Wildland Firefighter
Health & Safety Report

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In this issue:

- **Energy requirements**
- **Energy supplements**
- **Nutritional strategies**
- **Micronutrients**
- **Immune function**

Background

This report, the sixth in a series, reviews activities related to the Missoula Technology and Development Center (MTDC) project on wildland firefighter health and safety. The project focuses on three main areas:

Work, Rest, and Fatigue
Development of an objective approach for the determination of work/rest standards and recommended assignment lengths for crews and overhead.

Energy and Nutrition
Improvement of the energy intake, nutrition, and immune function of wildland firefighters.

Fitness and Work Capacity
Implementation of work capacity and medical standards and improvement of the health, safety, and productivity of firefighters.

Energy and Nutrition

This report focuses on energy and nutrition, and their influence on health and performance. MTDC reviewed the relevant literature, interviewed firefighters, met with contracting officers, and conducted field studies. The suggestions that follow provide a basic approach to wildland firefighter nutrition that ensures adequate energy and nutrients, supports immune function and health, maintains cognitive function, and delays fatigue during arduous wildland firefighting. Our field studies corroborate existing research, such as that found in the document, *Military Strategies for Sustainment of Nutrition and Immune Function in the Field* (published by the Institute of Medicine of the National Academy of Sciences, National Academy Press, Washington, DC, 708 pp. 1999).

The featured topic of this report outlines basic recommendations for feeding the wildland firefighter. The research section provides documented support for the recommendations, including the results of recent field studies on wildland firefighters. The risk management section details the problems associated with low blood glucose (hypoglycemia). The field notes section provides additional food for thought.

A firefighter samples his blood glucose level during a study of the effects of carbohydrate supplementation (page 6).

0251–2837–MTDC

Featured Topic

Feeding the Wildland Firefighter

Recent research has identified nutritional strategies that will improve the health, safety, and productivity of wildland firefighters. The right food sources, properly timed, provide energy and nutrients that help sustain work output and maintain the function of the immune system. Supplemental high-energy foods delay fatigue and enhance immune function while maintaining the firefighter's ability to think and make decisions during periods of hard work. This report outlines simple strategies for maintaining health, safety, and performance during prolonged periods of arduous work.

Energy

Research by the University of Montana Human Performance Laboratory and the Missoula Technology and Development Center has demonstrated the energy demands and energy intake of wildland firefighters. In a recent field study (Ruby and others 2002), male firefighters burned an average of 4,758 kilocalories a day while they consumed only 4,068 kilocalories. The daily caloric deficit of 690 kilocalories results in a 1.25-kilogram (2.76-pound) weight loss over the course of a 14-day assignment. Female firefighters burned an average of 3,550 kilocalories per day, while consuming 3,222 kilocalories, for a daily deficit of 328 kilocalories. They lost 0.6 kilograms (1.3 pounds) of body weight in 14 days. This energy deficit could result in significant weight loss, including loss of lean body weight. When energy intake falls short of requirements, the body derives needed energy from muscle tissue. This loss of lean tissue will increase the likelihood of fatigue and could reduce the ability of a firefighter to perform arduous work.

The study by Ruby and others shows that some male firefighters may require over 6,000 kilocalories of food daily, while some females may require more than 5,000 kilocalories during a long, hard shift. The meals provided in fire camp are planned to meet the caloric demands of wildland firefighting. Computerized nutritional analysis of the meals yields a daily total of 5,800 kilocalories, but the firefighter must eat all the food provided to receive all 5,800 kilocalories. The computer analysis also indicates that most meals exceed dietary recommendations for fat and were somewhat low in nutritional carbohydrates. Complex carbohydrates (such as potatoes, corn, rice, beans, and whole-grained breads and pasta) provide energy while also supplying needed nutrients and fiber.

Dietary Recommendations

Studies of endurance athletes, soldiers, and wildland firefighters support the need for a diet that is high in carbohydrates and low in fat. Carbohydrates help maintain immune function, while too much fat may degrade the function of the immune system, increasing the risk of upper respiratory and other health problems. We recommend the performance diet for wildland firefighters and for everyone who wants to engage in vigorous physical activity (table 1).

Table 1—The performance diet.

Nutrient	Percent of daily calories
Carbohydrates	60
Fat	25
Protein	15

Approach these levels by:

- Increasing the intake of complex carbohydrates (potatoes, corn, rice, beans, and whole-grained breads and pasta) and fruit (fresh, dried, or canned)
- Maintaining the usual level of fat, emphasizing healthy fats in nuts, seeds, and oils while minimizing saturated and hydrogenated fats
- Consuming high-carbohydrate energy supplements during and immediately after work

Protein—Endurance and strength athletes need 1.2 to 1.6 grams of protein per kilogram of body weight daily. Fire camp meals provide this much protein. Excess protein is not recommended for firefighters because it can compromise carbohydrate intake, increase fat intake, and lead to chronic dehydration in active individuals.

Nutrients—You can get the vitamins, minerals, antioxidants, and immune-friendly foods your body needs by eating the recommended number of servings of fruits and vegetables. For the prolonged arduous work of firefighting, you should try to eat four servings of fruit and five servings of vegetables daily (one serving is about the size of your fist). An apple or orange is one serving, as is $^1/_2$ cup of apricots, dried fruit, or fruit juice. Two and one-half cups of vegetables will meet the daily requirement. Select dark leaf lettuce and a variety of vegetables (such as green beans or carrots).

Antioxidants—In addition to an increased need for vitamins and minerals, firefighters need increased levels of antioxidants (including vitamins C and E, minerals zinc and selenium, and phytochemicals) to counter the oxidative stress associated with high levels of energy expenditure, exposure to smoke, and sunshine. Research shows that the most effective way to achieve the benefits of nutrients is to consume nutritious food, not vitamin/mineral supplements.

Energy Supplements

Solid and liquid carbohydrate supplements provide muscle energy and help keep you thinking clearly while helping to maintain or even improve immune function.

Solid Supplements

During Work—The energy bars used by endurance athletes are an excellent way to supplement energy between meals. Consuming one 250-kilocalorie bar between breakfast and lunch and one between lunch and dinner provides an additional 500 kilocalories of energy each day. Less expensive candy bars are a reasonable substitute for energy bars and have proven more palatable in taste tests. However, candy bars contain more fat than energy bars, and the chocolate in some bars tends to melt when exposed to heat.

After Work—Studies show that carbohydrate replacement (in liver and muscle) is most rapid during the 2 hours immediately after the work shift. Firefighters should be provided with at least 500 kilocalories of energy replacement in the 2 hours after work. Carbohydrate supplements will ensure the firefighter's ability to recover and be ready for work the following day. Liquid carbohydrate sources are absorbed faster than solid supplements; they aid rehydration and may speed recovery. Grape and cranberry juices are high in carbohydrates. Ingesting some protein (1 gram of protein per 4 grams of carbohydrates) within 2 hours after work may reduce muscle stress and accelerate replacement of muscle glycogen. Sports recovery drinks that provide this ratio of carbohydrates and protein are available in powdered form.

Combining the energy supplements consumed between meals with those taken after work yields an additional 1,000 kilocalories of energy.

Liquid Supplements

Firefighters need to consume fluids before, during, and after work to maintain hydration. Carbohydrate/electrolyte beverages (C/E or sports beverages) provide fluid, energy, and electrolytes needed during prolonged work. Sports beverages promote increased fluid intake and help maintain blood sugar during arduous work. The electrolytes help conserve fluid that might otherwise be lost in urine.

During Work—MTDC recommends that one-third to one-half of fluid needs be met by drinking a sports beverage. Because firefighters need about 1 liter (about 1 quart) of fluid for each hour of work, they will need 4 to 6 quarts of sports beverage for a 12-hour shift. Firefighters can be given packets of dried drink mix that they can mix as needed. A 3- to

5-percent carbohydrate solution (30 to 50 grams of carbohydrates per liter of water) is well tolerated during work in the heat. Four liters of water with 200 grams of carbohydrates provides 800 kilocalories of energy. The balance of fluid needs should be met by consuming water at regular intervals (about 8 ounces every 15 minutes). Drinking a sports beverage and water is the safest way to maintain hydration while providing additional carbohydrates to maintain blood glucose.

After Work—To rehydrate and to replace muscle and liver carbohydrate stores, firefighters should consume about 2 quarts of a sports beverage in the 2 hours immediately after work. A higher carbohydrate concentration (10 to 15 percent) is tolerated after work, when the crew is traveling or waiting for transport. The electrolytes in the drink help retain the needed fluid. This approach ensures fluid replacement, muscle recovery, and optimal replacement of muscle carbohydrate stores (muscle glycogen).

The liquid energy consumed during and after work provides an additional 1,000 kilocalories of energy.

Energy Summary

The energy consumed in meals, combined with solid and liquid carbohydrate supplements, provides the fuel to power firefighters during long shifts and extended assignments (table 2).

Table 2—Daily energy sources.

Energy source	Approximate kilocalories
Meals	4,000
Solid supplements	1,000
Liquid supplements	1,000
Total energy	more than 6,000

Recommendations for Firefighter Nutrition

- Eat more complex carbohydrates (potatoes, corn, rice, beans and whole-grained breads and pasta).
- Eat fatty foods (steak, cheese) and added fats (margarine, mayonnaise) in moderation.
- Consume supplemental carbohydrate energy (energy or candy bars) between meals.
- Consume one-third to one-half of daily fluids in the form of a carbohydrate/electrolyte sports beverage. Carry enough powdered drink mix for 4 to 6 quarts of beverage.
- Consume solid and liquid energy supplements immediately after the work shift.
- Eat four servings of fruits and five servings of vegetables daily (a serving is a fist-sized portion).
- Consider taking a daily vitamin/mineral supplement if dietary recommendations cannot be met, when environmental conditions (such as smoke) are severe, or when appetite or food availability limits energy and nutrient intake.

Questions and Answers

Q. Has one sports beverage been proven to be more effective than the others?

A. No. Research has not demonstrated meaningful differences among competing products. The important point is to get fluid, carbohydrates (50 grams per liter), and electrolytes in your sports beverage.

Q. What about the so-called “energy” drinks? Are they suitable for hydration?

A. No. Most of the beverages sold as energy drinks contain more carbohydrates (80 to 120 grams per liter) than are needed during work (30 to 50 grams per liter). The high concentration of carbohydrates could slow the rate at which fluid is absorbed from the intestines. In addition, most of these products contain caffeine (a diuretic), guarana, ephedra, or other stimulants that could interfere with the body’s ability to withstand heat stress.

Q. Has one energy bar been proven to provide superior results?

A. No. Studies have not demonstrated differences in athletic performance or immune function, regardless of the type of carbohydrates, or the balance of carbohydrates, protein, and fat in the product.

Q. Can candy bars be used to provide solid energy supplementation?

A. Yes, but keep several points in mind. Candy bars contain more fat than energy bars. The chocolate in candy bars melts in the heat. Some candy bars contain peanuts that could trigger allergic reactions in a small number of firefighters. MTDC recommends a mix of candy and energy bars. Consume the chocolate before temperatures rise.

Q. Does a firefighter need additional protein?

A. No. The protein provided in the meals is more than adequate, even for the arduous work of firefighting. Recent studies suggest that ingesting some protein (1 gram of protein per 4 grams of carbohydrates) within 2 hours after work may reduce muscle stress and accelerate replacement of muscle glycogen.

Brian Sharkey, Ph.D., MTDC; Brent Ruby, Ph.D., and Carla Cox, R.D., both with the University of Montana Human Performance Laboratory. References are available from Brian Sharkey at: *bsharkey@fs.fed.us*

This report first appeared as an MTDC Tech Tip, *Feeding the Wildland Firefighter* (0251–2323–MTDC), August 2002.

An electronic copy of the Tech Tip is available on the Internet at the address: *http://www.fs.fed.us/cgi-bin/enter.pl?link=/pubs/htmlpubs/htm02512323/*

Research

Carbohydrates and Work Rate

Our laboratory at the University of Montana has demonstrated that the total energy expenditure of extended wildfire suppression may exceed 6,000 kilocalories/day (*Medicine and Science in Sports and Exercise* 34(6): 1048–54, 2002). The purpose of this study was to determine the effects of supplemental carbohydrate (CHO) feedings on self-selected work rates during extended arduous wildland fire suppression. Subjects included wildland firefighters (*n* = 20 hotshots) during two wildfires in Idaho and Oregon. Subjects consumed 200 milliliters (6.8 ounces) per hour of a 20-percent maltodextrin solution (40-gram carbohydrate) or a placebo (PLA) drink in a counterbalanced crossover design and were allowed to drink water freely during the day. Blood samples were collected at 2-hour intervals with an automated glucometer. The self-selected hourly work rate was determined using accelerometers as established by Heil (*Applied Ergonomics* 33: 405–13, 2002). Data were analyzed using a priori planned comparisons across trials.

During the 20-percent carbohydrate trials, blood glucose (millimoles) was significantly higher immediately before lunch, after lunch, and after shift (figure 1).

> To convert millimoles to milligrams per deciliter divide millimoles by 0.0555; for example:
>
> **6 millimoles = 108 milligrams/deciliter**

The self-selected work rate was similar across trials during the initial hours after breakfast, but was significantly different later in the morning (mean work rate 4 to 6 hours after breakfast: CHO=58,088, PLA=40,191 activity counts/hour). Work rate was also similar across trials during the early hours after lunch but was significantly different later in the afternoon (mean work rate 4 to 6 hours after lunch: CHO=64,172, PLA=47,528 activity counts/hour, figure 2).

The results indicate that carbohydrate supplements maintain blood glucose and work rate between meals. With

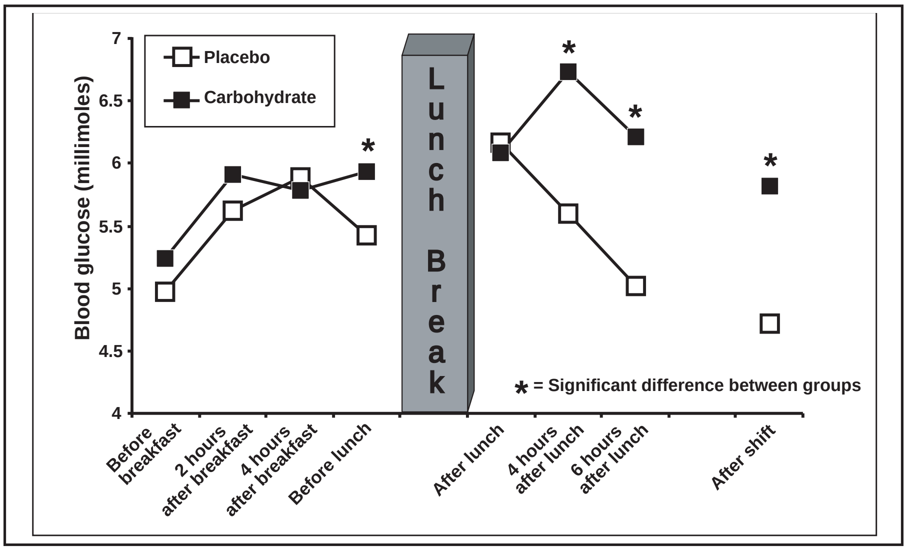


Figure 1—Changes in blood glucose levels during work performed after breakfast and lunch.

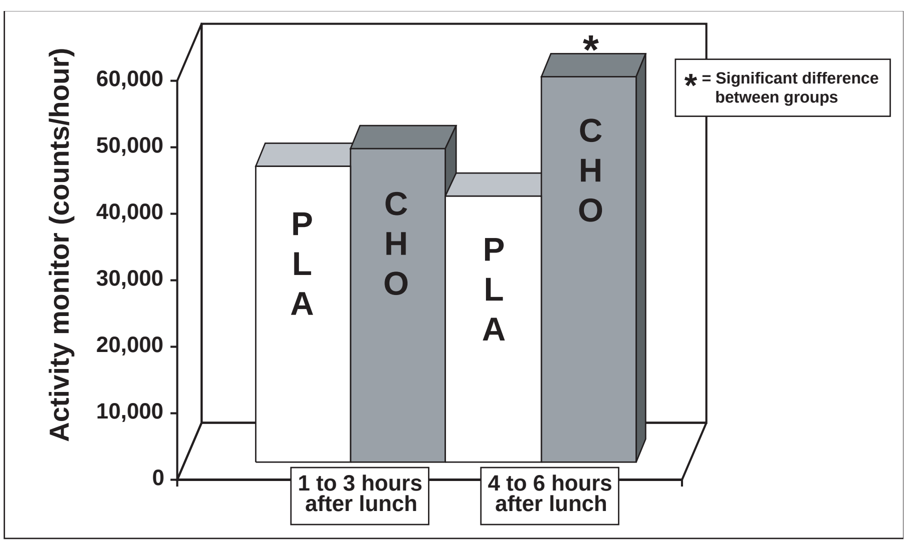


Figure 2—Average activity counts in the hours after lunch (PLA = placebo, CHO = carbohydrate drink).

carbohydrates, workers selected a higher work rate, as indicated by the activity monitors. The effects were most pronounced 4 to 6 hours after breakfast and lunch. Although the work rate for wildland fire suppression is moderate, the long work shift creates a need for supplemental carbohydrates. The supplement provides the carbohydrates needed to fuel working muscles and to maintain blood glucose levels and cognitive function.

Conclusions—Self-selected work rate is higher during arduous wildland fire suppression when carbohydrates are delivered at a rate of 40 grams/hour (160 kilocalories/hour) in a 20-percent solution administered at the rate of 200 milliliters/hour.

This study was supported by MTDC.

B. Ruby, S. Gaskill, D. Lankford, D. Slivka, D. Heil, and B. Sharkey. 2003. *Carbohydrate Feedings Increase Self-Selected Work Rates During Arduous Wildfire Suppression*. Paper accepted for presentation at the June 2003 meeting of the American College of Sports Medicine, San Francisco.

Supplemental Carbohydrates

The effectiveness of consuming carbohydrates during endurance exercise has been widely documented. However, carbohydrate ingestion during extended exercise at lower intensities has received little attention. This study attempted to determine the effects of carbohydrate feeding on blood glucose and self-selected hiking speed during a prolonged submaximal exercise. Subjects (n = 12) completed two 24-kilometer hikes 7 days apart in a single-blind double-crossover design. Blood glucose concentration was measured with an automated glucometer before the hike, hourly during the hike, and after the hike. Subjects consumed 200 milliliters of a carbohydrate (40 grams/hour, 20-percent maltodextrin) or placebo drink hourly. The subjects' ratings of perceived exertion were recorded hourly using the Borg 6–20 scale. Data were analyzed using a priori planned comparisons across trials.

Blood glucose (millimoles) was similar for both groups before exercise and for the first 8 kilometers of the hike. Afterward, blood glucose remained significantly higher ($p < 0.05$) during the carbohydrate trial (figure 3).

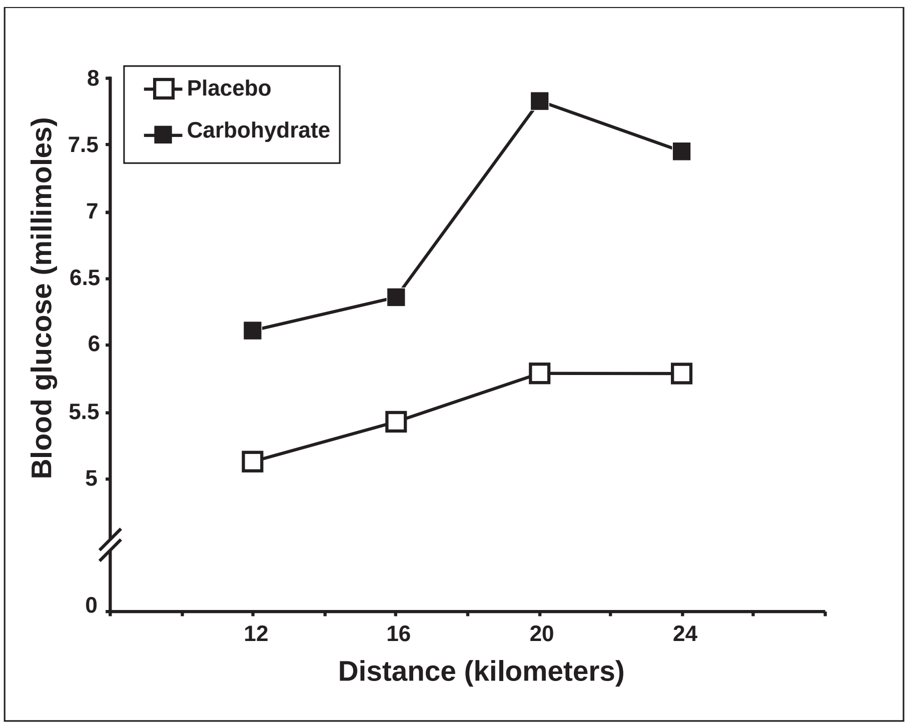


Figure 3—Blood glucose levels during a 24-kilometer hike.

Subjects self-selected a faster hiking speed during the carbohydrate trial, demonstrated by a significant difference in return time (124 and 136 minutes for the carbohydrate and placebo trials, respectively, $p < 0.05$) despite no differences in the ratings of perceived exertion (11.92 vs. 11.75, $p < 0.05$). These data demonstrate that supplemental carbohydrate feedings can improve self-selected exercise performance during low- to moderate-exertion extended hiking, regardless of the subject's rating of perceived exertion.

B. Ruby, S. Gaskill, and others. 2003. *Liquid Carbohydrate Feeding Improves Self-Selected Exercise Performance During a 24 km Hike*. Paper accepted for presentation at the June 2003 meeting of the American College of Sports Medicine, San Francisco.

Carbohydrate and Cognitive Function

The brain requires a continuous supply of glucose to function adequately. During aerobic exercise, peripheral glucose requirements increase, and carbohydrate supplementation improves performance. This study investigated the effects of carbohydrate supplementation on cognitive function. A double-blind, placebo-controlled, between-subjects design was used. Young men (n = 143) were randomly assigned to one of three groups: a 6-percent (by volume) carbohydrate, 12-percent carbohydrate, or placebo beverage. Each group received six doses. All subjects consumed two meals.

During the 10-hour study, the subjects performed physically demanding tasks, including a 19.3-kilometer (12-mile) road march and two 4.8-kilometer (3-mile) runs, interspersed with rest and other activities. Subjects responded as rapidly as possible to auditory stimuli (20 per hour) from vigilance monitors they wore on their wrists. A self-report mood questionnaire was used to assess cognitive function. Vigilance consistently improved in a dose-related manner when supplemental carbohydrates were administered. Vigilance was highest for those receiving 12-percent carbohydrate doses and lowest for those receiving the placebo. Mood results agreed with the results from the vigilance monitors. Subjects who received carbohydrates reported less confusion and greater vigor than did those who received the placebo.

Supplemental carbohydrates enhance vigilance and improve mood during sustained exertion. This study also shows that monitoring devices can be used to assess the effects of nutritional factors on cognition during field activities.

H. Lieberman, C. Falco, and S. Slade. 2002. *Carbohydrate Administration During a Day of Sustained Aerobic Activity Improves Vigilance, as Assessed by a Novel Ambulatory Monitoring Device, and Mood.* American Journal of Clinical Nutrition, 76:120–127.

Carbohydrate and Protein Supplement

Will a carbohydrate and protein supplement be more effective in replenishing muscle glycogen after exercise compared to a supplement containing as much carbohydrate, but no protein? After 2.5 hours of intense cycling to deplete muscle glycogen stores, subjects (n = 7) received, in a rank order design, a supplement with 80 grams of carbohydrates, 28 grams of protein, and 6 grams of fat (CHO-Pro), 80 grams of carbohydrates and 6 grams of fat (LCHO), or 108 grams of carbohydrates and 6 grams of fat (HCHO) 10 minutes after exercise and 2 hours after exercise. Muscle glycogen of the vastus lateralis muscle on the front of the thigh was determined using nuclear magnetic resonance spectroscopy before exercise and during 4 hours of recovery. Exercise significantly reduced the muscle glycogen stores (40 to 41 millimoles/liter). After 240 minutes of recovery, muscle glycogen levels were significantly higher for the CHO-Pro treatment (88.8 millimoles/liter, compared to 70 and 75.5 millimoles/liter for the LCHO and HCHO treatments, respectively). Glycogen storage did not differ significantly between the LCHO and HCHO treatments. These results suggest that a carbohydrate-protein supplement is more effective for rapidly replenishing muscle glycogen after exercise than a supplement with as much carbohydrate, but no protein.

J. Ivy and others. 2002. *Early Post-Exercise Muscle Glycogen Recovery is Enhanced with a Carbohydrate-Protein Supplement.* Journal of Applied Physiology, 93:1337–1344.

Sleep and Energy Deprivation

Studies examining the effects of prolonged physiological stress have relied primarily on tests that were not occupationally relevant and often did not establish test-retest reliability. This study evaluated changes in occupational task performance and body composition during 72 hours of military occupational stress. Ten male subjects (22 years old, 183 centimeters tall, weighing 87 kilograms) participated in physical performance tests during days 1 to 4 of a control and experimental period. During the period, subjects engaged in sustained physical exertion of 4,500 kilocalories per day while sleeping for only 2 hours per day and receiving only 1,600 kilocalories per day of nutrients. Military occupational physical performance was measured by:

- Time to complete a six-station indoor obstacle course
- Number of 20.5-kilogram boxes lifted to 1.3 meters during a 10-minute box-lifting trial
- Landing distance from a target for a 35-millimeter grenade throw

Subjects were provided with strong verbal encouragement. Body mass (–3.1 percent), fat-free mass (–2.3 percent), and fat mass (–7.3 percent) all declined significantly by the end of the 4-day experimental period. The obstacle course and box-lifting trials showed temporal changes as performance was significantly lower on day 3 as compared to day 1, but showed some recovery on day 4. The grenade throw showed no change during the period. The data show that soldiers are able to perform militarily relevant physical performance tasks at a similar capacity to their normally rested and fed state, despite having lost fat-free mass, after 72 hours of military operational stress (physical exertion, sleep deprivation and restricted caloric intake).

C. Pandorf and others. 2002. *Physical Performance Responses to 72 Hours of Prolonged Work, Sleep Deprivation and Caloric Restriction.* Medicine and Science in Sports and Exercise, 34: s194. U.S. Army Institute of Environmental Medicine.

Editors note: This study confirms the ability of trained and motivated workers to sustain performance of meaningful physical work despite fatigue caused by prolonged work and deprivation of food and sleep.

Risk Management

Hypoglycemia and Cognitive Function

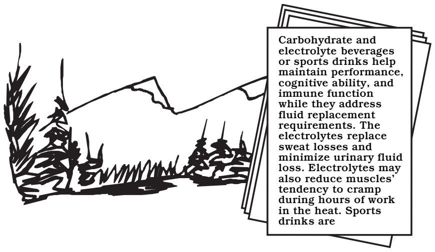
Low levels of blood sugar (hypoglycemia) can affect performance, cognitive function, and behavior. The brain and nervous system depend on blood sugar (glucose) for energy. After a meal, glucose is stored in the liver and muscles. During prolonged exertion, the body uses glucose as a source of energy. Stored glucose is depleted, blood glucose declines, and the nervous system and cognitive function are adversely affected (table 3). During periods of prolonged arduous work, it is important to maintain adequate blood glucose levels to sustain coordination, concentration, vigilance, and the ability to make decisions.

Table 3—Symptoms of hypoglycemia.

Physical	Psychological/ cognitive
Exhaustion	Anxiety
Headaches	Depression
Rapid pulse	Irritability
Drowsiness	Lack of concentration
Dizziness	Confusion
Loss of coordination	Indecisiveness
Blurred vision	
Vertigo	

Because blood sugar is used by muscles during hard work, prolonged exertion can contribute to hypoglycemia. Blood glucose levels can be maintained with the use of solid and liquid carbohydrate supplements.

Field Notes

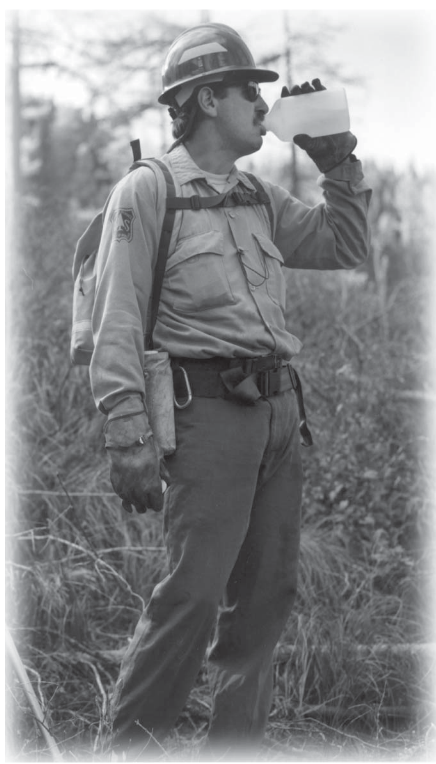


Sports Beverages

Carbohydrate and electrolyte beverages or sports drinks help maintain performance, cognitive ability, and immune function while they address fluid replacement requirements. The electrolytes replace sweat loss and minimize urinary fluid loss. Electrolytes may also reduce muscles' tendency to cramp during hours of work in the heat. Sports drinks are recommended for fluid replacement during work and for recovery after the shift.

During Work—Fluid replacement during work requires a balance between restoring critical fluids and the need for energy. Most sports drinks contain between 5 and 8 percent of carbohydrates per liter of fluid. Higher levels of carbohydrates may seem too sweet or syrupy for use during work. High levels of carbohydrates can slow absorption of the fluid. All the major brands of sports drinks include moderate levels of sodium and potassium, and a few contain small amounts of magnesium. A powdered drink mix allows each firefighter to mix the drink to personal taste. Up to half of an individual's fluid needs should be replaced with a sports drink, and the balance should be water. Firefighters should take frequent drinks to ensure consumption of 1 liter of fluid per hour of work.

After Work—Rehydration or recovery drinks may contain more carbohydrates and some protein (1 gram of protein per 4 grams of carbohydrates). The carbohydrates restore muscle and liver glycogen levels and the protein aids muscle recovery. Electrolytes in the beverage minimize urinary water loss. A firefighter should consume about 2 liters of the beverage in the 2 hours immediately after work. Solid food containing carbohydrates, protein, and some electrolytes will also aid muscle recovery. Water also aids rehydration, but unless the water contains electrolytes, about one-third of the water will be lost in the urine.



High-Fat Diet?

Is prolonged work or endurance training possible on a high-fat diet? In an experiment reported in 1928, researchers studied the effects of 11 days of exercise performance on a high-fat diet as compared to a high-carbohydrate diet. The authors described the subject's ability to handle the exercise:

"After the first two to three days the subject felt very tired and sleepy, in fact did sleep several hours between experiments, and had no desire to work or to do anything else. The work seemed harder, although it was the same as in the previous series. In the last few experiments the subject became dizzy on the ergometer (bicycle) toward the end of the work period and afterward expressed the fear that he might have fallen off. But he stuck pluckily until the series was completed. The very last experiment had to be discontinued at the end of 6.4 minutes because of dizziness."

In contrast, when the subject consumed the carbohydrate diet, all exercise tests were performed without problems.

An earlier study (1920) found that some subjects experienced excessive fatigue during exertion after 3 days on a very high-fat diet, while a few failed to observe an appreciable difference. Current studies on the topic are equally equivocal, suggesting the possibility of an individual response to a high-fat diet. However, since high-fat intake suppresses the immune response and has serious health consequences (heart disease, obesity, diabetes), a firefighter has no reason to consume a high-fat diet.

Krogh and Lindhard. 1920. Biochemical Journal, 14: 290–363.
Marsh and Murlin. 1928. Journal of Nutrition, 1: 105–137.

All wildland firefighter health and safety reports are available on the Internet at the address: *http://www.fs.fed.us/cgi-bin/enter.pl?link=/pubs/htmlpubs/wfhsr/*

Previous issues of Wildland Firefighter Health and Safety Report include:

No. 1 Oxidative Stress
Spring 2000

No. 2 Immune Function
Fall 2000

No. 3 Heat Stress and Hydration
Spring 2001

No. 4 Work Capacity Tests
Fall 2001

No. 5 Work and Fatigue
Spring 2002

Coming up. . .

The Spring 2003 Wildland Firefighter Health and Safety Report will consider:

- Medical standards
- Medical examinations
- Medical tests

If you have comments, questions, or suggestions about this project, send them to Brian Sharkey at: *bsharkey@fs.fed.us*.

A firefighter collects an immune function measure (salivary immunoglobulin) and completes a fatigue and mood questionnaire as part of the carbohydrate supplement study (Ruby and others, p. 6). The immune function and fatigue data will appear in the Spring 2003 edition of this report.

Library Card

Sharkey, Brian. 2002. Wildland firefighter health and safety report No. 6. Tech. Rep. 0251–2837–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 12 p.

This issue focuses on energy and nutrition and their influence on health and performance. The report summarizes studies indicating that:

- Carbohydrate supplements taken hourly during long shifts of firefighting or 24-kilometer hikes, help maintain blood glucose levels and increase the work accomplished.
- A 12-percent carbohydrate beverage helped subjects stay mentally vigilant during a 19.3-kilometer road march and two 4.8-kilometer runs, interspersed with rest and other activities.
- A carbohydrate and protein supplement restored muscle glycogen more effectively than carbohydrates alone after exercise.
- Soldiers who received only 2 hours of sleep a day and only 1,600 kilocalories of nutrients while undergoing 4,500 kilocalories of exertion a day for 4 days were able to perform physically at near-normal levels, even though they lost 3.1 percent of body mass during the period.

Keywords: carbohydrate, fire fighting, firefighting, hydration, nutrition, protein, rest, safety at work, working hours

Additional single copies of this document may be ordered from:

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