Wildland Firefighter
Health & Safety Report

Spring 2004 Missoula Technology and Development Center No. 8

In this issue:

Background

This report, the eighth 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
Determination of work/rest guidelines, recommended assignment lengths, and fatigue countermeasures for crews and overhead personnel.

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

Fitness and Work Capacity
Use of work capacity and medical standards to ensure the health, safety, and productivity of wildland firefighters.

Immune Function

The Wildland Firefighter Health and Safety project was outlined during a national conference summarized in the report, *Wildland Firefighter Health and Safety: Recommendations of the April 1999 Conference* (9951–2841–MTDC). One of the scientific presentations at the conference was on "Wildland Firefighting and the Immune Response." The featured topic in this issue of the *Wildland Firefighter Health and Safety Report* outlines current efforts to maintain immune function in wildland firefighters, including the use of immune function as an objective measure for determining shift length and the length of an assignment. The section on research provides summaries of recent field studies related to immune function. The risk management section outlines proven strategies for maintaining immune function during wildland fire suppression activities. The field notes section presents guidelines for selecting liquid and solid energy supplements to maintain immune function in wildland firefighters.

A firefighter collects an immune function sample (salivary immunoglobulin).

0451–2802–MTDC

Wildland Firefighting and the Immune Response

The human immune system is a complex arrangement of organs, tissues, cells, and molecules that protect the body from infectious microbes (including viruses, bacteria, fungi, parasites, and others). Fire camp records indicate that 30 to 50 percent of visits to first aid stations are for upper respiratory problems, including coughs, colds, and sore throats. A number of factors in the firefighting environment are known to compromise immune function. They include fatigue, exhaustion, stress, inadequate energy and nutrition, dehydration, smoke, and sleep deprivation. Wildland firefighting clearly presents a challenge to immune function and health. The goals of this phase of the project are to:

- Identify operational methods for assessing immune response in the field.
- Conduct field studies of immune response during fire suppression activities.
- Examine the use of immune function as an objective measure for the study of work, rest, and fatigue.
- Identify and test operational strategies for maintaining immune function in the field.
- Implement effective operational strategies in the field.

Measuring Immune Response

Dozens of tests are used to measure different aspects of the immune response. Skin-sensitivity tests measure the reaction of the skin to foreign assaults. Blood tests indicate the levels of white blood cells (leukocytes), cytokines, natural killer cells, T cells, immunoglobulin (A, G, and M), and other elements of the immune response. We needed a relatively noninvasive test that could be used in the field, without disrupting the work or rest of firefighters. Study of the literature and conversations with researchers led to a decision to conduct trials using salivary immunoglobulin A (sIgA) as an indicator of an individual's immune response.

SIgA—The secretory immune system of the upper respiratory tract's mucosal tissues is considered the body's first line of defense against pathogens. SIgA, the major component of that system, inhibits attachment and replication of pathogens, preventing their entry into the body. Numerous studies have shown that sIgA decreases significantly after a bout of prolonged, intense effort, such as a marathon run. As many as 25 percent of the finishers in a marathon will experience an upper respiratory tract infection within 2 weeks after the event. After longer races, more than 50 percent of the finishers may experience an upper respiratory tract infection.

This decline in sIgA after arduous effort is viewed as a period of decreased immunity, when viruses and bacteria can gain a foothold. The data suggest that the stress of prolonged effort suppresses the immune system, decreasing host protection. After successful laboratory trials, sIgA levels were used as an indicator of immune function in field studies of wildland firefighters.

Field Studies

The initial field study looked at sIgA before and after a 14-h shift on the fireline. Hotshot firefighters provided saliva samples before and immediately after the shift and before work the following day. Values fell dramatically (from 76.9 µg/min to 14 µg/min) in the sample taken after a shift, but recovered to baseline levels (82.4 µg/min) the following morning. When sIgA was measured before and after a shift of 21 h, the immune response declined, failed to fully recover the following morning, and remained depressed during 5 additional days of work (figure 1).

Also measured in this study was a fatigue index calculated from heart rates recorded after a standardized stepping test. Fatigue measured after the 14-h shift rose significantly, but returned to baseline levels before the next day's work. Measures of immune function went down when measures of fatigue went up, as reported by Ruby and others in *Wildland Firefighter Health and Safety Report*, No. 5 (0251–2815–MTDC, *http://www.fs.fed.us/eng/t-d.php?link=pubs/htmlpubs/htm02512815*).

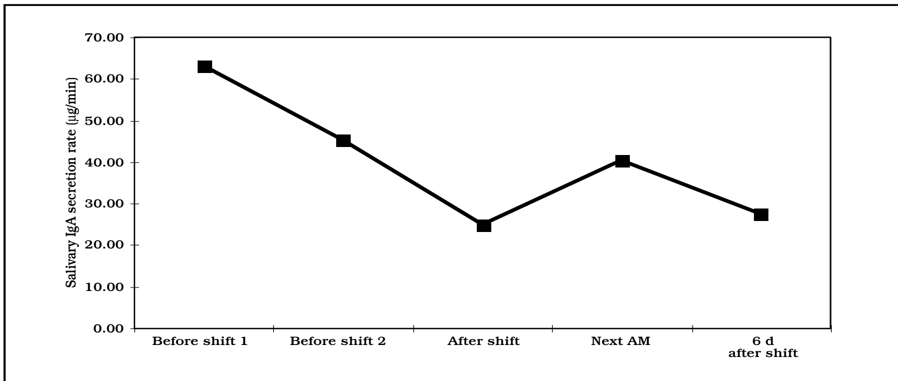


Figure 1—Changes in salivary IgA secretion rate in response to a single work shift of 21.4 ± 0.3 h (*n* = 11) followed by 5 d of 14 ± 0.7-h shifts.

The second study investigated the effects of energy expenditure and consecutive days of work on immune function (as measured by sIgA). The results indicated the immune function's ability to recover after shifts with moderate energy expenditure, its failure to recover after hard shifts, and its progressive decline with consecutive days of hard work. As before, the fatigue index was inversely related to immune function. A summary of the study is included in this report.

Operational Strategies

During studies of immune function in difficult field conditions, such as during military training, researchers have investigated the effects of nutritional supplements on various aspects of the immune response. Nutrients that appear to play a role in immune function include the amino acids, glutamine and arginine, certain vitamins and antioxidants, proteins, and some fatty acids. However, supplementing diets with these nutrients has not provided consistent significant benefits to immune function during periods of prolonged arduous work. Total energy intake appears to play the greatest role in maintaining the immune function. Researchers recommend optimizing soldiers' nutritional status before deployment and maintaining nutritional status during the operation.

Studies of endurance events and military training have shown consistent benefits from liquid and solid carbohydrate supplements, suggesting that total energy intake needs to be maintained during periods of prolonged arduous work. Based on these studies, we decided to investigate the effects of liquid carbohydrate supplementation on work output, fatigue, and immune function in wildland firefighters. The results, reported in *Wildland Firefighter Health and Safety Report*, No. 6, (0251–2837–MTDC, *http://www.fs.fed.us/eng/t-d.php?link=pubs/htmlpubs/htm02512837*), showed that carbohydrate supplementation improved blood glucose levels, increased energy expenditure and work rate, and reduced fatigue, especially later in a work shift.

The sIgA levels of firefighters who received supplemental carbohydrates fell significantly less and recovered better 12 h after a shift (table 1).

Carbohydrate supplements provide energy for working muscles and the brain and nervous system. When blood glucose levels are maintained, the body secretes less cortisol, a stress hormone that suppresses the immune response. Without carbohydrate supplementation, sIgA remained depressed at the beginning of the next work shift (see page 4).

Researchers from the University of Montana and MTDC have summarized aspects of these findings in the tech tip, *Feeding the Wildland Firefighter* (0251–2323–MTDC, *http://www.fs.fed.us/eng/t-d.php?link=pubs/htmlpubs/htm02512323*). The dietary recommendations are based on energy and nutritional requirements, field studies of firefighter energy balance, analysis of the energy and nutrients available in fire camp meals, and published studies of athletes, soldiers, and wildland firefighters. The tech tip includes recommendations for liquid and solid carbohydrate supplementation during and after work. The field notes section of this report provides practical guidelines for selecting liquid and solid carbohydrate supplements.

Table 1—The effect of carbohydrate supplementation on sIgA levels of wildland firefighters. The values show the percent sIgA levels were above or below baseline values.

Time	**Carbohydrate** (percent)	**Placebo** (percent)
End of shift	-32	-47
12 h after shift	3	-23

Carbohydrate Supplements and Immune Function

Short-term exercise studies have shown limited beneficial effect of carbohydrate supplementation on salivary immunogobulin-A (sIgA) levels after exercise. This study evaluated the effects of carbohydrate supplementation during a 12-h work shift on sIgA values immediately after the shift and 12 h later. During an extended shift of firefighting, 29 wildland firefighters were evaluated. In a single-blind, random-crossover design conducted on consecutive days, the firefighters received 200 mL/h of either a 20 percent carbohydrate drink (providing 160 kcal of carbohydrate per hour) or a drink without carbohydrate. At the end of the shift, the group that received a carbohydrate drink also received a drink with an additional 400 kcal of carbohydrate. Four-min forced salivary samples were collected before and after the shift and the morning after each treatment. Samples were analyzed using an Elisa assay. A two-way repeated measures ANOVA (analysis of variance) was used to evaluate the salivary data.

Immediately after the shift, both groups had a significant decrease in sIgA compared to values before the shift, but the decrease in sIgA was significantly less for the group that received supplemental carbohydrates than for the group that had not (figure 2). After 12 h of rest, sIgA values for firefighters who received carbohydrates had returned to the levels before the shift, but the sIgA levels of those who had not received carbohydrates remained significantly depressed. Additionally, during the final 6 h of their shifts, the subjects who received supplemental carbohydrates maintained higher blood glucose values than those who did not receive carbohydrates, and performed significantly (23 percent) more work (486 kcal/h of work compared to 395 kcal/h for firefighters who did not receive carbohydrates).

Prolonged arduous work has been shown to decrease sIgA and increase the incidence of upper respiratory tract infection. Carbohydrate supplementation during long shifts helps maintain the immune function in wildland firefighters and improves their recovery after extended arduous work, while allowing them to perform more work. The improved immune function may be related to decreased cortisol concentrations when blood glucose levels are maintained. The effect of improved immune function on upper respiratory tract infection rates in wildland firefighters has yet to be studied.

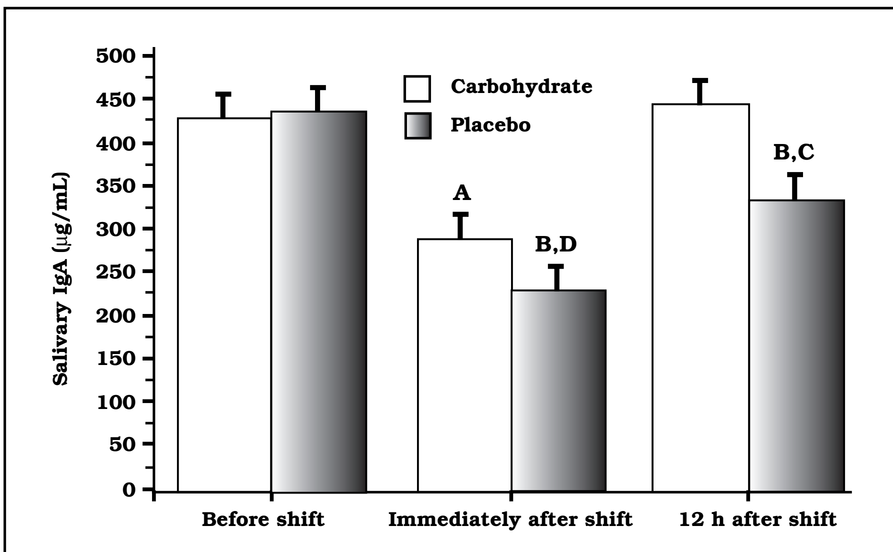


Figure 2—Changes in salivary IgA levels (µg/mL) before the shift, immediately after the shift, and 12 h after the shift. Standard error values are shown above each bar.

A: $p < 0.05$ that the difference in values compared to those before the shift within the carbohydrate trial was due solely to chance.

B: $p < 0.05$ that the difference in values compared to those before the shift within the placebo trial was due solely to chance.

C: $p < 0.05$ that the difference in values compared to the carbohydrate trial was due solely to chance.

D: $p = 0.0553$ that the difference in values compared to the carbohydrate trial was due solely to chance.

Effects of Carbohydrate Supplementation on sIgA During Long Duration Arduous Work by S. Harger, S. Gaskill, and B. Ruby, Paper presented at the annual meeting of the American College of Sports Medicine, Indianapolis, IN 2004. Supported by the USDA Forest Service, Missoula Technology and Development Center.

Work, Fatigue, and Immune Function

Maintaining health during the 6- to 8-month season of arduous wildland firefighting is important for crews. Little research has been done to monitor crew health, relating the amount of work accomplished and fatigue to immune function. This study compared sIgA fluctuations during a wildland firefighter's duty cycle to the energy expenditure during work. We also compared the sIgA data to the results of a field test designed to monitor fatigue. Eleven elite wildland firefighters (hotshot crew members) were monitored during the first 9 d and the following mornings during a 14-d duty cycle. Firefighters wore activity monitors to estimate caloric expenditure. Salivary IgA was collected by a forced 4-min collection each morning before breakfast and immediately after the shift. Additionally, after each saliva sample, a bench step protocol was used to calculate a fatigue index from the sum of the resting heart rate (after 5 min of seated rest), exercise heart rate (after 1 min of bench stepping on an 8-in step, 30 steps per minute) and a seated recovery heart rate (30 s after stepping). Firefighting activities included fireline construction, chain saw work, cutting brush in steep mountainous terrain, and 2 d of lighter mopup duties (on days 3 and 4).

Average energy expenditure was 3,094 kcal/shift (4.3 kcal/min) ranging from 1,247 to 4,853 kcal/shift (figure 3). The peak sustained 10-min average work output (for all subjects) was 17.2 kcal/min. Salivary IgA was depressed at the end of each work shift ($p < 0.01$), but was fully or partially recovered by the next morning, after 10 to 12 h of rest and sleep. On the mornings after days of moderate and light work (less than 3,000 kcal—days 3, 4, and 5), immune function recovered to baseline values.

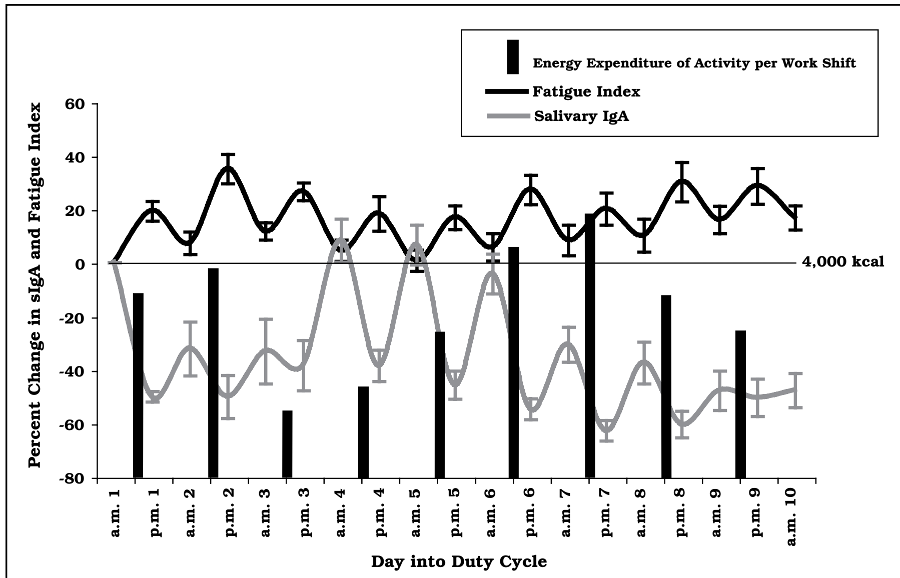


Figure 3—Changes in salivary IgA and fatigue index after days of variable energy expenditure. Values that return to 0 percent reflect recovery. Larger positive values represent fatigue (the fatigue index). Smaller negative values indicate immune function suppression.

- Error bars (that look like the letter 'I') show the standard error.
- Vertical bars represent relative work during each shift.
- The black line represents the percent change in the fatigue index.
- The gray line represents the change in salivary IgA.

After days of heavy work (more than 3,000 kcal—days 1, 2, 6, 7, and 8), recovery the morning afterward was significantly reduced, ranging from 7 to 17 percent below the baseline values. By the 10th morning, after 3 d with an average 4,160 kcal of work per day and a moderate day with 2,340 kcal of work, immune function remained significantly (17 percent) depressed. The fatigue index values were inversely related to sIgA ($r = -0.82$) and followed a similar pattern of recovery (or lack of recovery), relative to work intensity. These data show that wildland firefighters become immune depressed after hard work (more than 3,000 kcal/d), especially after several days of sustained work of more than 3,000 kcal/d.

The fatigue index, using a simple standardized step test, appears as sensitive as sIgA in identifying patterns of immune depression and fatigue. Although these data suggest that physically fit wildland firefighters can sustain arduous duty cycles, days of lighter activity should be interspersed among arduous days to sustain immune function and to prevent fatigue from accumulating.

Relationship of Work to Salivary IgA and Fatigue in Wildland Firefighters by S. Gaskill and B. Ruby, University of Montana. Supported by the USDA Forest Service, Missoula Technology and Development Center.

Carbohydrates and Work Rate

Although supplemental carbohydrate feedings are common during extended endurance exercise, limited data are available to support the efficacy of supplemental feeding in arduous occupational settings, such as wildland firefighting. Energy expenditure for wildland firefighters may exceed 6,000 kcal/d.

This study determined the effects of liquid and solid carbohydrate supplements on work rates during extended arduous wildland fire suppression. Subjects included 10 hotshot and 5 type II wildland firefighters at two wildland fires in Montana during the 2003 season. Subjects consumed liquid supplements every even hour and a solid supplement every odd hour or a similarly flavored placebo drink in a counter-balanced crossover design. The liquid supplement was 200 mL/h of 20 percent carbohydrate (160 kcal/h). The solid supplement was 25 g carbohydrate, 10 g protein, and 2 g fat (160 kcal/h). Firefighters were allowed to drink water as they wished during the day.

Blood samples were collected at 2-h intervals with automated glucometers. The firefighter wore accelerometers (the Actical made by Mini Mitter, Inc.) that recorded their hourly work rate. Data were analyzed using a two-way ANOVA with repeated measures.

Firefighters who received carbohydrate supplements during their work shift had significantly higher blood glucose levels immediately before lunch and 4 and 6 h after lunch (figure 4). The work rate was significantly higher during the entire work shift for firefighters who received the liquid and solid carbohydrate supplements compared to those who received the placebo. This was especially true late in the shift, when the work rates were nearly twice as high for firefighters who received carbohydrate supplements (figure 5). The results show that firefighters accomplished more work during arduous wildfire suppression when they received 160 kcal/h of carbohydrate supplements. This approach to providing supplemental energy should be evaluated for its ability to enhance cognitive function, critical decision making, and overall safety on the fireline.

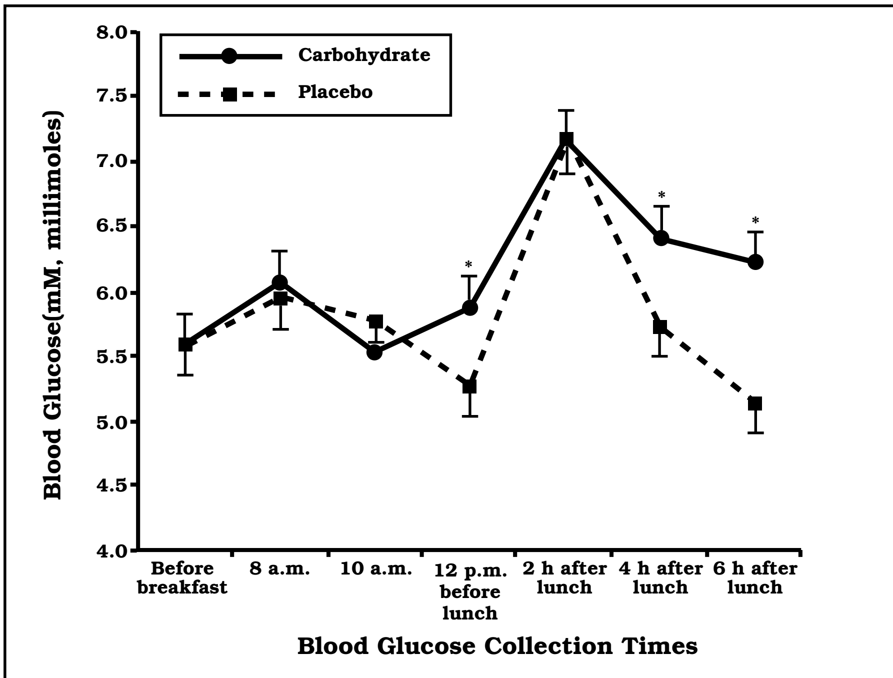


Figure 4—Changes in blood glucose during the wildland fire suppression work shift. The probability is less than 0.01 that the difference between the blood glucose values for firefighters who received carbohydrate supplements and those who received placebos was due to chance.

Carbohydrate Feedings Increase Self-Selected Work Rates During Arduous Wildfire Suppression by B. Ruby, S. Gaskill, S. Harger, D. Heil, and B. Sharkey. Paper presented at the annual meeting of the American College of Sports Medicine, Indianapolis, IN 2004. Supported by the USDA Forest Service, Missoula Technology and Development Center, and Gatorade.

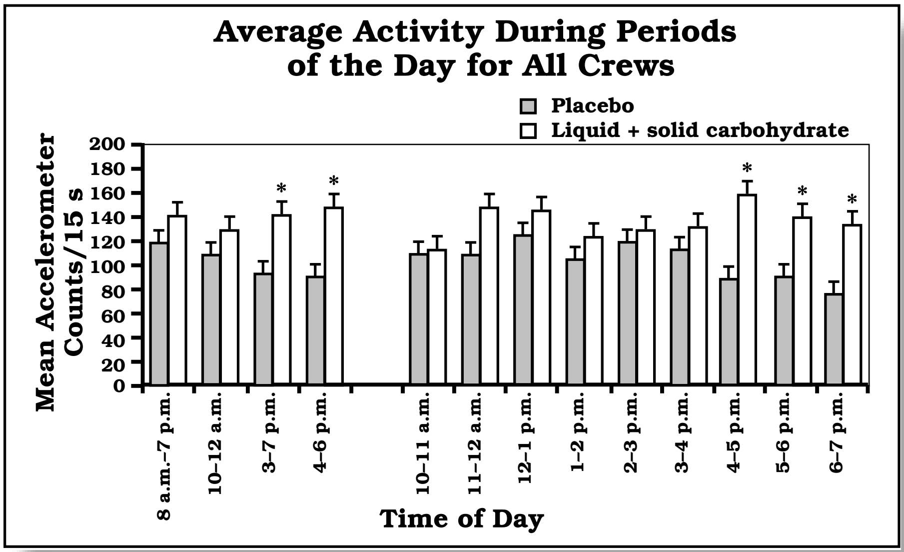


Figure 5—Work accomplished during a wildland firefighting shift as monitored with accelerometers worn by firefighters. Standard error bars are shown.

* The probability is less than 0.01 that the difference in values for firefighters who received carbohydrate supplements and those who received placebos was due solely to chance.

Nutritional Attitudes of Wildland Firefighters

The purpose of this study was to determine the beliefs and attitudes of wildland firefighters about carbohydrate, protein, hydration, and nutritional supplements. The survey included 71 questions addressing general nutrition, fluid and hydration needs, protein and carbohydrate needs, attitudes toward nutritional supplements, and sources the firefighters relied on for nutrition information. The 123 wildland firefighters who voluntarily filled out the survey had common misconceptions regarding carbohydrate, fat, protein, and the use of nutritional supplements. The subjects were unaware of the role of carbohydrate, fat, and protein as energy sources during arduous work. The contributions of vitamins and minerals were also unclear. The respondents were best informed in the area of hydration and fluid replacement, where they answered correctly 71 percent of the time. The most influential sources of nutrition information were the catering system, food unit leader, crew supervisor, and family members. In the survey, 75 percent of the respondents agreed that a basic class in nutrition should be one of the requirements for wildland firefighter training. This survey showed that fire crew members had numerous misconceptions and lack information concerning the nutritional demands of wildland firefighting. The authors recommended that nutrition education be incorporated into the basic training of elite wildland firefighters.

Nutritional Attitudes and Beliefs of Wildland Firefighters by K. Kodeski, B. Ruby, S. Gaskill, B. Brown, and A. Szalda-Petree, University of Montana. Paper submitted for publication in the Journal of Nutrition Education and Behavior.

Risk Management

Maintaining Immune Function

Studies by the U.S. Navy indicate a significant increase in upper respiratory tract infections 9 d after sailors embark on a long deployment. Group living conditions, such as those experienced in military training and wildland fire camps, lead to similar trends in upper respiratory infections. In addition to the stress of group living, the arduous work of wildland firefighting has the potential to reduce the body's ability to resist viral and bacterial infections. When arduous work is combined with insufficient rest, the immune system is more likely to be depressed. Studies of overwork and overtraining indicate a series of physiological, biochemical, and psychological changes that reduce immune function and work capacity. These changes may include:

- Muscle microtrauma, increased numbers of white blood cells, and the release of inflammatory interleukins, leading to systemic inflammation
- Elevated cytokines coordinating a whole-body response that
    - Induces mood and sickness behaviors
    - Breaks down tissue protein to produce blood glucose
- Increases in the stress hormone, cortisol, with the suppression of the immune function increasing the likelihood of infection

When muscle protein is broken down to provide energy, lean tissue is lost, compromising muscle strength and endurance. If illness occurs, recovery may take many weeks. Maintaining a healthy immune system makes good sense.

Maintaining Your Immune System: Before the Fire Season

Physical Activity/Fitness— One of the best ways to ensure a healthy immune response is to engage in regular, moderate physical activity. Studies show an "inverted U" relationship between activity and immune function (figure 6). Sedentary individuals have a reduced immune response compared to those who are more active. Immune function peaks with regular moderate activity, decreasing when activity leads to fatigue or exhaustion. Of course, the term moderate is relative. Moderate could mean a brisk 30-min walk for some individuals or a vigorous 3-h bike ride for an athlete. If you engage in moderate activity most days of the week, your immune system will function at an optimal level.

Nutrition—Studies conducted on soldiers indicate that nutritional status should be optimized before deployment when the deployment has the potential to compromise immune function. One guide to adequate nutrition is maintenance of body weight. Recent weight loss could compromise immune response, as well as strength and endurance. Studies show that firefighters have a difficult time maintaining muscle mass during a long fire assignment.

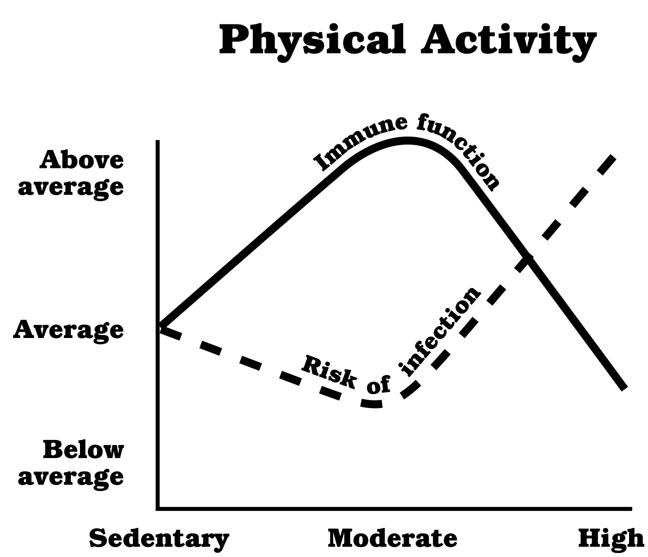


Figure 6—The relationship of physical activity to immune function and the risk of infection.

It is unwise to begin any campaign in a compromised state. Firefighters should never attempt to lose weight while working on the fireline.

Good nutrition involves appropriate percentages of carbohydrate (60 percent of calories), fat (20 to 25 percent of calories), and protein (15 to 20 percent of calories). Carbohydrate should consist of complex carbohydrates such as beans, corn, rice, potatoes, and whole-grained breads and pasta. At least two to four servings of fruits and three to five servings of vegetables should be consumed daily (eat more when you're on a fire). Fat intake should be low, because high-fat diets suppress immune function. No more than one-third of fats should be saturated and hydrogenated fats (trans fats in processed foods). Daily vitamin and mineral supplements may be useful during periods of weight loss or when you can't get the recommended servings of fruits and vegetables.

Rest/sleep—Firefighters should be well rested before deployment. Sleep deprivation compromises immune function. Fire camp is not the place to catch up on lost sleep.

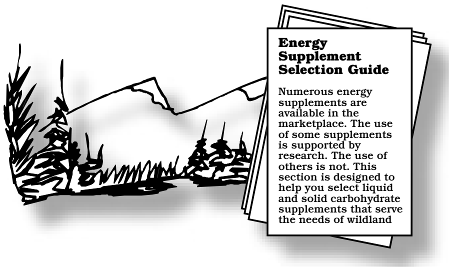
Maintaining Your Immune System: During the Fire Season

Once the fire season has begun:

- Avoid allowing fatigue and exhaustion to accumulate by interspersing days of lighter activity between days of hard work.
- Get 7 to 8 h of sleep each night.
- Use short (less than 20 min) and long (more than 90 min) naps when possible.
- Maintain body weight.
- Wash hands after using the toilet and before meals.
- Eat regular meals and use liquid and solid carbohydrate supplements.
- Maintain adequate hydration. Drink before, during, and after work.
- Use carbohydrate and electrolyte (sports) drinks for up to half of fluid needs.
- Avoid sharing water bottles except in emergencies.
- Consider taking vitamin, mineral, and antioxidant supplements during periods of hard work and stress.
- Try to avoid excessive exposure to smoke.
- Consider taking days off when upper respiratory symptoms are "below the neck" (fever, deep cough, muscle aches, nausea, and diarrhea).

Note: Do not adhere to a low-carbohydrate diet while engaged in arduous firefighting activities. High-protein and low-carbohydrate diets do not provide the energy needed for long shifts of arduous work. Muscle mass is lost when protein is broken down to form glucose for energy. In addition, a high-protein and low-carbohydrate diet increases fat intake, which can suppress immune function. Low-carbohydrate diets are only appropriate for individuals who intend to remain sedentary. These diets appear effective in the early stages because the low carbohydrate intake leads to a significant loss of water (carbohydrate). These diets lead to weight loss because they provide fewer calories than the average person burns. However, the long-term effects of such diets have not been studied. They raise concerns about increasing risks of heart disease, colorectal and breast cancer, impaired kidney function, and complications of diabetes.

Field Notes



Energy Supplement Selection Guide

Numerous energy supplements are available in the marketplace. The use of some supplements is supported by research. The use of others is not. This section is designed to help you select liquid and solid carbohydrate supplements that serve the needs of wildland firefighters.

Sports Drinks

These guidelines are intended to guide the purchase of energy replacement beverages for wildland firefighters. They are based on published studies, field research on firefighters (conducted by MTDC and University of Montana researchers), and on position statements published by the American College of Sports Medicine and the National Athletic Trainers Association.

Recommendation—Firefighters need 1 L of fluid for each hour of work. We recommend that sport drinks comprise one-third to one-half of fluid needs, with the balance supplied by water. That will ensure about 100 kcal of carbohydrate for each hour of work (for example, 1/3 of 300 kcal = 100 kcal/h). Additional carbohydrate can be supplied by solid supplements, such as energy bars.

Sports Drinks

Guidelines—Consult the nutrition information label found on the product's package. The information covers the constituents in the mixed or liquid state and is presented per liter of fluid (1 L = 1.0567 qt). Because manufacturers list products for 8, 12, or 16 oz servings, it may be necessary to convert ounces to liters:

Multiply by	4.2 to convert an 8-oz serving to liters.
	2.8 to convert a 12-oz serving to liters.
	2.1 to convert a 16-oz serving to liters.

For 21 g of carbohydrate in a 12-oz serving, multiply 21 g by 2.8 to get grams per liter (21 x 2.8 = 58.8 g/L).

Serving size		1 L
Calories per serving		180 to 320 kcal/L
Carbohydrate	Total	45 to 80 g/L (4.5 to 8 percent)
	Type	glucose, sucrose, maltose, maltodextrin, or fructose (try to avoid products where fructose or high fructose corn syrup is the first carbohydrate in the list of ingredients)
Sodium		140 to 500 mg/L
Potassium		80 to 308 mg/L

The following ingredients are **not** required, either because the ingredient is provided in meals or there is no substantial proof that these ingredients contribute to performance or immune function when they are provided as a supplement. Ephedra, guarana, or other herbal products are not acceptable. Vitamins should not exceed 100 percent of the recommended dietary allowance.

Protein	0 to 15 g/L
Magnesium	0 to 56 mg/L
Vitamin C	0 to 100 mg/L
Vitamin E	0 to 160 IU/L (international units per liter)

Sports drinks that meet the specifications include:

Advocare Pos-3*
All Sport*
Cytomax
Comp 1 (Arizona Sports Drink)
Enervit G*
Extran Thirstquencher*
G Push**
GU_20
Gatorade
Powerade*
Revenge Sport

*High fructose, **High sodium

A higher carbohydrate concentration (for instance, 10 percent or 100 g/L and 400 kcal/L) can be tolerated after work, when the crew is traveling or awaiting transport. The addition of some protein (a ratio of 1 g of protein for 4 g of carbohydrate) within 2 h after work may reduce muscle stress and accelerate replacement of muscle glycogen. Fruit drinks or colas provide carbohydrate, and solid food snacks can supply additional carbohydrate, protein, and electrolytes. A total of 300 to 500 kcal of carbohydrate energy (liquid and solid) is recommended within 2 h after work.

Energy Bars

These guidelines are intended to guide the purchase of energy bars (solid carbohydrate supplements) for wildland firefighters. They are based on published studies conducted on athletes and military populations, and on field research conducted on wildland firefighters by MTDC and University of Montana researchers. For further information consult the tech tip *Feeding the Wildland Firefighter* (0251–2323–MTDC, *http://www.fs.fed.us/eng/t-d.php?link=pubs/htmlpubs/htm02512323*).

Candy Bars?—Some candy bars contain an adequate supply of carbohydrate. However, because candy bars are high in saturated fat, their use should be limited. Candy bars used to provide supplemental carbohydrate should provide at least 30 grams of carbohydrate per serving. While candy bars remain a cost-effective alternative to energy bars, they should not be used to meet more than 25 percent of the solid energy supplement mix (for instance, provide three energy bars for every candy bar).

Recommendation—We recommend that firefighters consume one-third to one-half of an energy or candy bar during each hour of hard work (one-third of a 240-kcal energy bar would be 80 kcal). These solid carbohydrate supplements should be consumed in addition to carbohydrate supplied in fluid-replacement beverages, providing a total of 160 to 240 kcal of supplemental energy for each hour of work.

Energy Bars

Guidelines—Consult the nutrition information label found on the product's package. All specifications are listed in units per serving (for instance, calories per energy bar). Each bar constitutes one serving.

Amount per serving	One energy or candy bar	
Calories per serving	200 to 300 kcal per bar	
Carbohydrate	Total	40 to 70 g
	Type	glucose, sucrose, maltose, maltodextrin, or fructose

The following ingredients are **not** required, either because the ingredient is provided in meals or there is no substantial proof that the ingredient contributes to performance or immune function when it is provided as a supplement. Avoid paying more for ingredients that have not been proven effective. Ephedra, guarana, or other herbal products are not acceptable.

Protein	up to 15 g (1 g protein per 4 g of carbohydrate)
Fat	Should not exceed 25 percent of total calories
Sodium:	Should not exceed 500 mg per bar
Potassium:	Should not exceed 308 mg per bar
Vitamins:	Should not exceed 100 percent of the recommended dietary allowance
Minerals:	Should not exceed 100 percent of the recommended dietary allowance

The addition of some protein (1 g of protein per 4 g of carbohydrate, with a total of 300 to 500 kcal of carbohydrate consumed) within 2 h after work may reduce muscle stress and accelerate replacement of muscle glycogen. Other solid food snacks can supply some protein. Liquid supplements can provide additional carbohydrate energy and electrolytes to improve fluid retention.

Energy bars that meet the specifications include:

Cliff Bar
Gatorade Bar
Harvest Bar
Power Bar

A number of other energy bars meet most of the specifications.

B. Sharkey, B. Ruby, S. Gaskill, and C. Cox, MTDC and the University of Montana Human Performance Laboratory.

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

Library Card

Sharkey, Brian. 2004. Wildland firefighter health and safety report No. 7. 0451–2802–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 12 p.

This issue focuses on efforts to maintain immune function in wildland firefighters. The research section provides summaries of recent field studies related to immune function. The risk management section outlines proven strategies for maintaining immune function during wildland fire suppression activities. The field notes section presents guidelines for selecting liquid and solid energy supplements to maintain immune function in wildland firefighters.

Keywords: Employee health, energy expenditure, energy supplements, fatigue, immune function, salivary immunoglobulin, upper respiratory tract infection

Additional single copies of this document may be ordered from:

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