 1, 2, and 3 (Figure 15), these three groups were combined (WHR$\leq$0.814; n=107) and compared as one group with quartile 4 (WHR>0.814; n=38). Though the soldiers with a higher WHR tended to perform better on the machine lift, bench press, and military press, the only significant difference between the two groups was a stronger performance on the torque task ($p<0.05$) by the high WHR group . The lack of statistical significance in analysis of the other strength tasks may be attributed to unequal sample sizes. The relationship between the post-BCT WHR and events of the final APFT revealed that those soldiers with the lower WHR performed significantly more sit-ups ($p<0.01$) and significantly more push ups ($p<0.05$), but were no different from the high WHR group in 2-mile run time. Thus, we concluded that the WHR had little predictive value for strength performance.

STRENGTH AND PERFORMANCE TASK TESTS

Performance Changes Pre- to Post-BCT

The results of the strength and performance measures are listed in Table 39. All measures were significantly improved from pre- to post-BCT, with changes ranging from 15.8% in the bench press to 4.1% in the peak power and torque tasks. The increase in machine lifting strength (8.4%) was not as great as that reported previously (12.4%) for female basic trainees (Teves et al., 1985). However, the average score was higher pre- and post-BCT by approximately 10 kg. Stronger individuals would not be expected to have as large an increase in strength as individuals who started BCT at a lower level of fitness (Fleck & Kraemer, 1987). The techniques used in the machine lift differed slightly from previous studies and may have been the reason for the higher score in the current sample of females. The differences in the current study were 1) the load was incremented by 2.3 kg, rather than the standard 4.6 kg (Stevenson et al., 1995), 2) rest was allowed between lifts as the maximum was approached, and 3) more emphasis was placed on lifting technique.

Table 39. Physical performance measures pre- and post-BCT.

Physical Performance Measure	n	Pre-BCT	Post-BCT	% change
Machine lift (kg)	124	40.4±8.8	43.8±9.4*	8.4
Bench press (kg)	138	30.3±6.4	35.1±6.8*	15.8
Military press (kg)	137	27.3±5.4	29.6±4.9*	8.4
Vertical jump (cm)	129	29.0±5.7	31.8±5.9*	9.7
Peak power (W)	125	2208.7±494.0	2413.7±483.3*	4.1
Torque (Nm)	137	156.7±30.3	163.1±30.0*	4.1
Load carriage ($m \cdot s^{-1}$)	109	3.40±0.49	3.57±0.47*	3.8

* Significant difference pre- to post-BCT ($p<0.01$)

The results of the four APFTs are displayed in Appendix B and Figures 16-18. Similar to the strength and performance task tests, progressive improvement was observed in the performance of the three events tested by the APFT. Interpretation of absolute numbers showed the most improvement in the push-up event (119%). However, interpretation of the scores showed greatest improvement in scores for the 2-mile run (395%). The graders for the fourth APFT were different than the graders who scored APFTs 1, 2, and 3. This difference in graders for the last APFT may explain the change in the general upward trend in performance of all the events. This was especially evident in push-up performance.

Effects of the Army Weight Control Program on Muscle Strength and Task Performance

The results of the soldiers were divided into two groups: a group that included the results of those soldiers meeting the weight-for-height standard upon entry into BCT IAW AR 40-501 (Department of the Army, 1989) (pass), and a group that included the results of those soldiers not meeting the standard (fail). A two-way analysis of variance with repeated measures was used to examine group differences in the strength, power and task performance measurements pre- and post-BCT. There was a significant improvement ($p<0.01$) in all measures pre- to post-BCT for both groups. The group consisting of soldiers failing the weight-for-height standard performed as well as, or better than, the group passing the standard. There were significant group differences on all measures of strength ($p<0.01$). Those soldiers failing the weight-for-height standard were 15% stronger on the machine lift, 12% stronger on the bench press and 14% stronger on the military press (Figure 19). The fail group generated 17% more power on the vertical jump than the pass group (Figure 20), but the groups did not differ in vertical jump height. This was probably because the fail group had to generate more power to propel a greater mass to the same height than the group that passed the weight-for-height standard. The fail group demonstrated superior torque performance (12%, $p<0.01$) (Figure 21), but did not differ from the pass group in load carriage task performance. Increased body weight for height is typically a combination of increased body fat and fat-free mass, which would result in better performance of strength demanding tasks. Excess body weight would

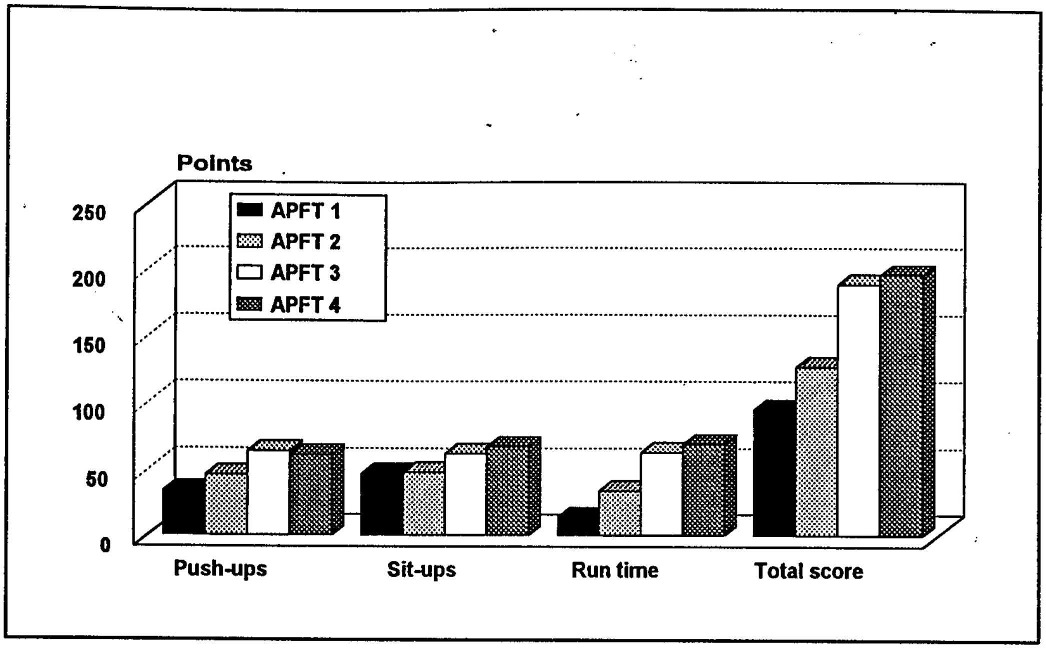


Figure 16. Points for each of the three individual events and total score for each of the four Army Physical Fitness Tests (APFT).

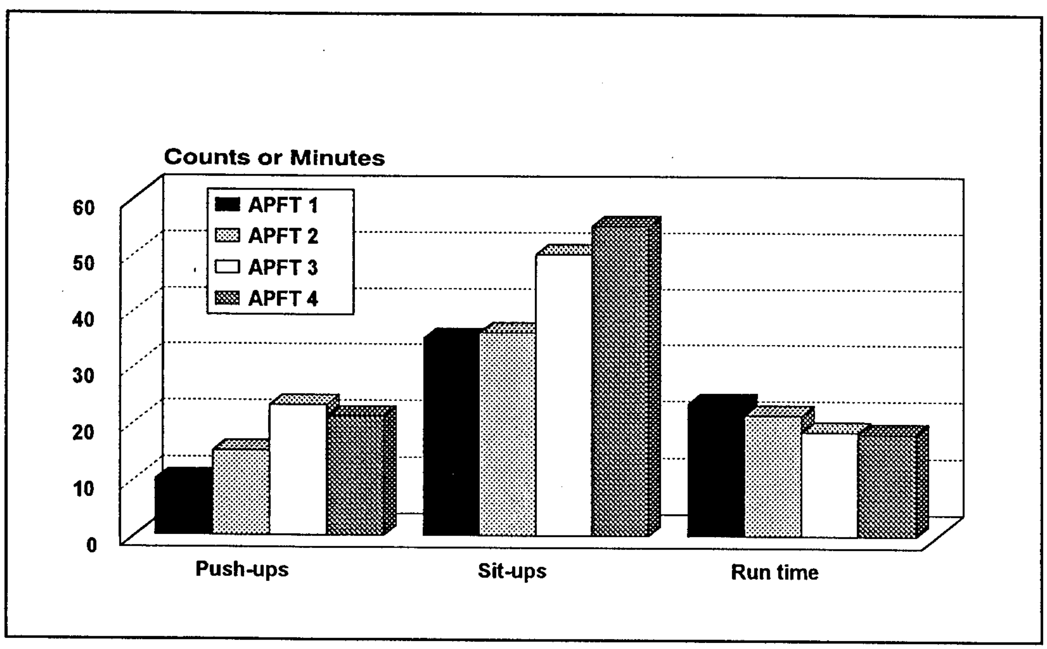


Figure 17. Absolute number of push-ups and sit-ups, as well as average run time for each of the four Army Physical Fitness Tests (APFT).

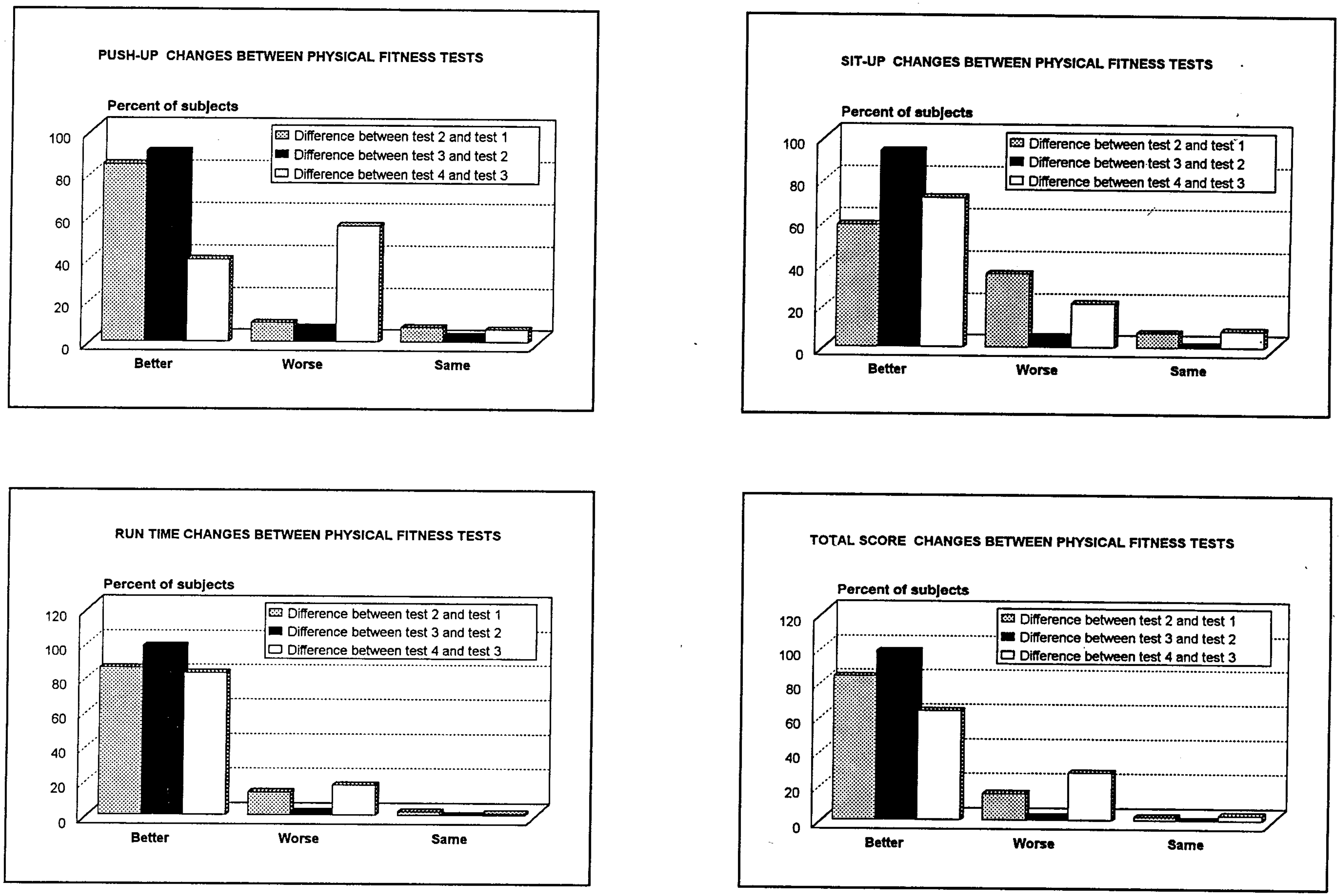


Figure 18. Changes in performance of individual events and total scores of Army Physical Fitness Tests (APFT) over BCT.

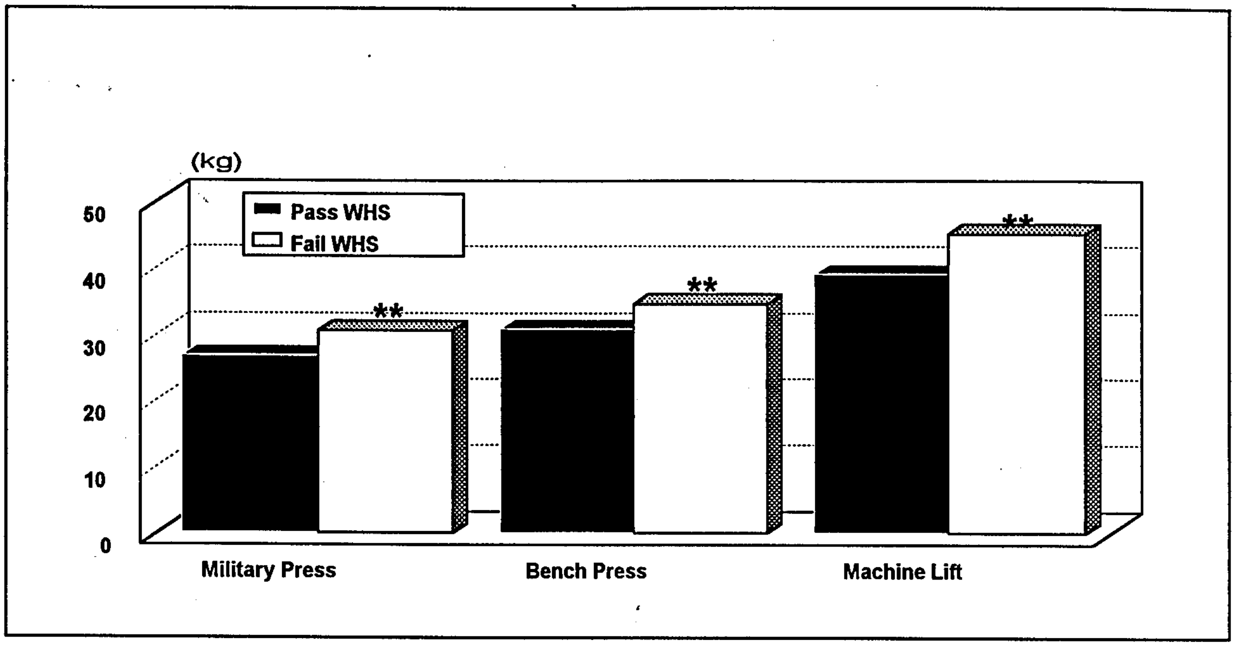


Figure 19. Group differences in strength between soldiers who met and those who failed to meet the weight-for-height standard (WHS; AR 40-501) assessed pre-BCT (** p<0.01).

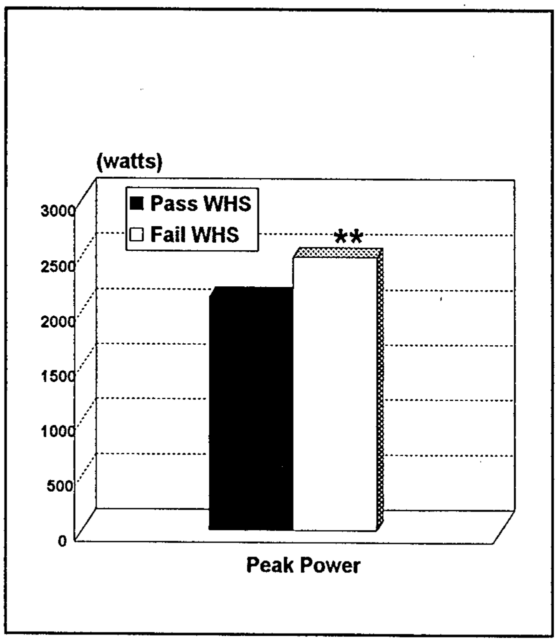


Figure 20. Group differences in peak power between soldiers who met and those who failed to meet the weight-for-height standard (WHS; AR 40-501) assessed pre-BCT (** p<0.01).

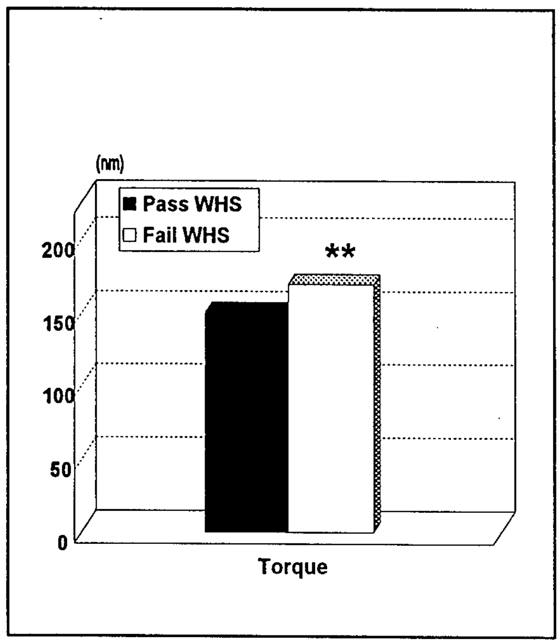


Figure 21. Group differences in torque between soldiers who met and those who failed to meet the weight-for-height standard (WHS; AR 40-501) assessed pre-BCT (** p<0.01).

be expected to negatively affect performance of the vertical jump and the load carriage task. However, there were no group differences for these tasks.

There was a significant ($p<0.05$) interaction effect (group by time of measurement) for military press and jump power. Group means pre- and post-BCT are listed in Table 40. A post hoc Tukey test revealed that the fail group had significantly higher scores on both variables before and after BCT ($p<0.01$). Both groups increased pre- to post-BCT ($p<0.01$); however, the percentage increase from pre- to post-BCT appeared to be greater in the pass group (11% for military press, 13% for jump power) than in the fail group (6% for military press and 6% for jump power).

The results of the soldiers were divided into two groups based upon whether the soldiers passed or failed the percent body fat standard IAW AR 600-9 (Department of Army, 1990b) regardless of whether they passed or failed the weight-for-height standard. A two-way repeated measures analysis of variance test was conducted to compare the performance of the two groups pre- and post-BCT. All measures improved significantly ($p<0.01$) pre- to post-BCT. The group failing the percent body fat standard was significantly stronger ($p<0.05$) than the passing group by 9% on the machine lift, 8% on the bench press and 7% on the military press (Figure 22). The group failing the body fat standard had a significantly lower vertical jump (-8%, $p<0.05$, Figure 23), but produced a higher power output during the jump (8%, $p<0.05$, Figure 24). There were no group differences in the torque task or the load carriage task. There were significant interaction effects ($p<0.05$) for military press and jump power. A post hoc Tukey test revealed that the fail group had significantly higher scores pre- and post-BCT on both variables ($p<0.01$). Both groups increased pre- to post-BCT ($p<0.01$); however, the percentage increase from pre- to post-BCT appeared to be greater in the pass group (10% for military press, 11% for jump power) than in the fail group (5% for military press, 5% for jump power). Individual means for each group pre- and post-BCT are listed in Table 41.

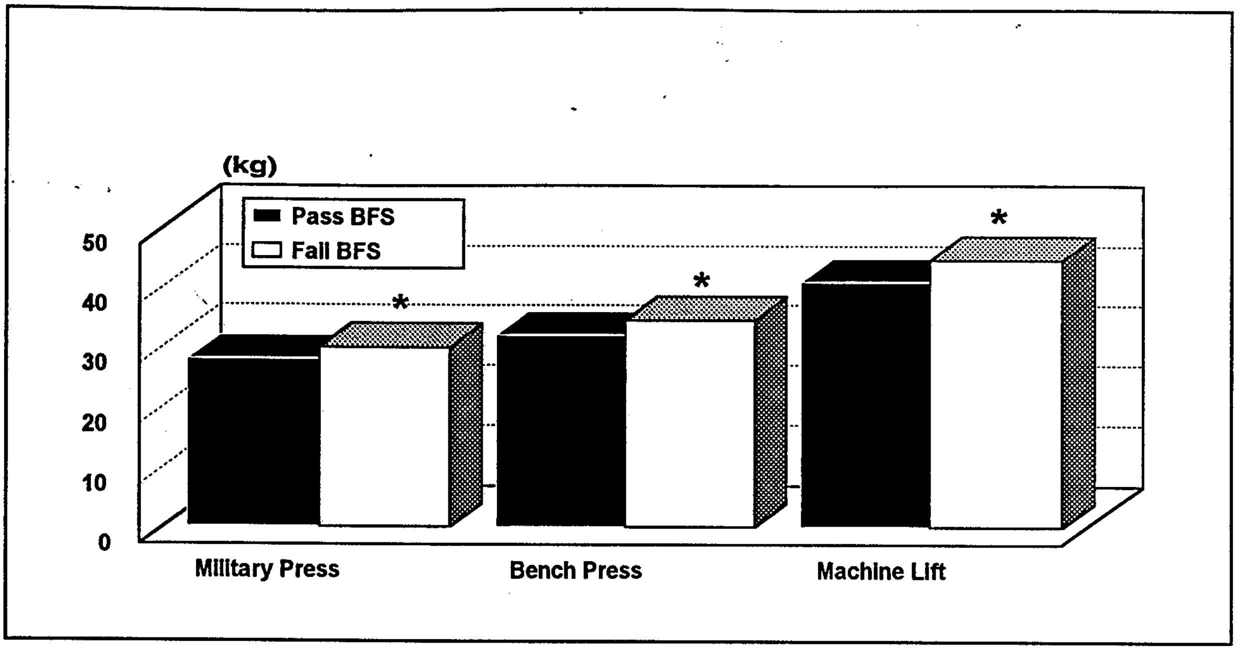


Figure 22. Group differences in strength between soldiers who met and those who failed to meet the body fat standard (BFS; AR600-9) assessed pre-BCT (* $p<0.05$).

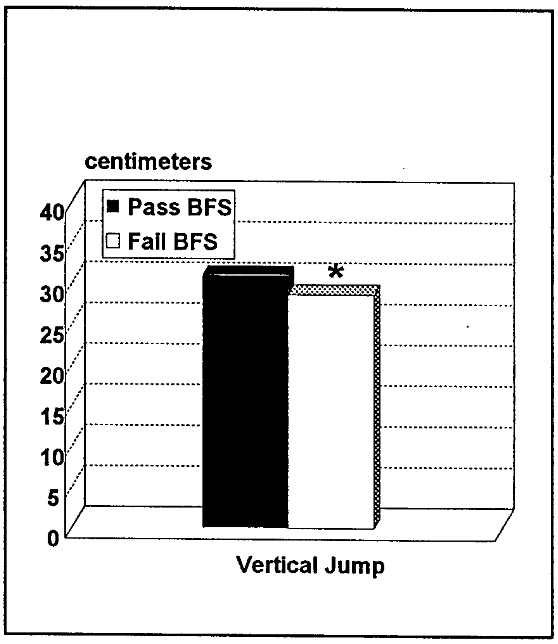


Figure 23. Group differences in vertical jump between soldiers who met and those who failed to meet the body fat standard (BFS; AR 600-9) assessed pre-BCT (* $p<0.05$).

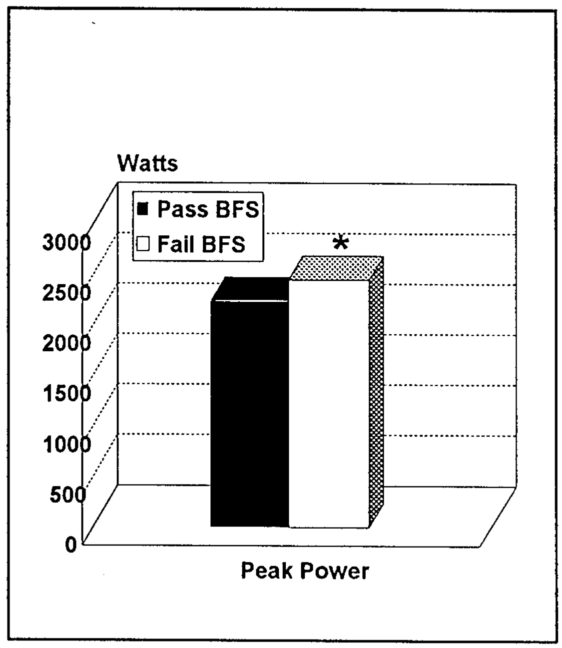


Figure 24. Group differences in peak power between soldiers who met and those who failed to meet the body fat standard (BFS; AR 600-9) assessed pre-BCT (* $p<0.05$).

Table 40. Strength and performance measures pre- and post-BCT by weight-for-height standard (WHS) group (mean±SD). Sample size for each group is listed in column one.

Physical Performance Measure		Pass WHS	Fail WHS
Machine lift (kg) (n = 62 pass, 62 fail)	pre-BCT	37.6±7.1	43.2±9.4
	post-BCT	40.6±7.9	46.9±9.7
Bench press (kg) (n = 69 pass, 69 fail)	pre-BCT	28.4±6.3	32.2±5.8
	post-BCT	33.3±6.2	36.9±6.9
Military press (kg) (n = 71 pass, 66 fail)	pre-BCT	25.5±4.8	29.2±5.3
	post-BCT	28.4±4.6	30.9±4.9
Vertical jump (cm) (n = 62 pass, 67 fail)	pre-BCT	29.4±5.5	28.6±5.9
	post-BCT	32.6±6.0	31.2±5.8
Peak power (W) (n = 61 pass, 64 fail)	pre-BCT	1995.3±434.7	2412.1±462.8
	post-BCT	2257.5±453.0	2562.7±467.1
Torque (Nm) (n = 70 pass, 67 fail)	pre-BCT	146.0±26.4	167.8±30.4
	post-BCT	155.1±28.5	171.4±29.5
Load carriage ($m \cdot s^{-1}$) (n = 56 pass, 53 fail)	pre-BCT	3.35±0.48	3.44±0.50
	post-BCT	3.54±0.48	3.59±0.49

The strength differences between body fat standard pass and fail groups were reduced by one-third to one-half that of the weight-for-height standard pass and fail groups. The body fat standard greatly reduced the tendency to eliminate stronger women from the Army by retaining the women with more fat-free mass.

Table 41. Strength and performance measures pre- and post-BCT by body fat standard (BFS) group (mean±SD). Sample size for each group is listed in column one.

Physical Performance Measure		Pass BFS	Fail BFS
Machine lift (kg) (n = 37 pass, 87 fail)	pre-BCT	39.4±8.3	42.8±9.4
	post-BCT	42.6±8.6	46.4±10.6
Bench press (kg) (n = 40 pass, 98 fail)	pre-BCT	29.4±6.4	32.5±5.8
	post-BCT	34.5±6.5	36.6±7.3
Military press (kg) (n = 38 pass, 99 fail)	pre-BCT	26.6±5.1	29.2±5.7
	post-BCT	29.2±4.8	30.6±5.1
Vertical jump (cm) (n = 39 pass, 90 fail)	pre-BCT	29.6±5.6	27.6±5.6
	post-BCT	32.7±5.7	29.9±6.1
Peak power (W) (n = 37 pass, 88 fail)	pre-BCT	2128.5±494.7	2399.5±442.7
	post-BCT	2370.8±483.3	2515.8±474.3
Torque (Nm) (n = 40 pass, 97 fail)	pre-BCT	153.7±28.6	163.9±33.4
	post-BCT	161.0±30.6	168.2±28.4
Load carriage ($m \cdot s^{-1}$) (n = 30 pass, 79 fail)	pre-BCT	3.38±0.49	3.44±0.50
	post-BCT	3.55±0.47	3.61±0.48

Relationship Between Service-Specific Body Fat Equations and Muscle Strength and Task Performance

All branches of the military utilize different methods and have different standards for determining acceptable percentage body fat. The Navy bases their standard on health issues and places sailors considered overfat (>30% body fat) on a weight control and exercise program (Hodgdon, 1992). A circumference test of percent body fat is made every 6 months, without the initial weight-for-height screening used by the Army. The Marine Corps, utilizing a different circumference estimation, has set the upper limit of percent body fat at 26% for female Marines (Hodgdon, 1992). The Air Force uses the Navy equation with body fat standards set at 28% for women $\leq$ 29 years old and 32% for women older than 29 years. Neither the Navy nor Marines allow for an increase in body fat with increasing age, as allowed by the Army and Air Force.

Using the service-specific equations and different percent body fat standards, the effects of each of the services' pass/fail criterion were examined as they related to performance. The group effect means resulting from two-way analyses of variance are listed in Table 42. There was a surprising amount of consistency in the outcomes. The failure rates were 29% - 33% for the Army, Navy and Marines, but the Air Force was somewhat higher at 46%. Regardless of the method used, the fail group was stronger on the machine lift, bench press, and military press; there were no differences in the load carriage task. Also, the power produced during the vertical jump was consistently higher in the fail groups. There were inconsistencies in the torque task and the vertical jump. The difference between the Army pass and fail groups did not reach the accepted level of significance, but tended to be greater in the fail group ($p<0.10$). The Navy ($p<0.05$), Air Force, and Marine Corps ($p<0.01$) fail groups produced significantly more torque than the pass groups. The opposite results were obtained for the vertical jump. Analysis of the Army method found a higher vertical jump score for the pass group than the fail group ($p<0.02$). The Navy method marginally supported this ($p=0.053$), but the Marine Corps and Air Force methods revealed no differences between pass and fail groups for vertical jump. The similarities in the performance outcomes for women who passed and failed the body fat standards used by the various branches of the armed services were surprising, as the acceptable percent body fat varies from 26% (Marines) to 30% and above (Army).

Effects of Fat-Free Mass on Muscle Strength and Performance

The total fat-free mass and the regional fat-free mass for arms, legs, and trunk were correlated with muscle strength pre- and post-BCT (Tables 43 and 44). All strength measures (bench press, military press, and machine lift) were significantly correlated ($p<0.01$) with total and regional fat-free mass with correlations ranging from $r=0.32$ to $r=0.71$ before and after BCT. Vertical jump was significantly correlated ($p<0.01$) with total and limb fat-free mass, but was not correlated with trunk fat-free mass. Peak power was more strongly correlated with total and regional fat-free mass

Table 42. Strength and performance measures by pass/fail body fat groupings for Army, Navy, Marine Corps and Air Force women's body fat standards (mean and (n)).

	Army		Navy		Marine Corps		Air Force	
	Pass	Fail	Pass	Fail	Pass	Fail	Pass	Fail
Machine lift (kg)	41.0	44.6[1]	40.9	44.9[1]	41.0	44.5[1]	39.9	45.0[1]
	(87)	(37)	(86)	(38)	(84)	(40)	(65)	(55)
Bench press (kg)	32.0	34.5[1]	31.5	35.3[2]	32.0	34.3[1]	31.5	34.7[1]
	(98)	(40)	(94)	(44)	(93)	(45)	(72)	(61)
Military press (kg)	27.9	29.9[1]	27.6	30.3[1]	27.7	30.1[2]	27.5	29.8[1]
	(99)	(38)	(94)	(43)	(94)	(43)	(74)	(58)
Vertical jump (cm)	31.1	28.7[1]	31.1	29.1	30.9	29.3	31.1	29.7
	(90)	(39)	(86)	(43)	(87)	(42)	(67)	(62)
Peak power (W)	2249.7	2457.6[1]	2219.6	2485.8[2]	2205.3	2528.1[2]	2168.3	2466.0[1]
	(88)	(37)	(82)	(43)	(84)	(41)	(65)	(60)
Torque (Nm)	157.3	166.0	154.9	170.8[1]	154.4	171.4[2]	152.2	169.2[1]
	(97)	(40)	(94)	(43)	(93)	(44)	(75)	(62)
Load carriage ($m \cdot s^{-1}$)	3.46	3.53	3.45	3.54	3.47	3.50	3.45	3.51
	(79)	(30)	(74)	(35)	(73)	(36)	(58)	(51)

[1] Significant group effect ($p<0.05$).
[2] Significant group effect ($p<0.01$).

Table 43. Pre-BCT correlation of body weight, total body fat_{DEXA}, and regional and total fat-free mass with muscle strength, power, and task performance variables.

	Body Weight	% Total Body Fat_{DEXA}	Arm FFM_{DEXA}	Leg FFM_{DEXA}	Trunk FFM_{DEXA}	Total FFM_{DEXA}
Machine lift (kg)	0.44**	-0.02	0.64**	0.62**	0.50**	0.62**
Bench press (kg)	0.40**	0.08	0.50**	0.71**	0.49**	0.49**
Military press (kg)	0.46**	0.10	0.56**	0.43**	0.55**	0.55**
Vertical jump (cm)	0.00	-0.31**	0.33**	0.39**	0.16	0.28**
Peak power (W)	0.68**	0.22*	0.69**	0.72**	0.58**	0.73**
Torque (Nm)	0.59**	0.08	0.70**	0.65**	0.70**	0.75**
Load carriage ($m \cdot s^{-1}$)	0.21**	-0.24**	0.46**	0.53**	0.47**	0.51**
Push-ups (#)	-0.24**	-0.44**	0.11	0.05	0.11	0.11
Push-ups (score)	-0.25**	-0.44**	0.12	0.02	0.11	0.10
Sit-ups (#)	0.08	-0.34**	0.16	0.27**	0.14	0.23**
Sit-ups (score)	-0.06	-0.32**	0.17*	0.24**	0.15	0.22**
2-mile run (sec)	0.05	0.30**	-0.12	-0.15	-0.23**	-0.21*
2-mile run (score)	0.00	-0.18*	0.11	0.13	0.21*	0.18*

*p<0.05, **p<0.01 level.

Table 44. Post-BCT correlation of body weight, total body fat_{DEXA}, and regional and total fat-free mass with muscle strength, power, and task performance variables.

	Body Weight	% Total Body Fat_{DEXA}	Arm FFM_{DEXA}	Leg FFM_{DEXA}	Trunk FFM_{DEXA}	Total FFM_{DEXA}
Machine lift (kg)	0.48**	0.04	0.63*	0.57**	0.49**	0.59**
Bench press (kg)	0.35**	0.05	0.46**	0.32**	0.45**	0.41**
Military press (kg)	0.42**	0.06	0.55**	0.41**	0.48**	0.51**
Vertical jump (cm)	0.01	-0.41**	0.28**	0.42**	0.17	0.34**
Peak power (W)	0.64**	0.05	0.68**	0.76**	0.60**	0.77**
Torque (Nm)	0.54**	0.09	0.67**	0.54**	0.59**	0.64**
Load carriage ($m \cdot s^{-1}$)	0.26**	-0.16	0.43**	0.49**	0.38**	0.32**
Push-ups (#)	-0.32**	-0.39**	-0.08	-0.12	-0.05	-0.08
Push-ups (score)	-0.33**	-0.39**	-0.09	-0.11	-0.11	-0.11
Sit-ups (#)	-0.22**	-0.27**	0.01	0.00	-0.08	-0.04
Sit-ups (score)	-0.19*	-0.25**	0.03	-0.01	-0.08	-0.03
2-mile run (sec)	0.28**	0.46**	0.07	-0.05	0.05	-0.01
2-mile run (score)	-0.22**	-0.37**	-0.10	0.00	-0.04	0.00

*p<0.05, **p<0.01 level.

than was vertical jump. The task performance variables were both significantly correlated ($p<0.01$) with total and regional fat-free mass before and after BCT.

The correlations between changes in body weight and fat-free mass and changes in muscle strength, power and task performance measures are listed in Table 45. A change in body weight was positively correlated with a change in bench press, military press, peak power and load carriage task performance ($p<0.01$). The change in arm fat-free mass was not significantly correlated with change in any strength measure, but change in military press was positively correlated with the change in leg and torso fat-free mass ($p<0.05$).

All strength and performance variables increased significantly from pre- to post-BCT, but the changes in strength and performance were not highly correlated with changes in fat-free mass. It is likely that the increases in strength were due to changes in neural factors, rather than to muscle hypertrophy. These neural factors might include the efficiency of the recruitment pattern of muscle fibers, the synchronization of motor unit firing, or the ability to stimulate high threshold fast twitch motor units (Moritani and DeVries, 1980; Fleck & Kraemer, 1987).

The correlations between the APFT test scores and the strength, power, and task performance variables are listed in Table 46. As might be expected, the measures of muscular endurance (push-ups and sit-ups) tended to be significantly correlated with measures of strength (machine lift, bench press, and military press) and with load carriage performance. The load carriage task was designed to be an indicator of anaerobic capacity and was the measure most consistently related to the APFT test items pre- and post-BCT. The correlations ranged from $r=-0.42$ with run time to $r=0.41$ with total score. The poor correlation between push-ups and the torque task was surprising, as these are both upper body exercises. None of these correlations were above $r=0.50$ indicating that APFT events are not highly representative of muscle strength, power, or the tasks selected. Rather, the APFT is an indicator of muscular endurance and aerobic capacity.

Several authors have proposed the use of a minimal fat-free mass standard (Harman and Frykman, 1992; Hodgdon, 1992; Vogel, 1992) instead of, or in addition to

Table 45. Correlations of the BCT change in weight, regional and total fat-free mass with the BCT change in strength, power, and task performance variables.

Δ in:	ΔWeight	ΔArm FFM_{DEXA}	ΔLeg FFM_{DEXA}	ΔTrunk FFM_{DEXA}	ΔTotal FFM_{DEXA}
Machine lift (kg)	0.17	0.11	0.06	0.14	0.16
Bench press (kg)	0.31**	0.18	0.14	0.14	0.21*
Military press (kg)	0.31**	0.12	0.21*	0.19*	0.26**
Jump height (cm)	-0.03	-0.12	-0.04	-0.02	-0.07
Jump power (W)	0.35**	-0.10	0.09	0.06	-0.15
Torque (Nm)	-0.01	0.02	-0.01	0.00	-0.04
Load carriage ($m \cdot s^{-1}$)	0.25**	0.07	0.16	0.07	0.21*
Push-ups (#)	-0.03	0.01	0.03	-0.07	0.05
Push-ups (score)	-0.08	0.12	0.02	-0.04	0.13
Sit-ups (#)	-0.18*	-0.11	-0.15	0.11	0.05
Sit-ups (score)	-0.14	-0.11	-0.12	0.10	0.10
2-mile run (sec)	-0.02	-0.06	-0.16	0.08	-0.11
2-mile run (score)	0.13	0.03	0.10	-0.04	0.09

*p<0.05, **p<0.01 level.

Table 46. Correlations of Army Physical Fitness Test performance and muscle strength, power, and task performance measured pre- and post-BCT.

	Push-ups	Sit-ups	Run time	Total points
Machine lift (kg)				
Pre-BCT	0 .32**	0.32**	-0.22*	0.32**
Post-BCT	0 .27**	0.30**	-0.09	0.23*
Bench press (kg)				
Pre-BCT	0.50**	0.33**	-0.26**	0.45**
Post-BCT	0.41**	0.23*	-0.10	0.27**
Military press (kg)				
Pre-BCT	0.36**	0.25*	-0.20*	0.36**
Post-BCT	0.29**	0.10	-0.10	0.17
Vertical jump (cm)				
Pre-BCT	0.30**	0.38**	-0.18	0.27**
Post-BCT	0.25*	0.26**	-0.25*	0.26**
Peak power (W)				
Pre-BCT	0.06	0.21*	-0.08	0.11
Post-BCT	-0.01	0.06	0.00	-0.02
Torque (Nm)				
Pre-BCT	0.23*	.16	-0.22*	0.25*
Post-BCT	0.06	.04	-0.05	0.02
Load carriage ($m \cdot s^{-1}$)				
Pre-BCT	0.33**	0.34**	- 0.42**	0.41**
Post-BCT	0.34**	0.31**	- 0.39**	0.37**

(** p<0.01, * p<0.05)

a maximal percent body fat standard. The soldiers were divided into quintiles based on total fat-free mass to examine the effect of fat-free mass on performance. A repeated measures analysis of variance was performed on the seven strength and performance measures collected pre- and post-BCT for each of the quintile groupings. The performance and strength variables grouped by total body fat-free mass quintiles are illustrated in Figure 25. The main effects for quintiles and pre- to post-BCT were significant for all measures of strength and power ($p<0.01$). For all measures, soldiers with more total body fat-free mass had significantly better scores than the lower quintiles.

Physical Performance and MOS Selection

Military occupational specialties (MOS) are classified into one of five lifting categories ranging from light to very heavy, as shown in Table 47 (Department of the Army, 1994). A repeated measures ANOVA was conducted to determine if there were strength or performance differences between the MOS categories pre- or post-BCT. There were no group differences for any of the strength, power, or task performance variables. This indicates that the soldiers did not select an MOS based on the physical demands of the job. The stronger soldiers were not drawn to the heavier lifting jobs, nor the weaker soldiers to the lighter lifting jobs. Figure 26 shows the percentage of soldiers in each category who met the entrance standards for their MOS pre- and post-BCT.

Table 47. Army Military Occupational Specialty physical demand category lifting requirements (Department of Army, 1994).

	Occasional	Frequent	MOS open to female soldiers	
	(kg)	(kg)	number	% total
Light	9.0	4.5	25	10.5
Medium	22.7	11.3	37	15.5
Moderately heavy	36.3	18.1	54	22.6
Heavy	45.3	22.7	32	13.5
Very heavy	>45.3	>22.7	91	38.1

Female soldiers do not select an MOS based on their ability to perform the lifting requirements of the job. Therefore, a pre-assignment screening test to determine their lifting ability is needed. To examine the efficacy of using a fat-free mass standard as a pre-assignment screening test, the predictive relationships between fat-free mass

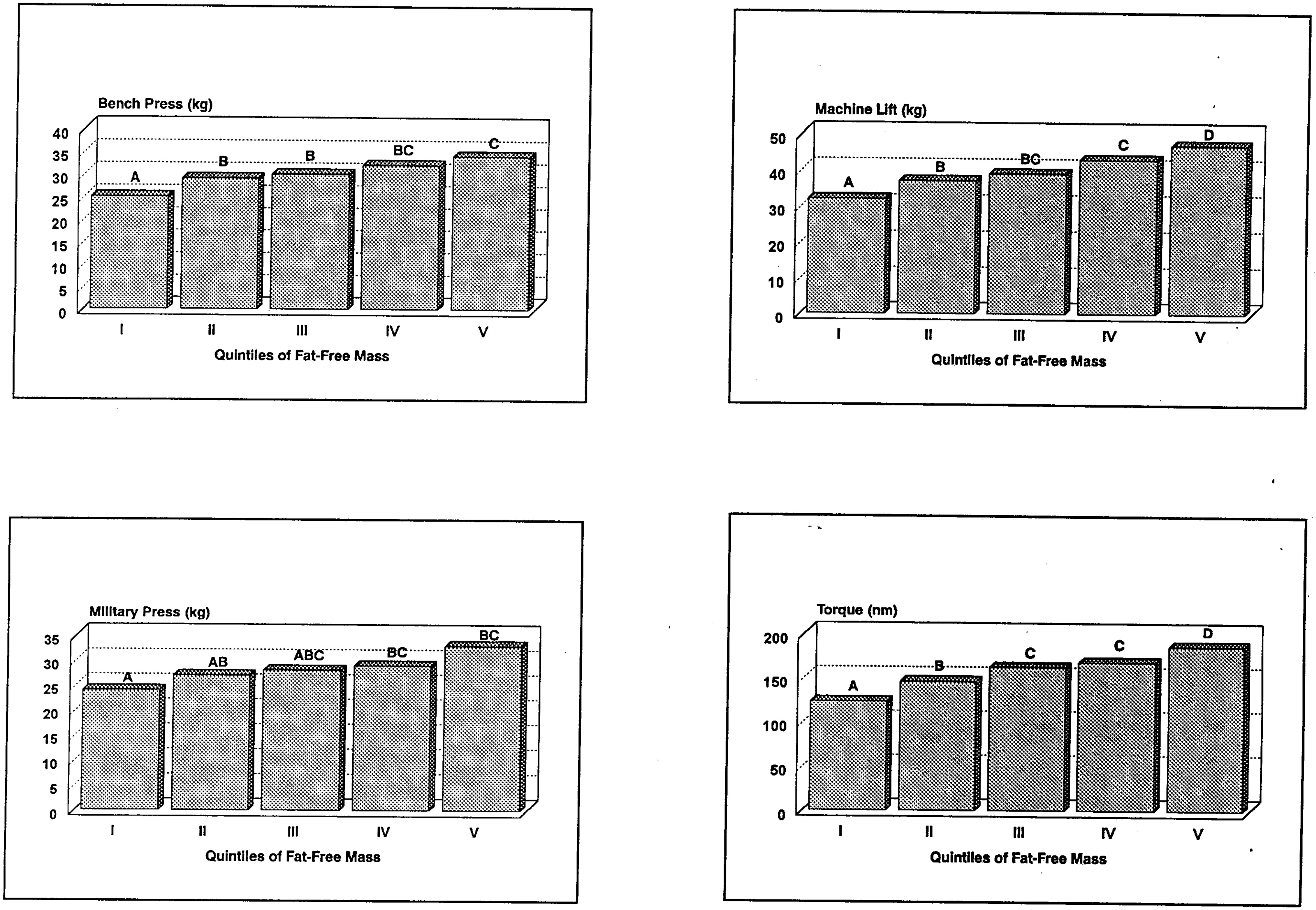


Figure 25. Muscle strength and performance measures grouped by whole body fat-free mass quintiles ($p<0.05$).

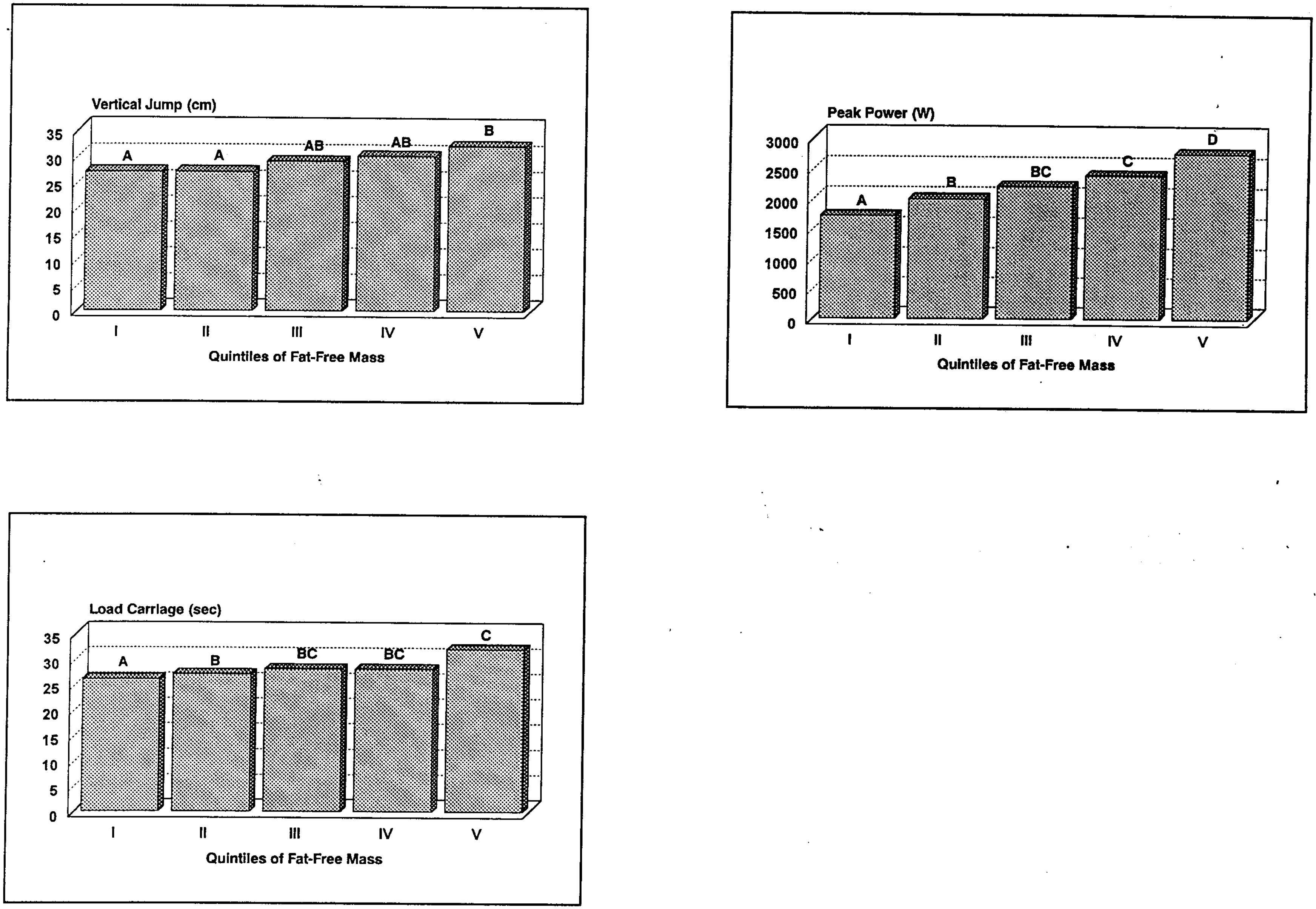


Figure 25. (cont.) Muscle strength and performance measurements grouped by whole body fat-free mass quintiles ($p<0.05$).

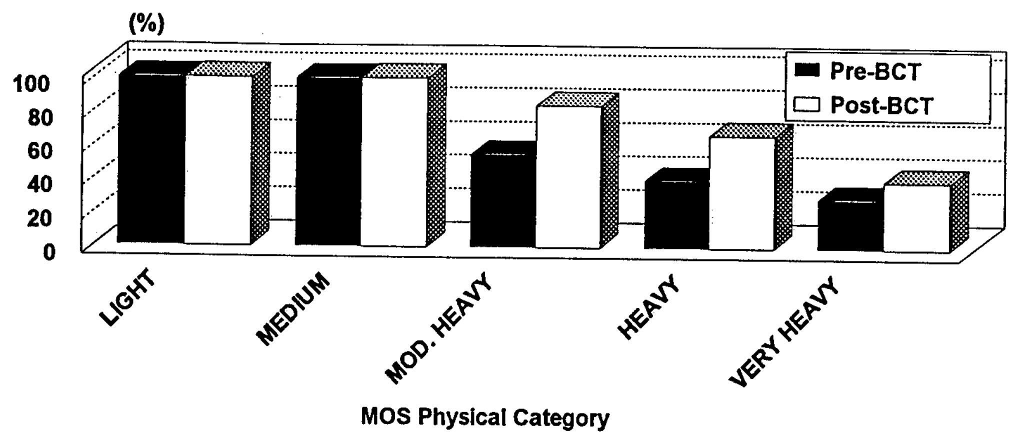


Figure 26. Percentage of soldiers strength-qualified for their assigned Military Occupational Specialty (MOS) pre- and post-BCT.

Table 48. Predictive equations for machine lift, torque task and load carriage task using fat-free mass as the predictor (A), and using all strength and body composition variables as predictors (B).

A.	R^2	SEE
Machine lift (kg) = -9.64 + 1.16 FFM	0.38	6.7
Torque task (nm) = -49.7 + 4.79 FFM	0.56	19.4
Load carriage ($m \cdot s^{-1}$) = 1.25 - 0.005 FFM	0.26	0.408
B.	R^2	SEE
Machine lift (kg)) = 5.26 + 0.01 Power +.55 BP	0.63	5.2
Torque task (Nm) = -48.1 + 3.73 FFM + 1.73 MP	0.63	18.0
Load carriage ($m \cdot s^{-1}$) = 2.46 - 0.029 ML -0 .0002 Power - 0.024 (%BF)	0.62	0.299

Note: FFM = fat-free mass; BP = bench press; MP = military press; ML = machine lift; %BF = percent body fat and maximal lifting capacity, torque task performance, and load carriage performance were examined. The predictive equations are all based on pre-BCT data and are listed in Table 48. The stepwise multiple regression equations for the three dependent variables using the strength and body composition variables as predictors are also listed. The relationship between fat-free mass and machine lift is illustrated in Figure 27. Illustrated also are the MOS physical demand category lifting limits. The relationship between fat-free mass and lift does not appear to be strong enough to use as a job assignment tool. It would exclude a large number of women capable of lifting the required load for heavier lifting category jobs. The equations for predicting torque and load carriage task performance from fat-free mass are of poor predictive value, accounting for 56% and 26% of the variance, respectively. The addition of the other strength and body composition variables as predictors strengthens the predictive capacity of the equations. Fat-free mass was the first variable to enter the equations for torque task performance.

Women with more fat-free mass performed better on all measurements, and regional and total fat-free mass was positively correlated with performance before and after BCT. These findings suggest that a minimum level of fat-free mass should be maintained for effective task performance and that this level should be adjusted based on the physical demands of the MOS. However, fat-free mass alone was not a good predictor of performance on the machine lift (r^2=0.38), the torque task (r^2=0.56), or the load carriage task (r^2=0.26). A method of pre-screening recruits for physically demanding MOSs is needed, as our results clearly show that there is no relationship between the strength of the individual and the physical demands of the MOS they select. While it would be expensive, the results of this study indicate that it would be more effective to use job specific task performance tests to screen female soldiers for occupational assignment. If validated, such a method could be used to quickly and safely screen individuals for physically demanding military jobs.

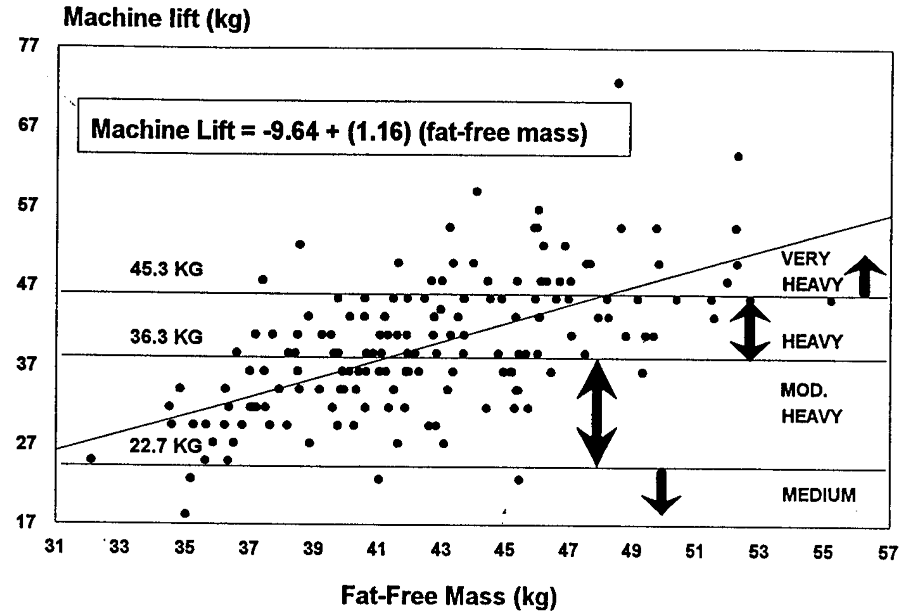


Figure 27. Relationship between fat-free mass and machine lift with the physical demand category lifting limits noted.

Effect of Prior Pregnancy Status on Strength and Performance Tasks

A comparison was made between the strength and performance results of those soldiers who reported to have been previously pregnant (n=52) and the results of those soldiers who reported no previous pregnancy (n=105). There were no significant differences between the two groups pre-BCT. Though both groups improved in strength over the period of BCT, a review of the post-BCT results demonstrated the previously pregnant group to be significantly stronger in the performance of the bench press and torque task ($p<0.05$). No significant differences were demonstrated between the two groups when evaluating scores for the first and last APFTs.

CLINICAL BIOCHEMISTRY

General Laboratory Results

Albumin and total proteins decreased across the three time periods, suggesting the possibility of an extracellular volume expansion occurring as a result of physical training (Table 49). However, this was not reflected in a reduced hematocrit or hemoglobin concentration, indicating that these changes cannot be explained by an acute hydration or dehydration occurring near the time of any of the blood samplings (Table 50). Though neither hematocrit nor hemoglobin demonstrated declines over BCT, other markers of iron and hematologic status did show disturbing changes (Table 50). For example, as an acute phase marker, ferritin normally increases as a function of inflammation or infection. However, it demonstrated a surprising decline through BCT. It is unlikely that this change can be explained by any change in oral contraceptive pill use. This suggests that reductions in iron stores may have been more significant than these other typical influences. Hematological status is discussed in further detail in the next section, as a substudy focus of this project.

Serum enzymes typically used as clinical markers of tissue injury remained relatively stable, with means within the normal range at all three time points (Table 51). Creatine kinase was an exception, and demonstrated a large rise at the midpoint, suggesting the occurrence of relatively strenuous physical training before this blood sample. This explanation is further substantiated by the concomitant increase in lactate dehydrogenase observed at this same time point.

Serum cholesterol remained unchanged, but the HDL subfraction increased and LDL decreased over time, reflecting an improvement in the status of cardiovascular health which is typical of modest fat weight loss and increased exercise habits (Table 49). Other biochemical evidence of maintenance or improvements in health status are reflected in the minimal changes in levels of circulating white blood cells (Table 52), and the increased responsiveness of T-lymphocytes to mitogens (refer to subsequent section on immunological assessment).

Vitamin status improved through BCT, with reductions in stimulated enzyme

Table 49. Biological markers of protein and lipid status.

Variable	Reference range	Blood #1	Blood #2	Blood #3
Albumin (g/dl)	(3.2 - 5.5)	4.6±0.3	4.4±0.3*	4.34±0.41*▲
Total protein (g/dl)	(6.7 - 8.2)	7.40±0.46	7.10±0.43*	6.91±0.63*▲
NEFA (mmol/L)	(0.10 - 0.60)	0.54±0.27	0.34±0.17*	0.24±0.14*▲
Glycerol (μmol/L)	(61 - 232)	72±30	56±26*	46±18*▲
Cholesterol (mg/dl)	(< 200)	175±34	171±31	173±34
HDL (mg/dl)	(> 35)	47±10	49±10	55±13*
LDL (mg/dl)	(<130)	114±29	107±25*	105±30*
Triglycerides (mg/dl)	(35 - 160)	65±40	67±28	57±28

*Significantly different from blood #1 ($p<0.05$)

▲ Significantly different from blood #2 ($p<0.05$)

Table 50. Biological markers of iron and hematologic status.

Variable	Reference range	Blood #1	Blood #2	Blood #3
Ferritin (ng/ml)	(22 - 447)	17.35±14.20	10.70±9.96*	10.90±9.09*
Hb (g/dl)	(12.1 - 17.2)	12.88±0.97	12.81±1.14	12.80±1.05
Hct (%)	(36.1 - 50.3)	38.16±2.59	37.96±3.17	39.07±2.91▴
Hpt (mg/dl)	(13 - 163)	104.09±43.91	84.63±41.56*	83.50±38.31*
Iron (μg/dl)	(50 -160)	76.15±35.06	78.67±38.68	75.20±35.77
Iron saturation (%)	(20 - 50)	22.88±10.58	23.99±10.83	22.76±11.93
MCH (pg)	(27.6 - 33.3)	30.17±2.17	30.17±1.97	29.42±2.07*▴
MCHC (g/dl)	(33.0 - 34.8)	33.75±0.66	33.73±0.90	32.75±0.64*▴
MCV (fl)	(82.2 - 97.4)	89.57±4.80	89.00±6.78	89.56±5.09
RBC ($x10^6$)	(3.9 - 5.7)	4.27±0.31	4.25±0.34	4.37±0.32*▴
RDW	(11.6 - 13.7)	12.68±0.88	12.92±0.86	13.43±2.22*▴
TIBC (μg/dl)	(250 - 450)	341.49±47.58	330.26±48.11	335.21±46.47

*Significantly different from blood #1 ($p<0.05$)

▴ Significantly different from blood #2 ($p<0.05$)

Table 51. Biological markers of liver function.

Variable	Reference range	Blood #1	Blood #2	Blood #3
Alanine aminotransferase (IU/L)	(10 - 60)	16.4±9.8	22.4±13.1*	19.1±8.3▲
Aspartate transaminase (IU/L)	(10 - 42)	23.1±8.2	30.3±12.3*	28.6±9.4*
Creatine kinase (IU/L)	(22 - 269)	205.4±625.6	355.8±547.9*	262.6±257.6
Lactate dehydrogenase (IU/L)	(91 - 180)	138.8±26.6	177.2±31.1*	164.8±28.4*▲
Uric acid (mg/dl)	(2.6 - 7.0)	4.6±0.8	4.3±0.8*	4.4±0.9*
GGT (IU/L)	(7 - 64)	17.8±12.6	18.2±14.4	17.5±11.6
Total bilirubin (mg/dl)	(0.2 - 1.0)	0.8±0.3	0.8±0.2*	0.7±0.2*▲

Table 52. White blood cell differential analysis.

Variable	Reference range	Blood #1	Blood #2	Blood #3
WBC ($x10^9$/L)	(3.6 - 9.6)	5.8±1.8	6.2±1.9	6.1±2.1
Lymphocyte ($x10^9$/L)	(20.5 - 51.1)	34.8±10.4	38.5±10.3	43.0±9.8
Monocyte ($x10^9$/L)	(0.1 - 0.6)	0.7±0.3	0.7±0.2	0.7±0.6
Granulocyte ($x10^9$/L)	(1.4 - 6.5)	5.7±1.2	5.3±1.1*	4.9±1.1*▲

*Significantly different from blood #1 ($p<0.05$)

▲ Significantly different from blood #2 ($p<0.05$)

Table 53. Biological markers of vitamin and mineral status.

Variable	Reference range	Blood #1	Blood #2	Blood #3
Vit A (μg/dl)	(30 - 80)	54.96±31.21	50.80±18.82	49.63±20.10
Vit B_1 (%stim)	(<23)	7.60±4.20	6.00±4.34*	5.70±4.50*
Vit B_2 (%stim)	(<76)	40.0±15.8	38.7±16.9	35.0±16.7*
Vit B_6 (%stim)	(<130)	99.4±34.7	85.0±18.4*	77.2±13.4*▲
Vit B_{12} (pg/ml)	(232 - 1138)	441±162	469±165	431±140
Vit C (mg/dl)	(5 -15)	6.78±3.77	21.58±37.91*	21.03±12.79*
Vit D (ng/ml)	(10 -50)	19.60±10.17	21.81±8.43	32.64±12.24*▲
Serum Folate (ng/ml)	(2.2 - 17.3)	7.63±3.84	4.65±4.52*	4.23±4.77*
RBCFolate (WBFolate X100)/Hct) (ng/ml)	(169 - 707)	147.94±68.13	164.48±64.29	171.20±69.22*
RBP (mg/dl)	(3 - 6)	3.92±0.79	3.89±0.70	3.85±0.69
Calcium (mg/dl)	(8.4 - 10.2)	10.1±0.4	9.8±0.3*	9.77±0.63*
Mg (mg/dl)	(1.8 - 2.5)	2.17±0.14	2.25±0.15*	2.19±0.19
Phos (mg/dl)	(2.5 - 4.6)	3.88±0.42	3.99±0.48	4.20±0.57*▲

*Significantly different from blood #1 ($p<0.05$)

▲ Significantly different from blood #2 ($p<0.05$)

activities, indicating improved thiamine (Vit B_1), riboflavin (Vit B_2), and B_6 intakes (Table 53). These observations are important when considered in concert with the menu content and dietary intake data already presented in Tables 7 and 8. In particular, these data suggested that the menu that was analyzed over a 7-day period was deficient in B_6 content (Table 7), and that the soldiers were only consuming 76% of their MRDA requirement of this vitamin (Table 8). This deficiency is not reflected in the biochemical data. Two other examples of differences between nutritional and biochemical assessments are noted in the analysis of calcium and magnesium, both of which were found to be deficient in the content of the menu and the intake of the soldiers (calcium - 73% of MRDA; magnesium - 89% of MRDA). Once again, the biochemical data did not reflect these problems. On the other hand, the determined adequacy observed with thiamine and riboflavin in the nutritional assessment is consistent with the biochemical evidence. As well, the reported deficiency in folic acid intake (65% of MRDA) may be reflected in the significant declines in serum folate levels; however, erythrocyte folate, increased over time. Other encouraging biochemical evidence of improvements in vitamin status were demonstrated in the significant increase observed in Vitamin D. There was relatively little change in Vitamin B_{12} or Vitamin A (as indicated by a stable retinol binding protein level). Vitamin C demonstrated a marked increase, with a mean near the lower limit of the normal range at the start of BCT, to levels above the normal range at mid- and post-BCT. This reflects the high Vitamin C fortification of many of the foods served to soldiers as well as other influences such as the restriction of smoking.

Iron Status

Iron deficiency is described as progressing in three stages: 1) iron stores in the bone marrow, liver, and spleen are depleted; 2) erythropoiesis diminishes as the iron supply to the erythroid marrow is reduced, and; 3) hemoglobin production falls, resulting in anemia (Life Sciences Research Office, 1991; Prasad & Prasad, 1991; Massey, 1992). The clinical characteristics of these stages are displayed in Table 54.

Table 54. Indicators of the progressive stages of iron deficiency.

ASSESSING IRON DEFICIENCY	
Stage of iron deficiency	Clinical indicator
I. Iron-deficient stores (iron depletion)	Plasma ferritin < 20 μg/L
II. Iron-deficient erythropoiesis	Transferrin saturation < 16%
	Total iron-binding capacity > 4000 μg/L
	Serum iron < 500 μg/L
	Red cell distribution width > 15%
	RBC protoporphyrin >700 μg/L
III. Iron-deficient anemia	Hemoglobin < 12 mg/ml
	Hematocrit < 36%

As previously mentioned, a significant decrease in serum ferritin was observed between the first and second blood draws in the current study (Table 50). Levels remained low for the third blood draw. The diagnostic function of serum ferritin concentration is to serve as a parameter for evaluating the size of body iron stores, and in healthy people it has been shown to be directly proportional to these stores. The critical level indicating the beginning of iron depletion is about 60ng/ml. Levels below 20ng/ml are associated with the absence of iron in the bone marrow. These numbers are of critical importance when evaluating not only the progressive decline in serum ferritin levels over the eight weeks of BCT, but also when consideration is given to the very low mean ferritin values observed at the time of the first blood sampling. Even before beginning BCT, 56% of the soldiers had ferritin values of less than 20ng/ml. This number increased to 84% by the end of BCT.

Mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular hemoglobin (MCH) were also significantly reduced at the end of BCT (Table 50). Reduction of these parameters is also associated with iron deficiency. Presence of this hypochromia, and low serum ferritin concentration, concurrent with hemoglobin within a normal range as was observed in this study can be interpreted as a depletion of iron stores and prelatent iron deficiency, respectively. This may be explained by an inadequate nutritional iron intake, which could be a possible causative agent in this study, since the soldiers were determined to only be taking in 90% of the MRDA standard for iron (Table 8). It is important to recall that the menu nutritional analysis only represented one week of the eight-week BCT cycle).

Besides the nutritional intake issue, another possible explanation for this iron-deficient status could be an increased rate of intravascular hemolysis and accelerated destruction of erythrocytes. Such a process would lead to a stimulation of erythropoiesis and to an increased iron requirement. This possibility did exist within this study since haptoglobin was seen to decrease significantly by the second blood draw, and remained low at the third blood draw (Table 50). Low serum haptoglobin levels are most frequently associated with conditions of increased intravascular hemolysis, or hemoglobin turnover. Further support for this hemolysis argument is provided by the statistically significant increase in lactate dehydrogenase (LDH) (Table 51), though the mean concentration of this enzyme did not fall outside of the normal range. Since tissue levels of LDH are considerably higher than normal serum levels, a leakage from even a small mass of damaged tissue can increase the observed serum level of LDH to a significant extent. The exact tissue source (i.e., erythrocytes vs. skeletal muscle) of the increase in LDH observed in this study cannot be determined, since no isoenzyme analysis was performed.

Other possible causes that may explain this negative iron balance could be a depression in intestinal iron absorption. Since such changes most likely occur only with certain pathologies, this is an unlikely explanation for the iron deficiency seen in the soldiers in this study. However, it is possible that problems with absorption may have resulted because of inadequate intake of the more easily absorbed heme iron, which is only found in meat, fish, and poultry. Reliance upon non-heme iron is highly dependent upon its bioavailability, which is considerably lower than is the bioavailability of heme iron. Since the major contributor to iron intake for these soldiers was determined to be grains (King, et al., 1994), it is possible that bioavailability may have been a contributing issue to the iron deficiency.

Another possible explanation for iron deficits could be an accelerated iron elimination and loss of iron due to profuse sweating, fecal loss, hemoglobinuria, hematuria, and menses. None of these avenues of iron loss were adequately assessed by this investigation. However, since studies suggest that minimal iron is generally lost through the skin, gastrointestinal, and urinary tracts, menstrual blood loss is most often considered as the primary cause of iron loss in healthy women. Record of menstrual cycle regularity revealed that more than half of the soldiers in this study reported two discrete menses (88/161) with a median interval of 28 days. Another 30 soldiers recorded 1 menses near mid- or post-BCT, indicating that their cycles had not ceased. This would suggest that these 118 soldiers continued to lose the approximate amount of 0.5mg of iron per day, which has been attributed to the demands of the menstrual cycle (Haymes, 1993). No menstruation was reported by 14 soldiers, and 29 reported only one episode at pre-BCT, suggesting that 43/161 women may have been, or became, amenorrheic during basic training.

Consequences of iron deficiency may be low levels of physical work capacity and excess lactate formation (not measured in this study). Since the subjects in this study demonstrated an improvement in endurance over the BCT period, as measured by 2-mile run times, it may seem that the degree of iron depletion was not sufficient to negatively influence aerobic capacity. However, an association between anemia and poor APFT performance was observed. The raw scores for each APFT event, as well as the test total score, were determined to be worse for the anemic group (Hgb<12) than for the nonanemic group (Hgb≥12). This was true for both the first and the last APFTs. Statistically significant differences existed between anemic and nonanemic groups when comparing run times for the last test and total scores for both APFTs. (The lack of significance for the difference in run times between these two groups for the first APFT was undoubtedly due to large variance in run time, since the range was 18.33 min to 35.00 min.)

Most studies that assess the effects of iron deficiency are largely based upon clinical definitions using ferritin and hemoglobin levels as discriminators of iron balance. However, the relationship between ferritin and hemoglobin concentrations and the existence of iron deficiency is quite inexact. In fact, it has been suggested that it is inadvisable to use a single status measure for detecting iron deficiency because of enormous intra subject variability in these measurements.

Forward linear regression was performed to determine the effects of four different clinical definitions of iron imbalance on the strength, performance, and fitness measures. After controlling for a number of potential confounders, none of the selected definitions (ferritin<20, iron saturation<16, ferritin<20 and iron sat<16, and hgb<12) added significantly to the models, and no model accounted for more than 33% of the calculated variance at the beginning of BCT.

Ethnic Differences

Many researchers have suggested an ethnic difference in hemoglobin levels (Garn et al., 1975; Meyers et al., 1979; Williams, 1981; Meyers et al., 1983; Pan & Habicht, 1991). Analyzed age by age, from the first year of life through the ninth decade, blacks have been shown to have lower hemoglobins than whites by approximately 1gm/100ml. This has been shown to be true in those of a higher economic status, as well as athletes. Despite the lack of a definitive resolution as to whether genetics or socioeconomic issues is the causative factor, consideration of this possible ethnic difference in hemoglobin concentrations raises an important question regarding the possibility of a need for different clinical laboratory standards.

An ANOVA that examined several iron parameters suggests the subjects within this study support this possibility of an ethnic difference (Table 55). However, no significant differences were seen among ethnic groups when they were compared based upon various definitions of iron deficiency and anemia (ferritin < 20; iron sat < 16; ferritin < 20 and iron sat < 16; ferritin < 20, iron sat < 16, and hgb < 12; and hgb <12).

Table 55. Ethnic differences in hematologic parameters.

	African American			Hispanic			Caucasian		
	Blood 1	Blood 2	Blood 3	Blood 1	Blood 2	Blood 3	Blood 1	Blood 2	Blood 3
Hct (%)	37.13	36.69	37.92	38.18	37.20	38.64	38.73*	38.71▴*	39.72*
Hgb (g/dl)	12.40	12.33	12.27	12.88	12.55	12.72	13.12*	13.08*	13.07*
RBCFolate ((WBFolate X100)/Hct) (ng/ml)		145.86	144.89		154.55	153.52		175.04*	185.94*

▴ significantly different from Hispanic for same blood draw; $p<.05$

* significantly different from African American for same blood draw; $p<.05$

NOTE: No significant differences were seen among efolate, iron sat, or ferritin levels.

Folate Status

Biochemical evidence indicates that iron and folate deficiencies frequently occur simultaneously. The first hematologic consequence of a negative folate balance is depression of serum folate concentrations, which may occur after only 3 weeks of dietary folate deprivation (O'Connor, 1991). Therefore, serum folate concentrations typically reflect recent folate intake. This is cause for concern when interpreting the folate biochemistries for the current study (Table 53). The group means for the serum values were low normal, and declined significantly over the 8-week training period. The presence of depressed red blood cell folate concentrations are felt to be more reflective of an actual biochemical folate deficiency. Depression of these concentrations occurs around 17-19 weeks of negative folate balance, and indicates a severe depletion of folate stores.

IMMUNOLOGICAL ASSESSMENT

The effects of BCT on proliferative responsiveness of T-lymphocytes to suboptimal and optimal doses of PHA-P for maximum proliferation *in vitro* are presented in Figures 28 and 29. Whole blood cultures pre-BCT, mid-BCT (at the end of week four), and post-BCT were stimulated with three concentrations of PHA-P. Blood cultures mid-BCT and post-BCT showed significantly higher ($p<0.05$) T-lymphocyte proliferation than similar cultures pre-BCT when stimulated with suboptimal (0.5 µg) and optimal (2.0 and 4.0 µg) concentrations of PHA-P for maximum proliferative responsiveness (Figure 28); percentage increases, respectively, of 149, 165, and 138 mid-BCT, and 48, 144, and 132 post-BCT (Figure 30).

Although the post-BCT proliferative responses of T-lymphocytes to PHA-P at 0.5 and 2.0 µg per blood culture were higher than the pre-BCT responses, they were lower than mid-BCT. Reduction was greater in the cultures stimulated with the lowest (0.5 µg) dose of PHA-P. This may reflect the effect of physical stress, which would agree with increased plasma IL-6 levels in the soldiers post-BCT (Figure 30).

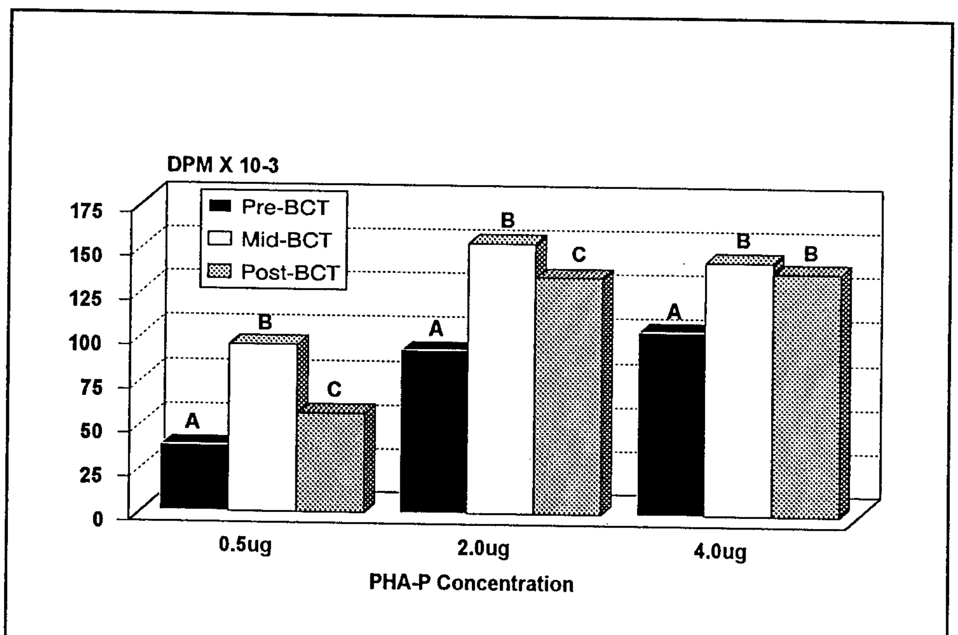


Figure 28. Proliferative responsiveness of T-lymphocytes to suboptimal (0.5μg) and optimal (2.0μg and 4.0μg) concentrations of PHA-P pre-BCT, mid-BCT, and post-BCT (n=48).

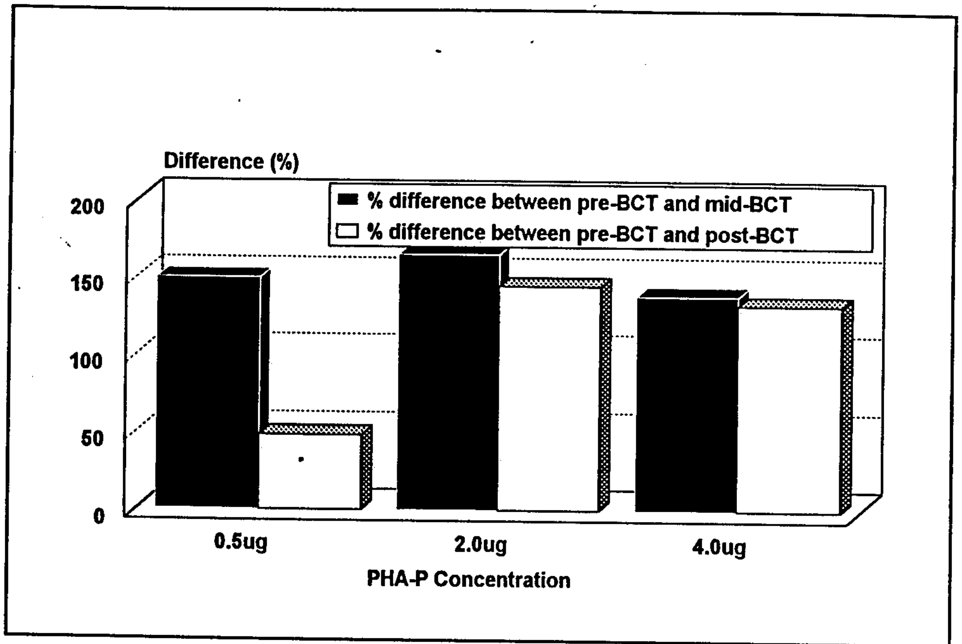


Figure 29. Percent difference in proliferative responsiveness of T-lymphocytes to suboptimal (0.5μg) and optimal (2.0μg and 4.0μg) concentrations of PHA-P (n=48).

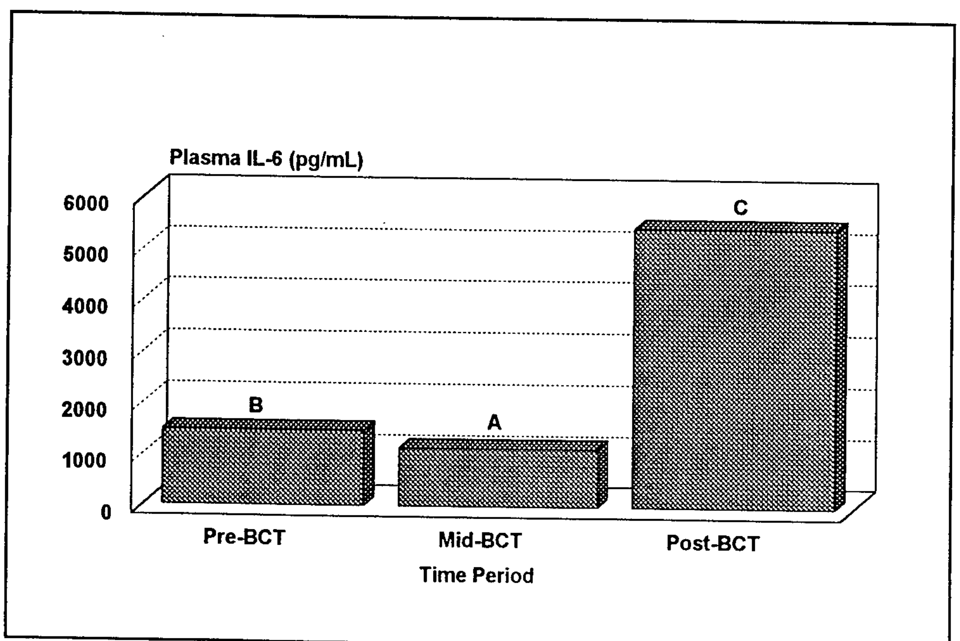


Figure 30. Plasma concentration of IL-6 at three different times during BCT (n=48).

The effects of BCT on systemic responsiveness to stressors, as measured by plasma levels of IL-6, are presented in Figure 30. Mid-BCT plasma showed a slight but significant decrease in IL-6 concentration, followed by a dramatic increase post-BCT, which may reflect the effects of recent heavy workloads (i.e., road-march).

The effects of BCT on T-lymphocyte immune responsiveness *in vitro* to tetanus are presented in Figures 31 and 32. Whole-blood cultures from volunteers pre-BCT, mid-BCT, and post-BCT were stimulated with three concentrations of tetanus toxoid (TT) antigen. Blood cultures stimulated with 3.2, 6.4 and 12.8 Lf of TT from soldiers mid-BCT and post-BCT showed significantly higher T-lymphocyte proliferation *in vitro* than similar cultures pre-BCT (Figure 31); percentage increases, respectively, of 74, 73, and 61 mid-BCT, and 94, 63, and 75 post-BCT (Figure 32). It is hypothesized that the increased proliferative responsiveness of T-lymphocytes to TT during BCT was the result of vaccination with TT, and not the result of training.

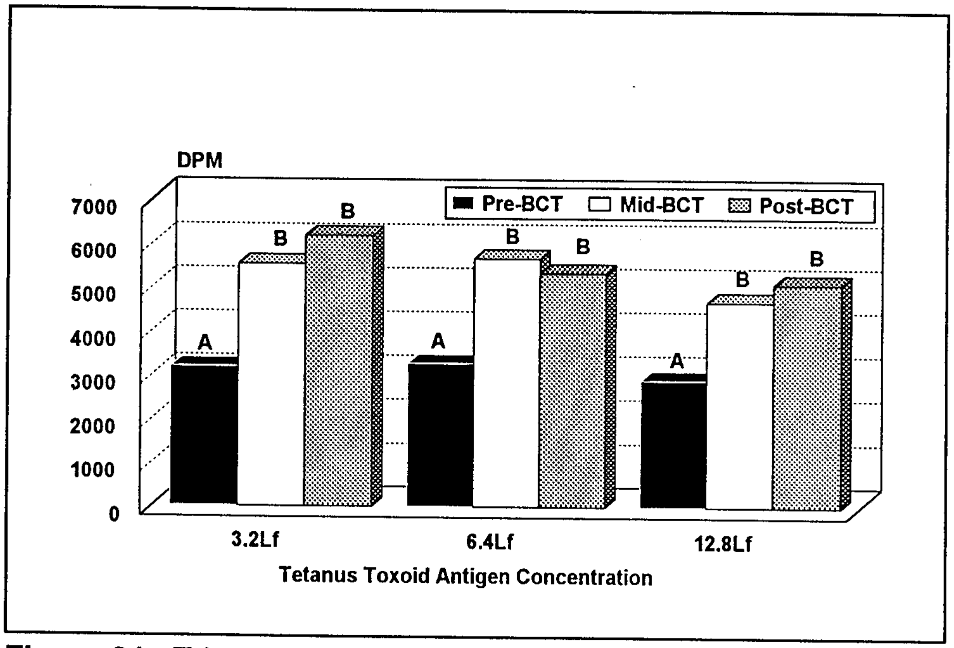


Figure 31. T-lymphocyte responsiveness to three concentrations of tetanus toxoid antigen at three different times during BCT (n=48).

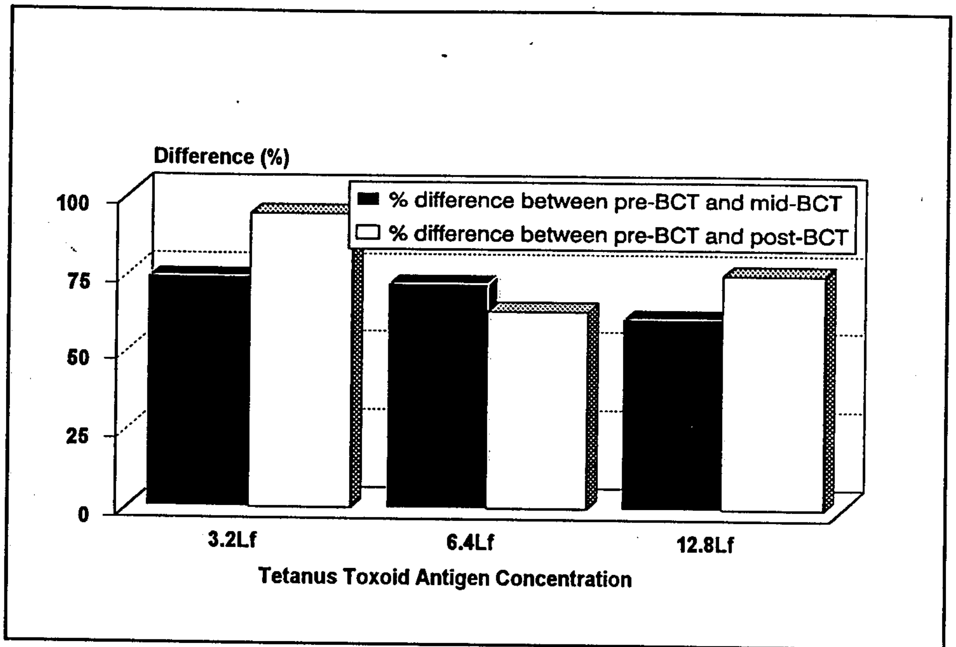


Figure 32. Percent difference in T-lymphocyte responsiveness of blood collected at three different times during BCT to three concentrations of tetanus toxoid antigen (n=48).

INJURY AND ILLNESS DATA

Incidence and Distribution of Injury

During the 8-week period of training, 66.7% (110/165) of soldiers incurred one or more injuries. Eighty-nine percent of these injuries resulted in a time-loss injury. The crude injury rate (initial injuries) was 33 injuries per 100 soldiers per month. Table 56 presents the frequency of injuries, the frequency of clinic visits, and the days lost from duty due to the injury. Overuse injuries were the most frequently reported injuries (74.1%) and resulted in the greatest number of lost duty days (1019 days). Stress reactions and stress fractures resulted in the greatest average number of duty days lost per overuse diagnosis (19 days per injury). The three most common injuries reported were generalized musculoskeletal overuse pain/strain, overuse fascitis, and traumatic joint sprains. These three categories of injury accounted for 79% of all injuries.

The anatomical sites of injury are shown in Table 57. Ninety-one percent of the injuries involved the lower extremity and low back. Seventy-eight percent of these were lower extremity injuries. The foot and ankle were the most common sites for injury resulting in the highest number of days lost from duty. The average number of days lost was highest in injuries affecting the knee and pelvis/hip areas, suggesting that the most severe injuries occurred at these sites. Stress reactions or stress fractures accounted for a total of ten injuries. Six of these were in the foot, three were in the lower leg, and one was in the ankle.

Incidence and Distribution of Illness

The cumulative incidence of soldiers with one or more illnesses was 57.0% (94/165). Thirteen percent of these illnesses resulted in time lost from duty. The frequency and distribution of different types of training illnesses are reported in Table 58. Upper respiratory infections, gynecological conditions, and dermatological complaints were the three most frequent illness categories recorded. Gynecological conditions accounted for 34.3% of all illnesses. Seven soldiers were diagnosed and treated with anemia, which accounted for the highest number of lost duty days,

Table 56. Frequency and distribution of injuries and associated loss of duty days.

	Injury		Total Clinic Visits* (Injury only)			Duty Days Lost		Total Clinic Visits* (Injury and Illness)
	#	%	#	%	mean	#	mean (range)	%
Overuse	**152**	**74.1**	**255**	**76.4**	**1.7**	**1019**	**6.7(0-45)**	**47.9**
Strain\Pain	108	52.7	180	53.9	1.7	624	5.8(0-45)	33.8
Fascitis	21	10.2	34	10.2	1.6	120	5.7(0-27)	6.4
Tendinitis\Bursitis	9	4.4	15	4.5	1.7	75	8.3(0-19)	2.8
Stress reaction	6	2.9	15	4.5	2.5	119	19.8(7-36)	2.8
Stress fracture	4	2.0	7	2.1	1.8	73	18.3(6-37)	1.3
Boot Neuropathy	3	1.4	3	0.9	1.0	3	1.0(0-3)	0.6
Rucksack palsey	1	0.5	1	0.3	1.0	5	5.0	0.2
Traumatic	**39**	**19.1**	**61**	**18.3**	**1.6**	**230**	**5.9(0-40)**	**11.5**
Sprain\Pain	33	16.1	51	15.3	1.5	143	4.3(0-21)	9.5
Fracture	2	1.0	3	0.9	1.5	55	27.5(15-40)	0.6
Contusion	2	1.0	3	0.9	1.5	3	1.5(0-3)	0.6
Dislocation	1	0.5	3	0.9	3.0	25	25.0	0.6
Hernia	1	0.5	1	0.3	1.0	4	4.0	0.2
Wound	**14**	**6.8**	**18**	**5.4**	**1.3**	**24**	**1.7(0-6)**	**3.4**
Blister	11	5.4	12	3.6	1.1	19	1.7(0-6)	2.3
Abrasion\Laceration	3	1.4	6	1.8	2.0	5	1.7(0-5)	1.1
TOTAL	**205**	**100.0**	**334**	**100.0**	**2.0**	**1273**	**6.2(0-45)**	**62.8**

* Total clinic visits = initial and follow-up visits

Table 57. Frequency and distribution of injuries by location and associated loss of duty days.

	Injury		Total Clinic Visits* (Injury only)			Duty Days Lost		Total Clinic Visits* (Injury and Illness)
	#	%	#	%	mean	#	mean (range)	%
Lower extremity	**161**	**78.5**	**267**	**79.5**	**1.7**	**1044**	**6.5 (0-44)**	**50.0**
Foot/Ankle	90	43.9	129	38.4	1.4	520	5.8 (0-36)	24.2
Knee	34	16.6	71	21.1	2.1	204	16.7 (0-42)	13.4
Lower leg	25	12.2	46	13.7	1.8	218	8.7 (0-44)	8.6
Pelvis/Hip	5	2.4	12	3.6	2.4	72	14.4 (0-38)	2.2
Thigh	4	1.9	4	1.2	1.0	14	3.5 (0-5)	0.7
Groin	3	1.5	5	1.5	1.7	16	5.3 (0-12)	0.9
Spine/Trunk	**32**	**15.7**	**44**	**13.1**	**1.4**	**131**	**4.1 (0-40)**	**8.2**
Lower back	25	12.2	36	10.7	1.4	112	4.5 (0-40)	6.7
Chest	3	1.5	4	1.2	1.3	19	6.3 (0-14)	0.7
Upper back	3	1.5	3	0.9	1.0	0	—	0.6
Neck	1	0.5	1	0.3	1.0	0	—	0.2
Upper extremity	**12**	**5.8**	**25**	**7.4**	**2.1**	98	**8.2 (0-25)**	**4.6**
Upper extremity	7	3.4	13	3.8	1.9	62	8.9 (3-25)	2.4
Shoulder	5	2.4	12	3.6	2.4	36	7.2 (0-19)	2.2
TOTAL	**205**	**100.0**	**336**	**100.0**	**1.6**	**1273**	**6.2 (0-44)**	**62.8**

* Total clinic visits = initial and follow-up visits

Table 58. Frequency and distribution of illnesses and associated loss of duty days.

	Illness		Total Clinic Visits* (Injury Only)			Duty Days Lost		Total Clinic Visits* (Injury and Illness)
	#	%	#	%	mean	#	mean (range)	%
Gynecological	**58**	**34.3**	**70**	**35.4**	**1.2**	**17**	**0.3(0-10)**	**13.1**
Infectious Vaginitis	33	19.5	37	18.7	1.1	10	0.3(0-10)	6.9
Menstrual Dysfunction	9	5.3	11	5.6	1.2	0	—	2.1
BCP Refill	6	3.6	6	3.0	1.0	0	—	1.1
Other	6	3.6	9	4.6	1.5	0	—	1.7
Pelvic Pain	4	2.3	7	3.5	1.8	7	1.8(0-7)	1.3
Respiratory	**50**	**29.6**	**61**	**30.8**	**1.2**	**23**	**0.5(0-7)**	**11.5**
Viral Infection	36	21.3	42	21.2	1.2	12	0.3(0-7)	7.9
Bacterial Infection	12	7.1	17	8.6	1.4	11	0.9(0-5)	3.2
Other	2	1.2	2	1.0	1.0	0	—	0.4
Dermis	**19**	**11.2**	**21**	**10.6**	**1.1**	**4**	**0.2(0-2)**	**3.9**
Non-Infectious Dermatitis	11	6.5	12	6.1	1.1	0	—	2.2
Infectious Dermatitis	5	3.0	6	3.0	1.2	0	—	1.1
Sunburn	3	1.7	3	1.5	1.0	4	1.3(0-2)	0.6
Gastrointestinal	**12**	**7.2**	**13**	**6.5**	**1.1**	**3**	**0.3(0-3)**	**2.4**
Other	6	3.6	7	3.5	1.2	0	—	1.3
Viral Infection	5	3.0	5	2.5	1.0	0	—	0.9
Bacterial Infection	1	0.6	1	0.5	1.0	3	3.0	0.2

Table 58. (Continued) Frequency and distribution of illnesses and associated loss of duty days.

	Illness		Total Clinic Visits* (Injury Only)			Duty Days Lost		Total Clinic Visits* (Injury and Illness)
	#	%	#	%	mean	#	mean (range)	%
Other	**12**	**7.1**	**14**	**7.0**	**1.2**	**14**	**1.4(0-14)**	**2.7**
Syncope	3	1.7	5	2.5	1.7	14	1.4(0-14)	0.9
Dehydration	2	1.2	2	1.0	1.0	0	—	0.4
Conjunctivitis	2	1.2	2	1.0	1.0	0	—	0.4
Dizziness	2	1.2	2	1.0	1.0	0	—	0.4
Other	2	1.2	2	1.0	1.0	0	—	0.4
+PPD	1	0.6	1	0.5	1.0	0	—	0.2
Urinary	**9**	**5.3**	**9**	**4.6**	**1.0**	**0**	—	**1.7**
Bacterial Infection	9	5.3	9	4.6	1.0	0	—	1.7
Blood	**7**	**4.1**	**7**	**3.6**	**1.0**	**30**	**4.3(0-30)**	**1.3**
Anemia	7	4.1	7	3.6	1.0	30	4.3(0-30)	1.3
Psychosocial	**2**	**1.2**	**3**	**1.5**	**1.5**	**50**	**25(13-37)**	**0.6**
Adjustment Disorder	2	1.2	3	1.5	1.5	50	25(13-37)	0.6
TOTAL	**169**	**100.0**	**198**	**100.0**	**1.2**	**141**	**0.8(0-30)**	**37.2**

* Total clinic visits = initial and follow-up visits

averaging 4.3 lost days per illness. This represents one soldier who received 30 days of limited duty. Two soldiers were dropped from training because of psychosocial adjustment disorders.

RISK FACTORS FOR INJURY

The associations of injury with physical characteristics and life style traits that existed prior to training are shown in Tables 59 and 60. Generally, there were no significant differences in injury risks for different age and body stature. However, for age, there was a tendency for older soldiers to be at lower risk for time-loss injury than their younger counterparts (RR=1.50, p=0.09, X^2 for linear trend). In addition, the leanest females were at lower risk for time-loss injury (RR=1.51, p=0.065, X^2). A weaker association is shown for BMI (RR=1.36). There was no significant association between injury and ethnicity.

In regard to life style traits, those who smoked before BCT were at significantly greater risk for injury when compared to non-smokers (RR=1.25, p=0.045, X^2). Soldiers who reported drinking alcohol prior to BCT also showed a significant trend for higher time-loss injury risk with increasing frequency (days/week) of consumption (RR=1.71, p=0.023, X^2 for linear trend).

The cumulative incidence of injury associated with physical fitness measures obtained at study entry are shown in Table 63. Initial run time showed a strong positive and statistically significant association with higher injury incidence and slower run times (p=0.01, X^2 for trend). All muscle strength measures showed an association with injury. Soldiers with weaker lower body and low back strength (measured by the incremental dynamic lift) were at greater risk for injury (p=0.046, X^2 for linear trend). Upper body strength (military press and bench press) displayed weak, non-statistically significant associations (RR=1.39, 1.32, respectively). Low muscle endurance (push-ups and sit-ups) was weakly and positively associated with time-loss injury (RR=1.38, 1.29, respectively). There was no significant association between injury and power measures. The strongest association between injury and fitness was the load carriage task, a functional measure combining power and total body strength (RR=1.79, p=0.002, X^2 for linear trend).

Table 59. Incidence of injury, time-loss injury, relative risks (RR), and 95% confidence intervals (CI) for age and physical characteristics.

		Injury			Time-Loss Injury		
	n	Incidence (%)	RR	95% CI	Incidence (%)	RR	95% CI
Age (years)							
<19	29	69.0	1.10	0.77<RR<1.59	65.5	1.50	0.93<RR<2.40
19-24	104	67.3	1.08	0.80<RR<1.45	57.7	1.32	0.86<RR<2.02
>24	32	62.5	1.00	—	43.8	1.00	—
Height (cm)							
<156.5	30	70.0	1.13	0.78<RR<1.63	50.0	0.91	0.56<RR<1.47
156.5-169.5	104	67.3	1.08	0.79<RR<1.49	58.7	1.06	0.74<RR<1.53
>169.5	29	62.1	1.00	—	55.2	1.00	—
Weight (kg)							
<52.7	29	79.3	1.25	0.90<RR<1.74	72.4	1.28	0.87<RR<1.88
52.7-70.3	104	64.4	1.02	0.75<RR<1.38	52.9	0.93	0.65<RR<1.34
>70.3	30	63.3	1.00	—	56.7	1.00	—
BMI (kg/m^2)							
<20.8	29	72.4	1.36	0.91<RR<2.03	65.5	1.31	0.84<RR<2.04
20.8-25.9	104	69.2	1.30	0.91<RR<1.86	54.8	1.10	0.74<RR<1.63
>25.9	30	53.3	1.00	—	50.0	1.00	—
Body Fat$_{DEXA}$ (%)							
<24	25	52.0	1.00	—	40.0	1.00	—
24-37.5	106	70.8	1.36	0.92<RR<2.02	60.4	1.51	0.91<RR<2.50
>37.5	25	56.0	1.08	0.65<RR<1.80	48.0	1.20	0.64<RR<2.25

Table 60. Incidence of injury, time-loss injury, relative risks (RR), and 95% confidence intervals (CI) for lifestyle traits.

		Injury			Time-Loss Injury		
	n	Incidence (%)	RR	95% CI	Incidence (%)	RR	95% CI
Cigarette Smoking							
Do not smoke	110	61.8	1.00	—	52.7	1.00	—
Do smoke	53	77.4	1.25	1.02<RR<1.54	66.0	1.25	0.96<RR<1.63
Alcohol Consumption							
Do not drink	60	60.0	1.00	—	50.0	1.00	—
One day per week	73	69.9	1.16	0.90<RR<1.50	56.2	1.12	0.81<RR<1.55
2-3 days per week	22	72.7	1.21	0.87<RR<1.68	72.7	1.45	1.01<RR<2.08
4-5 days per week	7	85.7	1.43	0.99<RR<2.06	85.7	1.71	1.16<RR<2.54

Table 61. Incidence of injury, time-loss injury, relative risks (RR) and 95% confidence intervals for cardiorespiratory and muscular endurance.

		Injury			Time-Loss Injury		
	n	Incidence (%)	RR	95% CI	Incidence (%)	RR	95% CI
2-mile run time (min)							
<21:00	30	50.0	1.00	—	43.3	1.00	—
21:00-26:30	98	67.3	1.35	0.92<RR<1.98	57.1	1.32	0.85<RR<2.06
26:30	31	77.4	1.55	1.03<RR<2.32	64.5	1.49	0.92<RR<2.42
Push-ups (#)							
<2	32	71.9	1.11	0.79<RR<1.56	62.5	1.38	0.86<RR<2.22
2-16	100	66.0	1.02	0.76<RR<1.38	58.0	1.28	0.84<RR<1.96
>16	31	64.5	1.00	—	45.2	1.00	—
Sit-ups (#)							
<21	29	69.0	1.29	0.84<RR<1.96	55.2	1.29	0.75<RR<2.21
21-48	106	69.8	1.30	0.90<RR<1.88	60.4	1.41	0.89<RR<2.22
>48	28	53.6	1.00	—	42.9	1.00	—

The cumulative incidence of injury slightly exceeded that of illness, 66.7% compared to 57.0%. However, the morbidity in terms of restricted and lost duty time was nine times greater for injury with most of the injuries being of the overuse type. Gynecological conditions accounted for the majority of illnesses. This finding is consistent with other basic trainee studies (Jones et al., 1988).

Low physical fitness has been shown to significantly increase the risk of being injured (Jones et al, 1992; Kimsey, 1993). Our data support these findings, as soldiers with slower run times were at greater risk. Individuals with greater strength, particularly lower extremity and low back strength, also had lower risks for injury. This was not shown in male trainees who had no association between muscle strength and injury. Push-ups and sit-ups appeared to follow the same trends as previous studies (Jones et al., 1988; Cowan et al., 1988; Jones et al., 1993).

The most significant physical performance predictor for injury was the load carriage task. The load carriage is a functional test designed to measure the individual's ability to apply total body strength and power to a task as a timed event. It is significantly correlated to incremental dynamic lift that measures lower body and low back strength (r= -0.70). Although strength is an important element to the load carriage, other factors may influence the performance of this task. These other factors may be partly responsible for why soldiers who performed best on this event had reduced musculoskeletal injuries. For example, a change in running posture is required with this task as the center of gravity migrates anteriorly. This postural adaptation along with agility and coordination is necessary to keep from stumbling or falling. Another factor influencing the success of the load carriage is motivation. Maximum effort on tasks that require more than a few seconds to complete is difficult to sustain. Soldiers who can be motivated or who can motivate themselves for this task may be the kind of individual who are less prone to injury.

Self-reported alcohol and smoking use prior to basic training as positive risk factors for injury were other important findings in this study. Cigarette smoking has been identified as a risk factor in other military (Jones et al., 1993; Friedl et al., 1992; Reynolds et al., 1994; O'Conner et al., 1993) and several civilian studies (Battie et al., 1989; Owen and Damron, 1984; Frymoyer et al., 1980; Svensson et al, 1983). However, our finding of increased injury risk with increasing self-reported alcohol consumption is not reported in any previous military study. This risk is associated with prior alcohol use (before BCT began) and does not represent injuries incurred while under the intoxicating influence of alcohol, since soldiers were not permitted to drink during BCT.

In this population of young female soldiers, the incidence of time-loss injury was higher in the very young (17 and 18 years). However, two other studies on military women report no difference in injury rates with age differences for female recruits (Kimsey, 1993; Bell, 1994). These data differ from what is reported for male recruits. Jones et al. (1988) found that older male Army recruits are at greater risk for musculoskeletal injury during basic training. Kimsey (1993) reports greater risk for male marine recruits with each subsequent year of age, increasing their risk of injury 18% per year. It is unclear why the youngest women recruits in this study are at greater risk for injury. This observation may be related to their fitness level. For example, Knapik et al. (1994) reported lower normative fitness scores for Army female soldiers in the age group 17-21 compared to 22-26. In our population, the mean run time for soldiers <19 years of age was 24.24 minutes; for women 19-24 years, was 23.95 minutes; and for women >24 years, was 22.36 minutes. The inverse relationship of fitness and age with women in this age category (roughly between 17 and 30 years) needs further exploration.

CONCLUSIONS

In interpreting the results of this study, no attempt should be made to suggest that these data are reflective of all female military personnel, or even all female basic combat trainees. The training environment for Army Basic Training has changed since this study was undertaken. Though the constitution of the company that participated in this study was all female soldiers, BCT is now gender-integrated. It is doubtful that this difference would have had much of an effect upon the various pre-BCT measures, but it could potentially have altered some of the post-BCT parameters. Interviews of soldiers who have been members of all-female basic training companies have suggested a tendency on the part of the soldier to "underachieve". They have also stated a feeling that the cadre have lower expectations of them. Soldiers from gender-integrated companies, however, have reported feelings of being more driven to achieve maximal physical performances. If accurate, this impression might suggest that the pre- to post-BCT improvement noted in all measured strength and performance variables in the current study could possibly have been even greater in a gender-integrated company.

The results of this study suggest that BCT outcome cannot be solely attributed to the training of the BCT environment. Performance by the female basic combat soldier is also strongly affected by pre-BCT health and fitness conditions. For example, more injuries were observed in those individuals who entered BCT at a lower level of fitness, as well as in those who reported higher levels of pre-BCT alcohol and cigarette consumption. Additionally, this population of women presented to BCT with a greater iron deficit then is typical for a comparable cohort.

It is important to recall that the primary purpose of this investigation was to examine the relationship(s) between health, nutrition, body composition, and physical performance in the female basic combat trainee. Although each of these parameters has been studied in female soldiers in the past (albeit, minimally), interworking relationships could not be assessed, since each parameter was generally studied in isolation and rarely in concert with other parameters of interest.

It is a common perception that the energy expenditure that results from the imposed stress and physical activity of BCT is sufficient to cause substantial weight loss. This study showed that although the activities of BCT do result in changes in body composition for female soldiers, very little (if any) measurable weight loss occurs. In fact, actual weight loss could only be predicted for women who entered BCT with a body fat_{DEXA}>35%.

Additionally, excess weight was not associated with performance deficits. In fact, soldiers who were assessed to be overfat IAW AR 40-501 and AR 600-9 performed the measured strength and performance tasks as well, or better than, those soldiers who were determined to be in compliance with these weight regulations. This same trend was observed in soldiers with a higher BMI. Though this strong relationship was observed between weight, fatness, and physical performance, this finding should not be not be interpreted as testimony that only largest and fattest female soldiers are qualified for the most demanding MOSs. This would be true if soldiers received no physical training upon entering the Army. However, the data from this study showed that all soldiers demonstrated improvement in physical performance after the 8 weeks of BCT, and an increasing number of soldiers became strength qualified for their MOS.

Three key issues regarding MOS strength requirements need to be determined. First, the validity of the stated requirements must be substantiated based upon intensive job site analyses. Second, examination of physical training regimes should be preformed to determine what modifications can be made so that a greater number of soldiers may become strength-qualified by the end of BCT or AIT. This would require that special attention be directed to upper extremity strength training, since this is noted to be more of a problem for women. Third, determination of the need for gender-neutral pre-BCT strength, requirements should be examined based upon these validated requirements, and an understanding of the maximal increase in strength which may be expected from an appropriately modified strength program. The answers to each of these three issues should be based upon scientific interpretation of sound quantitative data.

Gender-specific issues that are often anecdotally reported to present a problem for the female soldier or the commander of the female soldier were addressed. Soldiers who reported previous pregnancies demonstrated no differences in the strength and performance tasks, body anthropometry, or serum iron nutriture (not reported). On the other hand, the medical records review revealed that gynecologic problems were reported by over 34% of the soldiers. Since very few of these problems were of an emergent nature, the duty time lost for treatment of these conditions could possibly have been decreased if routine gynecologic care could have been provided without the need for time-consuming trips to the medical treatment facility by the soldier. For example, the cost effectiveness of assigning gynecologic health care practitioners to provide on-site routine care by rotating between companies with female soldiers may be worthy of investigation.

Assessment of eating attitudes and feelings revealed that this population of female soldiers in basic combat training compared favorably with a typical cohort of civilian American females. The majority of soldiers fell well within the normal range on all of the eight assessed scales of Eating Disorder Inventory. However, it is just as important to recognize the potential for health, performance, and psychological problems that may be experienced by those few soldiers who scored below normal. A more thorough review of the nutrition portion of this investigation has been presented by King et al. (1994).

RECOMMENDATIONS

1. The finding that many of these women were in a marginal iron status and did not improve (or actually worsened) through basic training needs to be followed up with studies to determine the prevalence and functional consequences of iron deficiency in Army women.

2. New female recruits had relatively low fitness levels. The improvements noted in physical capabilities over the course of BCT were still not enough for all soldiers to achieve minimum physical strength requirements for military occupational specialties available to the female soldier. This can be improved by further research into the optimization of female strength training and the incorporation of findings from such research into basic training.

3. Stress reactions were slightly reduced from the rate expected from previous studies; however, with the gender integration of BCT shortly after this study, this rate is predicted to increase for women again. Additional studies to determine predictors of stress fracture susceptibility and interventions should be conducted.

4. Gynecological care, including oral contraceptive refills, accounted for one third of all sick call visits; these usually involve an entire morning lost from training and might be handled more efficiently if gyn care could be brought to the soldiers.

5. Female recruits were fatter than expected, possibly reflecting the national trend to increased adiposity. The average body fat of new recruits was assessed at 31% using a reliable and sophisticated method (DEXA); at least one fourth of the group exceeded the Army body fat standards, assessed by height-weight screening tables and the circumference-based body fat determinations. The female soldiers who still exceeded Army body fat standards at the end of BCT are at risk in their first assignment for separation from the Army for failure to meet weight control standards. One approach to this problem is the development of an effective weight loss program for overfat female recruits and sensible weight control instruction for all female recruits.

6. The Army circumference method estimated this same group at 28% (a lower

estimate than the DEXA method gave), reiterating the point that the specific method is a non-interchangeable part of the standard, which currently gives the fattest soldiers the benefit of an underestimate. Apparently because abdominal fat patterning is not specifically detected in the method, some of the strongest women are protected against overestimation of body fat. Any future changes to female body fat standards should not ignore these related considerations.

7. The military services are still in need of a female equation derived on the basis of, or at least validated for, prediction of change in body composition (i.e., modest fat loss). Only the Army equation reflected a significant reduction in fat, which was demonstrated by DEXA in the overfat soldiers in this study; however, all equations demonstrated substantial individual variability, and these data requires further analysis.

8. Higher body weight and fat-free mass were correlated with greater muscular strength, a desirable trait in many military occupational specialties. This reaffirms the need to balance current body composition standards against strength requirements, perhaps with the eventual inclusion of minimum lean mass standards.

9. Additional nutrition intervention to help soldiers adopt an optimal diet with lower fat and higher carbohydrate energy content should be considered. This should include constructive interventions for eating disorders.

10. The apparent absence of any gross disruptions of menstrual regularity, the actual improvement in the immune function tests assessed, and the absence of large weight losses all indicate that basic training, as it was conducted for these soldiers, is not so stressful as to cause significant health concerns other than the potential for injuries during training. Numerous factors may contribute to these encouraging findings, including the prohibition of cigarette smoking during BCT and recent changes to make BCT a reflection of the real Army instead of a membership ordeal or military rite of passage. These attempts to make basic training a positive training experience optimize the health and performance of new soldiers and should continue.

11. Several serious musculoskeletal injuries were observed during the training. The cadre should continue to improve and modify training to minimize the risk of such injuries.

REFERENCES

Battie, M.C., Bigos, S.J., Fisher, L.D., et al. A prospective study of the role of cardiovascular risk factors and fitness in industrial back pain complaints. Spine, 14: 1412-1417, 1989.

Bayoumi, R.A. & Rosalki, S.B. Evaluation of methods of coenzyme activation of erythrocyte enzymes for detection of deficiency of vitamins B_1, B_2, and B_6. Clin Chem, 22: 327-335, 1976.

Bell, N.S. Injury etiology and prevention: selected topics. Masters Thesis. Harvard School of Public Health, May 1994.

Brudvig, T.J., Gudger, T.D. & Obermeyer, L. Stress fractures in 295 trainees: a one year study of incidence related to age, sex, and race. Mil Med, 148: 666-667, 1983.

CMNR (Committee on Military Nutrition Research). Military Nutrition Initiatives. Washington, D.C., National Academy of Sciences, 1991, Publication IOM-91-05.

Cowan, D., Jones, B., Tomlinson, P., et al. The epidemiology of physical training injuries in U.S. Army infantry trainees: methodology, population and risk factors. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T4-89, 1988.

Dawson-Hughes, B., Shipp, C., Sadowski, L. & Dallal, G. Bone density of the radius, spine, and hip in relation to percent of ideal body weight in post-menopausal women. Calcif Tissue Int, 40: 310-314, 1987.

Departments of the Army, the Navy, and the Air Force, Headquarters. Armed Forces Recipe Services. Washington, DC, 1989, TM 10-412/NAVSUP 7/AFM 146-12, Vol 1/MCOP 10110.42A.

Department of the Army. Standards of Medical Fitness. Washington, DC, Government Printing Office, 1989, Army Regulation 40-501.

Department of the Army. Enlisted Personnel. , Washington, DC, Government Printing Office, 1990a, Army Regulation 635-200.

Department of the Army. The Army Weight Control Program. , Washington, DC, Government Printing Office, 1990b, Army Regulation 600-9.

Department of the Army. Use of Volunteers as Subjects of Research. , Washington, DC, Government Printing Office, 1990c, Army Regulation 70-25.

Department of the Army. Military Occupational Classification Structure Development and Implementation., Washington, DC, Government Printing Office, 1994, Army Regulation 611-201.

Department of Defense. Military Manpower Statistics. Washington, DC, Government Printing Office, June 1994.

Field, C.J., Gougeon, R. & Marliss, E.B. Changes in circulating leukocytes and mitogen responses during very-low-energy all-protein diets. Am J Clin Nutr, 54: 123-129, 1991.

Fleck, S.J. & Kraemer, W.J. Designing Resistance Training Programs. Human Kinetics Books, Champaign, IL, 1987.

Friedl, K.E., Nuovo, J.A., Patience, T.H. & Dettori, J.R. Factors associated with stress fractures in young army women: indications for further research. Mil Med, 157: 334-338, 1992.

Frymoyer, J.W., Pope, M.H., Costanza, M.C., Rosen, J.C., Goggin, J.E. & Wilder, D.G. Epidemiologic studies of low-back pain. Spine, 5: 419-423, 1980.

Gardner, G.W., Edgerton, V.R., Senewiratne, B., Barnard, R.J. & Ohira, Y. Physical work capacity and metabolic stress in subjects with iron deficiency anemia. Am J Clin Nutr, 30: 910, 1977.

Gardner, L.I., Dzaidos, J.E., Jones, B.H., et al. Prevention of lower extremity stress fractures: a controlled trial of a shock-absorbent insole. Am J Public Health, 78: 1563-1567, 1988.

Garn, S.M., Smith, N.J. & Clark, D.C. Lifelong differences in hemoglobin levels between Blacks and Whites. J Natl Med Assoc, 67(2): 91-96, 1975.

Garner, D.M., Olmstead, M.P. & Polivy, J. Development and validation of multidimensional eating disorder inventory for anorexia nervosa and bulemia. Int J Eat Disord, 2(2): 15-34, 1983.

Gordon, C.C., Bradtmiller, B., Churchill, T., et al. 1988 anthropometric survey of U.S. Army personnel: methods and summary statistics. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report TR-89/044, 1989.

Harman, E.A. & Frykman, P.N. The relationship of body size and composition to the performance of physically demanding military tasks. In: Body Composition and Physical Performance. M.M. Marriott & J. Grumstrup-Scott (Eds.) National Academy Press, Washington, D.C.: 105-118, 1992.

Harman, E.A., Rosenstein, M.T., Frykman, P.N., Rosenstein, R.M. & Kraemer, W.J. Estimation of human power output from vertical jump. J Appl Sport Science Research, 5(3): 116-120, 1991.

Haymes, E.M. Dietary iron needs in exercising women: A rational plan to follow in evaluating iron status. Med Exerc Nutr Health, 2: 203-212, 1993.

Health and Welfare Canada. Promoting Healthy Weights: A Discussion Paper. Health Services and Promotion Branch, Health and Welfare, Ottawa, 1988.

Heaney, R.P. Nutritional factors in causation of osteoporosis. Ann Chir Gynaecol, 77: 176, 1988.

Hodgdon, J.A. Body composition in the military services: Standards and methods. In: Body Composition and Physical Performance. B.M. Marriott & J. Grumstrup-Scott (Eds.) National Academy Press, Washington, D.C.: 57-70, 1992.

Holm, G. & Palmblad, J. Acute energy deprivation in man: effect on cell-mediated immunological reactions. Clin Exp Immunol, 25: 207-211, 1976.

Jones, B.H., Bovee, M.W. & Knapik J.J. Associations among body composition, physical fitness, and injury in men and women Army trainees. In: Body composition and physical performance. B.M. Marriott & J. Gumstrup-Scott (Eds.) National Academy Press, Washington, D.C.: 141-172, 1992.

Jones, B.H., Cowan, D.N., Tomlinson, J.P., Robinson, J.R., Polly, D.W. & Frykman, P.N. Epidemiology of injuries associated with physical training among young men in the Army. Med Sci Sports Exerc, 25:197-203, 1993.

Jones, B.H. , Manikowski, R., Harris, J.M., et al. Incidence of and risk factors for injury and illness among male and female Army basic trainees. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T19-88, 1988.

Kimsey, C.D. The epidemiology of lower extremity injuries in United States Marine Corps recruits. Dissertation. School of Public Health, University of South Carolina, 1993.

King, N., Arsenault, J.E., Mutter, S.H., et al. Nutritional intake of female soldiers during the U.S. Army Basic Combat Training. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T94-17, 1994

Knapik, J., Benderet, L., Bahrke, M., O'Connor, J., Jones, B. & Vogel, J. Army Physical Fitness Test (APFT): normative data on 6022 soldiers. Natick, MA: US Army Research Institute of Environmental Medicine. Technical Report T94-7, 1994.

Lapidus, L., Bengtsson, C., Larsson B., et al. Distribution of adipose tissue and risk of cardiovascular disease and death. A 12-year follow-up of participants in the Population Study of Women in Gothenburg, Sweden. BMJ, 289: 1257-1261, 1984.

Laws, A., Terry, R.B. & Barrett-Connor, E. Behavioral covariates of waist-to-hip ratio in Rancho Bernardo. Am J Public Health, 80: 1358-1362, 1990.

LSRO (Life Sciences Research Office), Federation of American Societies for Experimental Biology. Nutrition monitoring in the United States - an update report on nutrition monitoring. Prepared for the U.S. Department of Agriculture and the U.S. Department of Health and Human Services. Washington, DC: U.S. Government Printing Office, DHHS Publication Number (PHS) 89-1255, Public Health Services, September 1989.

LSRO (Life Sciences Research Office), Federation of American Societies for Experimental Biology. Guidelines for the assessment and management of iron deficiency in women of childbearing age. Prepared for the Center for Food Safety and Applied Nutrition, the Food and Drug Administration, and the Department of Health and Human Services. Washington, DC: U.S. Government Printing Office, DHHS Publication Number (PHS) 89-1255, Public Health Services, February 1991.

Lukaski, H.C., Hall, C.B. & Siders, W.A. Altered metabolic response of iron-deficient women during graded maximal exercise. Eur J Appl Physiol, 63: 140, 1991.

Massey, A.C. Microcytic anemia: Differential diagnosis and management of iron deficiency anemia. Med Clin North Am, 76(3): 549-66, 1992.

Mazess, R.B., Barden, H.S., Bisek, J.P. & Hanson, J. Dual-energy X-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. Am J Clin Nutr, 51: 1106, 1990.

McDaniels, J.W., Skandis, R.J. & Madole, S.W. Weight lift capabilities of Air Force basic trainees. AFAMRL-TR-83-0001, May 1983.

Meyers, L.D., Habicht, J.P. & Johnson, C.L. Components of the difference in hemoglobin concentrations in blood between Black and White women in the United States. Am J Epidemiol, 109: 539-549, 1979.

Meyers, L.D., Habicht, J.P., Johnson, C.L. & Brownie, C. Prevalences of anemia and iron deficiency anemia in Black and White women in the United States estimated by two methods. Am J Public Health, 73: 1042-1049, 1983.

Moore, R.J., Friedl, K.E., Kramer, T.R., et al. Changes in soldier nutritional status and immune function during the Ranger training course. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T13-92, 1992.

Moritani, T. & DeVries, H. Neural factors versus hypertrophy in the time course of muscle strength gain. Am J Phys Med, 82: 521-524, 1979.

O'Connor, D.L. Interaction of iron and folate during reproduction. Prog Food Nutr Sci, 15: 231-254, 1991.

O'Connor, F.G. & Marlowe, S.S. Low back pain in military basic trainees. Spine, 18: 1351-1354, 1993.

Owen, B. & Damron, C.F. Personal characteristics and back injury among hospital nursing personnel. Res Nurs Health, 7: 305-313, 1984.

Pan, W.H. & Habicht, J.P. The non-iron-deficiency-related difference in hemoglobin concentration distribution between Blacks and Whites and between men and women. Am J Epidemiol, 134: 1410-1416, 1991.

Prasad, A.N. & Prasad, C. Iron deficiency: non-hematological manifestations. Prog Food Nutr Sci, 15: 255-283, 1991.

Presidential Commission on the Assignment of Women in the Armed Forces. Report to the President. Washington, D.C., Government Printing Office, 1992.

Reynolds, K.L., Heckel, H.A., Witt C.E., et al. Cigarette smoking, physical fitness and injuries in infantry soldiers. Am J Prev Med, 10(3): 145-150, 1994.

Rose, M.S., Buchbinder, J.C., Dugan, T.B., et al. Determination of nutrient intakes by a modified visual estimation method and computerized nutritional analysis for dietary assessments. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T6-88, 1987.

Rose, M.S., Finn, J., Radovsky, C., et al. Computerized analysis of nutrients (CAN) system. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T2-90, 1989b.

Rose, R.W., Baker, C.J., Salter, C., Wisnaskas, W., Edwards, J.S.A. & Rose, M.S. Dietary Assessment of U.S. Army Basic Trainees at Fort Jackson, S.C.. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T6-89, 1989a.

Rush, D. & Rosenberg, I.H. Folate supplements and neural tube defects. Nutr Rev, 50:25-26, 1992.

Schnakenberg, D., Carlson, D., Deems, S., Popper, R. & Hirsh, E. Validation of a visual observation method for nutritional evaluation of food service systems for military population. Fed Proc, 46: 875, 1987.

Scott, J.M., Kirke, P.N. & Weir, D.G. The role of nutrition in neural tube defects. Annu Rev Nutr, 10: 277, 1990.

Sharp, M.A. & Vogel, J.A. Maximal lifting strength in military personnel. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (Ed.) Taylor and Francis, Washington, D.C., 1992.

Soppi, E., Varjo, P., Eskola, J. & Laitinen, P.A. Effect of strenuous physical stress on circulating lymphocyte function before and after training. J Clin Lab Immunol, 8: 43-46 1982.

Stevenson, J.M., Greenhorn, D.R., Bryant, J.T., Deakin, J.M. & Smith, J.T. Gender fairness of a selection test using the incremental lifting machine. Appl Ergonomics, 1995 (In Press).

Svensson, H., Vedin, A., Wilhelmsson, C. & Anderson, G.B.J. Low-back pain in relation to other diseases and cardiovascular risk factors. Spine, 8: 277-285, 1983.

Teves, M.A., Wright, J.E. & Vogel, J.A. Performance on selected candidate screening test procedures before and after basic and advanced individual training. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T13-85, 1985.

Vogel, J.A. Obesity and its relation to physical fitness in the U.S. military. Armed Forces and Society, 18: 497-513, 1992.

Vogel, J.A. & Friedl, K.E. Body fat assessment in women. Sports Med, 13(4): 245-269, 1992.

Vogel, J.A., Kirkpatrick, J.W., Fitzgerald, P.I., Hodgdon, J.A. & Harman, E.A. Derivation of anthropometry based fat equations for the Army's weight control program. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T17-88, 1988.

Vuilleumier, R.A., Keller, H.E. & Keck, E. Clinical chemistry methods for the routine assessment of vitamin status in human populations. Part III. The apoenzyme stimulation tests for vitamin B_1, B_2, and B_6 adapted to the Cobas-Bio analyzer. Int J Vitam Nutr Res, 60: 126-135, 1990.

Williams, D.M. Racial differences of hemoglobin concentration: measurements of iron, copper, and zinc. Am J Clin Nutr, 34: 1694-1700, 1981.

Wing, R.R., Matthews, K.A., Kuller, L.H., Meilahn, E.N. & Plantinga, P. Waist to hip ratio in middle-aged women: Associations with behavioral and psychosocial factors and with changes in cardiovascular risk factors. Arterioscler Thromb, 11: 1250-1257, 1991.

DISTRIBUTION LIST

2 Copies to:

Defense Technical Information Center
ATTN: DTIC-DDA
Alexandria, VA 22304-6145

Office of the Assistant Secretary of Defense (Hlth Affairs)
ATTN: Medical Readiness
Washington, DC 20301-1200

Commander
U.S. Army Medical Research and Development Command
ATTN: MCMR-PLC
Fort Detrick
Frederick, MD 21702-5012

Commander
U.S. Army Medical Research and Development Command
ATTN: MCMR-PLE
Fort Detrick
Frederick, MD 21702-5012

Commandant
Army Medical Department Center and School
ATTN: HSMC-FR, Bldg. 2840
Fort Sam Houston, TX 78236

1 Copy to:

Joint Chiefs of Staff
Medical Plans and Operations Division
Deputy Director for Medical Readiness
ATTN: RAD Smyth
Pentagon, Washington, DC 20310

HQDA
Office of the Surgeon General
Preventive Medicine Consultant
ATTN: SGPS-PSP
5109 Leesburg Pike
Falls Church, VA 22041-3258

HQDA
Assistant Secretary of the Army for Research, Development and Acquisition
ATTN: SARD-TM
Pentagon, Washington, DC 20310

HQDA
Office of the Surgeon General
ATTN: DASG-ZA
5109 Leesburg Pike
Falls Church, VA 22041-3258

HQDA
Office of the Surgeon General
ATTN: DASG-DB
5109 Leesburg Pike
Falls Church, VA 22041-3258

HQDA
Office of the Surgeon General
Assistant Surgeon General
ATTN: DASG-RDZ/Executive Assistant
Room 3E368, The Pentagon
Washington, DC 20310-2300

HQDA
Office of the Surgeon General
ATTN: DASG-MS
5109 Leesburg Pike
Falls Church, VA 22041-3258

Uniformed Services University of the Health Sciences
Dean, School of Medicine
4301 Jones Bridge Road
Bethesda, MD 20814-4799

Uniformed Services University of the Health Sciences
ATTN: Department of Military and Emergency Medicine
4301 Jones Bridge Road
Bethesda, MD 20814-4799

Commandant
Army Medical Department Center & School
ATTN: Chief Librarian Stimson Library
Bldg 2840, Room 106
Fort Sam Houston, TX 78234-6100

Commandant
Army Medical Department Center & School
ATTN: Director of Combat Development
Fort Sam Houston, TX 78234-6100

Commander
U.S. Army Aeromedical Research Laboratory
ATTN: MCMR-UAX-SI
Fort Rucker, AL 36362-5292

Commander
U.S. Army Medical Research Institute of Chemical Defense
ATTN: MCMR-UVZ
Aberdeen Proving Ground, MD 21010-5425

Commander
U.S. Army Medical Materiel Development Activity
ATTN: MCMR-UMZ
Fort Detrick
Frederick, MD 21702-5009

Commander
U.S. Army Institute of Surgical Research
ATTN: MCMR-USZ
Fort Sam Houston, TX 78234-5012

Commander
U.S. Army Medical Research Institute of Infectious Diseases
ATTN: MCMR-UIZ-A
Fort Detrick
Frederick, MD 21702-5011

Director
Walter Reed Army Institute of Research
ATTN: MCMR-UWZ-C (Director for Research Management)
Washington, DC 20307-5100

Commander
U.S. Army Natick Research, Development & Engineering Center
ATTN: SATNC-Z
Natick, MA 01760-5000

Commander
U.S. Army Natick Research, Development & Engineering Center
ATTN: SATNC-T
Natick, MA 01760-5002

Commander
U.S. Army Natick Research, Development & Engineering Center
ATTN: SATNC-MIL
Natick, MA 01760-5040

Commander
U.S. Army Research Institute for Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Commander
U.S. Army Training and Doctrine Command
Office of the Surgeon
ATTN: ATMD
Fort Monroe, VA 23651-5000

Commander
U.S. Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010-5422

Director, Biological Sciences Division
Office of Naval Research - Code 141
800 N. Quincy Street
Arlington, VA 22217

Commanding Officer
Naval Medical Research & Development Command
NNMC/Bldg 1
Bethesda, MD 20889-5044

Commanding Officer
U.S. Navy Clothing & Textile Research Facility
P.O. Box 59
Natick, MA 01760-0001

Commanding Officer
Navy Environmental Health Center
2510 Walmer Avenue
Norfolk, VA 23513-2617

Commanding Officer
Naval Aerospace Medical Institute (Code 32)
Naval Air Station
Pensacola, FL 32508-5600

Commanding Officer
Naval Medical Research Institute
Bethesda, MD 20889

Commanding Officer
Naval Health Research Center
P.O. Box 85122
San Diego, CA 92138-9174

Commander
Armstrong Medical Research Laboratory
Wright-Patterson Air Force Base, OH 45433

Strughold Aeromedical Library
Document Services Section
2511 Kennedy Circle
Brooks AFB, TX 78235-5122

Commander
US Air Force School of Aerospace Medicine
Brooks Air Force Base, TX 78235-5000

Director
Human Research & Engineering
US Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5001

Commandant
U.S. Army Physical Fitness School
ATTN: ATSH-PF, Bldg. 468
Fort Benning, GA 31905