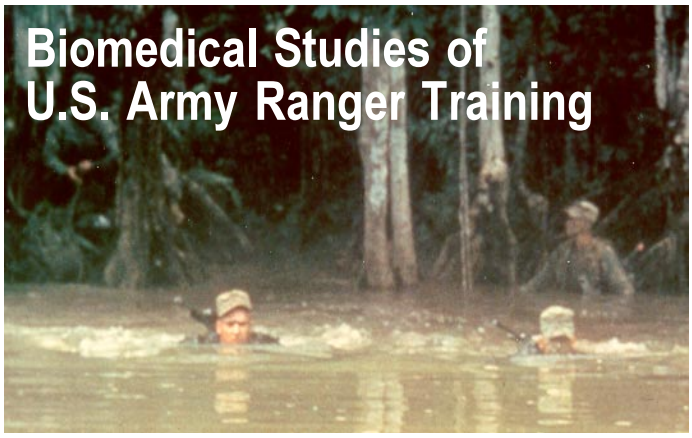
Biomedical Studies of U.S. Army Ranger Training



The eight week Ranger course has provided a unique testbed to define soldier stress limits, improve safety of high risk training, and identify strategies to extend limits of human performance in adverse conditions. Physiological studies of Ranger students and cadre have defined conditions which increase susceptibility to infection and to nonfreezing cold injury, effects of underfeeding on lean mass and physical performance, mental performance degradation produced by sleep deprivation, refeeding effects and recovery from intensive training, and nutritional adequacy of operational rations in high stress conditions.

Background

U.S. Army Ranger training tests the endurance and leadership abilities of young, male soldiers under stressful conditions. Inadequate sleep and hunger are two deliberate stressors imposed on students in this course; other stressors include temperature extremes and demanding physical activity. The effect of combined stressors on health and performance of soldiers undergoing such training has been the subject of research involving soldiers who freely volunteered and agreed to be tested.

The eight week Ranger Course has three phases of training environments: temperate forest, mountain, and coastal swamp, and previously included a desert phase. Each phase begins with a period of adequate feeding while soldiers are being taught new skills. This is followed by a period with restricted food intake and small unit tactical training involving patrols with rucksacks and weapons averaging 75 lbs. or more.

Several early studies quantified nutritional and sleep deprivation stressors. The first detailed biomedical study in 1964 concluded that the first phase of Ranger training produced modest weight loss because of very high physical demands but had no significant health and performance consequences. In a 1973 study men lost an average 10% of initial body weight; soldiers subsisted on C rations or Long Range Patrol rations during patrols (1 meal/day, 1200 kcal/day) while expending an average of 4020 kcal/d in the course. Important findings included decreased iron status and serum proteins, decline in treadmill measured maximal aerobic capacity, and moderate dehydration; evaluations of heart electrical activity showed no adverse changes. A recommendation was made to increase feeding by a modest 400 kcal/d. Sleep was measured using wrist-worn motion detectors (actigraphs) in Class 3-88, with average sleep estimated at 3.2 hours/day (sleep studies were repeated in Class 12-90 and 11-91, with an average 3.6 hours/day). To reduce the problem of inattentiveness ("droning") which occurs with increasing frequency from the accumulating sleep debt, a 36-48 block of rest between instructional phases was recommended.

Following an outbreak of pneumonia in Ranger students in 1989, studies were conducted to define stress effects and safe limits of food and sleep deprivation. Adding new technologies (e.g., doubly-labelled water for energy expenditure and water turnover, dual energy x-ray absorptiometry for body composition, new vitamin assays, and multiple antigen tests for immunological memory) to tests used in the 1973 study, a comprehensive study of summer Classes 11-90 and 11-91 evaluated effects of Ranger training before and with a 400 kcal/day increase in calories in a mixed diet. Because students are competitively evaluated, side-by-side control comparisons within the same class cpould not be performed.

Plans to expand the research from summer to winter Ranger courses were accelerated following hospitalizations and deaths of several students suffering from hypothermia in 1995. Field and laboratory studies are continuing to refine immersion cold limits for Ranger training and military cold strain models.

Ranger Training — Vital Statistics*

Parameter	Quantification**
Sleep	**3.6 hrs/day** (range: 0–6 hrs/dy)
Energy Expenditure	**4000 kcal/day** (including 6000 kcal/day in mountain phase)
Water Intake	**5.8 liters/day**
Energy Intake	**2800 kcal/day** (including 28 days at 1300 kcal/day)
Energy Deficit	**1200 kcal/day** (equivalent to 1/4 lb. body fat loss/day)
Body Weight Loss	**26.7 lbs** (range: 14–45 lbs.); **15.6% loss** (range: 9–23%)
Body Fat	**Start: 14.6%** (6–26%); **End: 38/50 men at lower limit of 4–5%**
Lifting Strength	**Start: 170 lbs.; End: 130 lbs.**

* Based on four phase summer training in 1990; many changes in the course have occurred since then

** Averages of 50 men over 8 weeks (50 completed the course and all measurements from a larger starting sample of 190)

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Research Findings

Energy Balance and Body Composition The typical Ranger student starts the course with 15% body fat and weighs 165 lbs.; two thirds of this fat is available for energy needs, representing 70,000 kcal of energy. This is just enough to make up the energy deficit from inadequate food intake for about 8 weeks of Ranger training. Weight loss averaged 16% of initial weight in Class 11-90, which put students just between using all of their available fat stores and not yet substantially consuming their lean tissue. Most students in Class 11-90 reached a minimal body fat of 4-5%, leaving only essential structural fat. In Class 11-91, which received more food, only one of 55 students reached minimum body fat while the rest averaged a 12% weight loss. The most extreme loss, one fourth of body weight – including a large amount of lean tissue, occurred in a soldier who started at only 7% body fat; however, another soldier started at the same size and body fat and lost the least weight which demonstrates an opposite extreme in metabolic efficiency. A subsequent study of winter Rangers (Class 1-96) receiving two MREs per day during the restricted ration phase demonstrated 4% body weight loss, with weight gain in some students.

The mountain phase had the highest energy demand, averaging 6000 kcal/day

Nutrition Testing of the MRE ration (version XII; 1350 kcal/meal) and a new Long-Life Ration Packet (1570 kcal) in Ranger training, based on extensive biochemical measures of nutrient status, demonstrated the nutritional adequacy of both of these rations when fed for 10 days with only a single meal per day even in this high stress setting. Another study using Ranger cadre at Camp Merrill in a three day intensive scenario compared a carbohydrate drink to placebo, and confirmed the performance benefit of supplemental carbohydrate taken during intensive training. This study contributed to the fielding of the new ERGO drink.

Physical and Mental Performance Ranger students lost 6-7% of their lean mass (10 lbs), correlating with a 40 lb. decline in maximal lifting strength; this reduced students to the average lift strength of other healthy young male soldiers (130 lbs). Strength decline was not improved by a modest increase in calories. Cognitive performance (Class 11-91) was impaired by the combined stressors; with the highest order functions (reasoning) were most impaired followed by pattern analysis (similar to map reading tasks) and decoding; memory was unaffected. Pattern analysis and decoding recovered during the start of training phases while reasoning performance only recovered at the end of the course when food and sleep were unrestricted. On all tests students sacrificed speed (15-33% slower) over accuracy. No physiological measures in these studies (or personality traits, assessed in Class 11-90) predicted success in the Ranger course, which suggests instead a primary role for individual motivation and specific skills for successful course completion.

Recovery from Stressors Metabolic and stress-related changes during the course included decreases in testosterone and thyroid hormones (reducing metabolism including heat production) while catabolic hormones such as cortisol were increased. These changes were promptly restored to normal with refeeding even within the course. One week after the course metabolic and immune function indicators were normal although sleep and eating patterns were disrupted. At 5 weeks graduates were normal including strength regain but 50% fatter than at the start (a normal overeating response). Six months after training students were fully recovered with no health problems detected by detailed physical examination except for residual toe numbness.

Susceptibility to Infection Students are particularly susceptible to soft tissue infections (cellulitis), and respiratory illnesses such as pneumonia, normally rare in healthy young soldiers, have also been a problem; 25% of students finishing the course in Class 11-90 had a diagnosed infection. With increased feeding immune function indicators were less impaired and infection rates were markedly reduced; however, the specific role of food intake remains uncertain because the comparison was not made in the same group or even the same year. In a 1999 report the National Academy of Sciences concluded that there is currently no known "magic bullet" supplement which overcomes the changes in Ranger student immune function produced by inadequate caloric intake and other stressors. Abrasions increase opportunities for infection; one recommendation was to increase knee protection for Rangers on patrol dropping to one knee at frequent stops. Another study with Ranger students tested the effectiveness of a vaccine in stressed soldiers using the FDA-approved Hepatitis A vaccine; in this preliminary study some students did not develop expected levels of immunity in response to the vaccine, and this is tentatively attributed to the reduced competence of the immune system in stressed soldiers.

Susceptibility to Cold Ranger students have had problems with cold injury and may be at special risk due to reductions in body fat insulation, cellular metabolism, and shivering responses. Students tested with a cold challenge within hours after completing the course (Class 1-96) did not show appropriate temperature regulating responses (e.g., shivering and heat production in response to reduced skin temperature) and had a lower tolerance for cold. Tolerance improved after 48 hours of refeeding and rest. Using disposable temperature pills which transmit body temperature as they transit the body, a new understanding has developed for the temperature extremes which occur in students sleeping in the environment with little insulation (Class 3-97), helping to confirm the accuracy of the cold strain model used to predict environmental risk during training (MERCURY). Recent studies to improve the accuracy of the model for Ranger students have led to discoveries on effects of repeated immersion and exercise before cold exposure, factors which increase hypothermia risk.