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Wildland Firefighter Health & Safety Report

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Background

The National Academy of Sciences defines human factors as: "Concerned with the performance of persons in a task-oriented environment interacting with equipment and/or other people." The Missoula Technology and Development Center (MTDC), along with a team at the University of Montana Human Performance Laboratory (UM Lab), has engaged in human factors work for many years. This report, the 14th in a series, reviews activities related to MTDC's project on wildland firefighter health and safety. The focus has been on work, rest, and fatigue; energy and nutrition; and fitness and work capacity. The focus now includes the psychosocial dimensions of human factors, such as conditions and circumstances that enhance or interfere with performance and health.

This Issue

This report's Featured Topic focuses on the changes in national nutrition contract shift food (figure 1). The Research section reviews project-related field studies on the effects of stress, including heat stress with different uniforms and workplace stress. The Risk Management section reviews one of the most common causes for trips to the first aid kit—blisters. The Field Notes section reviews energy drinks.

Figure 1—A shift food lunch from the Medano Fire (Colorado 2010).

Featured Topic

Shift Food in the National Contract

Research conducted by MTDC and the UM Lab during the 2005 to 2007 fire seasons shows that regular snacking and supplemental feeding throughout the day (shift food) enhance work output during the prelunch period and late in the work shift, with total work output increased by 15 to 20 percent. These studies also indicated that wildland firefighters consider intermittent feeding to be beneficial.

The U.S. Department of Agriculture, Forest Service modified the national lunch contract to include shift food and implemented the change during the 2010 fire season. To assess the effectiveness of the change, MTDC collected and recorded shift food lunches from the Medano Fire for 14 consecutive days. We analyzed the lunches for macronutrient (carbohydrate, fat, and protein) content and compared the lunches with recommendations for athletic performance made by the UM Lab, the American College of Sports Medicine, and the American Dietetic Association. Finally, we sent a questionnaire to firefighters to assess the new lunches from their viewpoint. The 2010 wildland fire nutrition contract provided a strong foundation for meeting the macronutrient needs of wildland firefighters. With small modifications and continued assessments, the contract and fire lunches will continue to improve.

Remember

Carbohydrates are the primary macronutrient used during exercise. Carbohydrates (sugars) eaten during exercise are converted to glucose for energy.

We have to look at daily macronutrient needs to understand the specific needs of firefighters. These needs are based on the intensity, frequency, and duration of a job. Studies by MTDC and the UM Lab show that, during wildland fire suppression, the energy cost for firefighters is about 5,000 kilocalories per day. Constructing fireline by hand, a common physical task for wildland firefighters, has an energy cost of 7.5 to 10 kilocalories per minute. This means a Snickers bar (about 250 kilocalories) is completely used in 25 to 30 minutes of building fireline. During arduous work on the fireline, studies show that muscle stores of carbohydrates decrease in proportion to the duration of the specific activity. Inadequate feeding during fireline shifts decreases the availability of carbohydrates and leads to decreased work performance. The following guidelines for macronutrients are recommended for wildland firefighting:

- 2.7 to 4.5 grams of carbohydrate per pound of body weight per day
- 0.5 to 0.8 grams of protein per pound of body weight per day
- 20 to 35 percent of total energy intake in fat

By these standards, a 165-pound firefighter would need 1,674 to 2,790 kilocalories of carbohydrate, 310 to 496 kilocalories of protein, and 1,000 to 1,750 kilocalories of fat per day—a total of 2,984 to 5,036 kilocalories a day.

On average, the Medano Fire lunches provided 8.5 items per lunch with 2,066 kilocalories. The lunches had 1,192 kilocalories (57 percent of the total kilocalories) of carbohydrate, 252 kilocalories (12 percent) of protein, and 675 kilocalories (32 percent) of fat. The macronutrient breakdown is consistent with the recommendations of the UM Lab team members after they conducted multiple field studies on ways to improve the lunches (table 1). The number of items in the lunches was below the recommended 10 to 14. A higher number of items allows for more frequent eating throughout the shift and helps to maintain blood glucose and increase self-selected work output.

Table 1—Macronutrients Needed by Wildland Firefighters in a Shift Food Lunch.

Contents of a Shift Food Lunch	Average Amount	Recommended Amount
Items	8.5	10 to 14
Kilocalories	2,065.75	2,000 to 2,500
Carbohydrate in grams	298.31	300 to 375
Protein in grams	63.56	63 to 78
Fat in grams	75.88	66 to 83

Beyond macronutrient needs, knowing firefighter perceptions of the foods provided in a shift food lunch is important. The best scientifically designed lunch won't do any good if the firefighter is not eating it. MTDC distributed a questionnaire nationwide to determine the current perception of the lunch program. We emailed the questionnaire to smokejumpers, helitack, rappellers, hotshot crews, type II handcrews, incident management teams (IMTs), and other single resources; 927 firefighters responded (table 2).

Table 2—Diversity of Questionnaire Respondents.

Job Options	Demographics
Smokejumper	19
Crew superintendent	62
Hotshot crewmember	151
Engine crewmember	145
Rappeller	13
Single resource	286
Fuels crew	14
Incident management team members	184
Other	244

Firefighters rated the lunches on overall quality and preference for items included. The sample population could choose ratings of excellent, good, poor, and very poor. About 520 people (56 percent) rated lunch quality as good; about 320 people (35 percent) rated lunch quality as poor; 60 people (6 percent) rated lunch quality as very poor; and 30 people (3 percent) rated lunch quality as excellent (figure 2). After finding out how the current lunches rated, MTDC wanted to know which items firefighters preferred to have in their lunches (figure 3). The top choices included tuna packets; fruit and nut combos/trail mixes; whole fruit (variety); raw vegetables (variety); nuts and seeds; and energy bars.

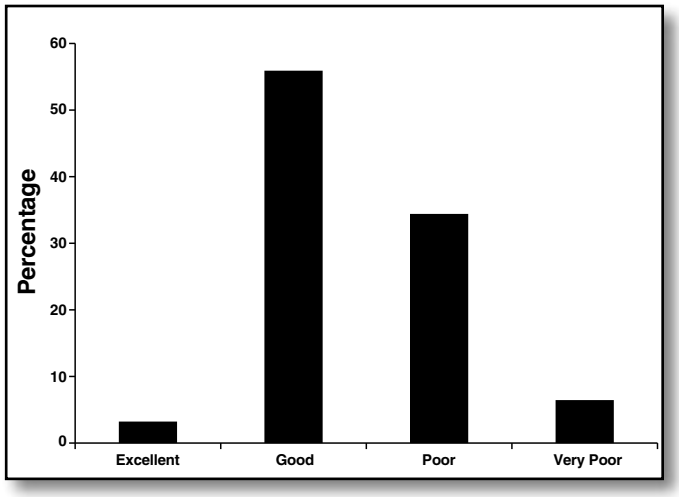

Figure 2—Quality of shift food lunches rated by wildland firefighters.

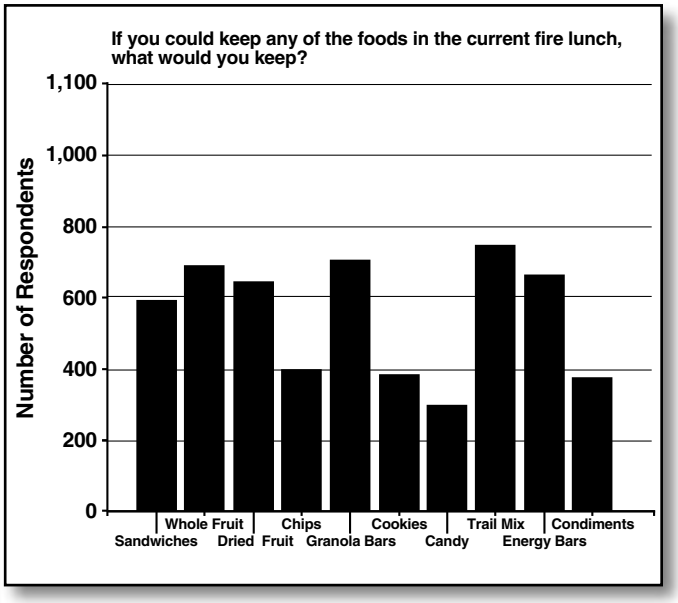

Figure 3—Items wildland firefighters liked in the current shift food lunches.

Firefighters don't like certain items in the lunches. If firefighters do not eat items, energy available and cost-effectiveness decrease. In an earlier study, the UM Lab increased shift food lunch cost-effectiveness by decreasing food discarded from the lunches. Firefighters requested the removal of chips, candy, and processed foods and suggested including fewer roast beef sandwiches and less cream cheese. The biggest problem appeared to be the lack of variety in day-to-day lunches.

The addition of energy bars in the modified national contract increased the macronutrient and micronutrient (vitamins and minerals) content of the new lunches. In general, the lunch program focused on macronutrients, but micronutrients play a significant role in major body functions and also must be included. Micronutrient content increases with an increase in fresh whole fruit and vegetables, energy bars (not protein bars), good quality sandwiches (including peanut butter and jelly on whole wheat bread), trail mixes, seeds, nuts, dried fruit, and vegetables.

However, there must be a balance with energy-dense foods. Items such as cream cheese, bagels, candy, and potato chips have a place in the lunch, too. With a diverse population, a variety of foods must be maintained to accommodate varying tastes and eating preferences while also maintaining the combination of nutrient- and energy-dense foods.

The lunches are designed to increase the frequency of eating smaller portions because wildland firefighters are constantly moving during a work shift. Less than 5 percent of a work shift is spent on a rest break (Broyles 2011). Some activities are more demanding than others. For example, hotshot crews digging fireline consume more energy than IMT members at meetings. The American College of Sports Medicine, the American Dietetic Association, and the Dietitians of Canada recommend eating a carbohydrate snack within the first 30 minutes of exercise and again every 2 hours.

Changes in the lunch program are helping to provide the nutrients and energy firefighters need to perform efficiently and effectively during a fire shift. Educating the wildland fire community on eating often throughout the day (at least every 2 hours) and on what to eat (carbohydrates) is important. You can find more information on eating during wildland fire incidents in the brochure "Eating for Health and Performance: The Wildland Firefighter" <http://www.fs.fed.us/eng/pubs/htmlpubs/htm06512833/index.htm>. Forest Service and U.S. Department of the Interior, Bureau of Land Management (BLM) employees can visit the MTDC Web site to view the PowerPoint presentation <http://fsweb.mtdc.wo.fs.fed.us/pubs/ppt_html/htm06512855>. The brochure and presentation are components of the "Wildland Firefighter Nutrition Education Program" <http://www.fs.fed.us/eng/pubs/htmlpubs/htm07512302/index.htm>. Also, Forest Service and BLM employees can read chapter 10 on nutrition and performance in "Fitness and Work Capacity: 2009 edition" (Brian Sharkey and Steven E. Gaskill 2009) at the MTDC Web site <http://fsweb.mtdc.wo.fs.fed.us/pubs/htmlpubs/htm09512804/index.htm>.

Shift Food Lunches

Shift food lunches are designed for fireline operations and not for camp-based individuals. The current health status of incident management team members (see Research section) is comparable to the general American population. Current shift food lunches contain enough kilocalories for an entire day of office work. Team members must think carefully before eating an entire shift food lunch. To prevent overeating, an option might be to split a lunch with a colleague.

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Research

This section reviews project-related field studies conducted on wildland firefighter health and safety issues: how personal protective equipment (PPE) can affect employees by causing heat stress and how incident teams handle workplace stress.

Effects of Stress

"It was more important to let heat out, than to keep it out."

Budd, G.M.; Brotherhood, J.R.; and others 1997. Project Aquarius 13. The thermal burden of high insulation and encapsulation in wildland firefighters' clothing, International Journal of Wildland Fire 7(2) 207–218.

Three Different Wildland Fire Suppression Uniforms and Heat Stress

Wildland firefighters wear required, flame-resistant clothing while performing arduous labor in hot, dry environments. Efficient heat dissipation is important because it helps prevent conditions such as hyperthermia and exhaustion. Some agencies require firefighters to wear multiple layers of clothing. This study compared the physiological effects of three different wildland firefighter uniforms worn during sustained submaximal exercise in the heat. Nine male volunteers with an average age of 25 performed three trials on a treadmill (3 miles per hour at 4-percent grade, the same work rate as the pack test) on separate days for more than 3 hours in a hot, dry environment (98.6 ºF, 30-percent relative humidity) with a 10-minute rest period each hour.

Trial participants wore T-shirts, tennis shoes, leather gloves, hardhats, and field packs (20.4 kg) in combination with three different outer layers. The participants tested Type I (Nomex) pants and shirts in trial FS-I, Nomex shirts and Type II Kevlar-blend pants in trial FS-II, and CAL FIRE standard issue Nomex shirts and brush pants over station pants in trial CF-III. MTDC analyzed results using a repeated measures analysis of variance (ANOVA) test. We found no significant differences in heart rates (HR) or weight changes. Over a period of time, participants in FS-I had a significantly lower physiological strain index (PSI)—a measure combining HR and core temperature—than participants in CF-III. Participants in FS-II tended to have lower PSI than participants in CF-III. Participants in FS-I and FS-II had lower core temperatures than participants in CF-III. Participants in CF-III showed significantly higher total body temperatures when compared to those in FS-I and FS-II (figure 4).

MTDC removed three of the nine study participants, before 3 full hours because their core body temperatures reached test termination levels (104 °F). Five participants reached core body temperatures of 103 °F or above. Individuals working in multiple layers of clothing in hot environments experience more physiological strain. PPE use is a balancing act—more protection results in a greater potential for heat stress.

Pattison, K.M.; Gaskill, S.E. (both of the University of Montana); Domitrovich, J.W. (MTDC). 2010.

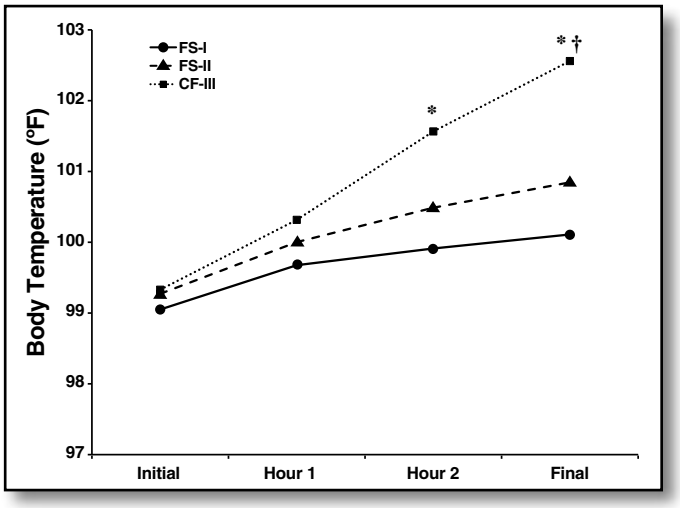


Figure 4—Core body temperature during 3-hour trials with three different wildland firefighting uniforms. **Note:** * means significantly warmer than FS-I; † means significantly warmer than FS-II.

Types of Fabrics and Sweat

Many different types of fabrics that promote sweat dispersion (also known as the ability to improve cooling of the body) are available on the market. A study in the journal "Medicine and Science in Sports and Exercise" shows that synthetic fabrics do not provide better body temperature cooling when compared with natural fabrics (Gavin and others 2001). The study finds evaporation of sweat increases greatly with the synthetic fibers, but this does not significantly decrease body temperature.

Incident Management Teams' Health and Workplace Stress

During a 4-year period, investigators from the UM Lab, supported by MTDC, evaluated IMTs and their members. The study focused on the health of team members, including their physical health, coronary heart disease (CHD) risk factors, and stress in the workplace.

Research findings indicated that team members shared similar CHD risk factors with the general U.S. population (2.6 risk factors for team members, 2.8 for the general population). Almost half of the team members reported high cholesterol levels and/or were taking cholesterol-reducing medications. Of team members, 59 percent were overweight, and more than a quarter (26 percent) of overweight individuals were categorized as obese.

Data from this research suggest the need for risk-reduction interventions, both at fire camp and away from fire camp, particularly for individuals whose job descriptions allow little or no physical activity while on team assignment or at their home units. Regular physical activity improves physical health, increases mental function, reduces stress, and also reduces the risk of acute coronary problems or stroke.

Prolonged stress can lead to physical symptoms in the body (upset stomach, headaches, eye strain). MTDC used multiple, diverse assessments to better understand the role that stress plays for team members and how they cope with it. For example, we analyzed saliva samples for salivary cortisol, a biophysical marker of stress. Results placed team members within normal ranges, suggesting that those tested did not experience any significant physical stress at the time of sampling.

Findings from these assessments indicate that team members fell within normal ranges regarding perceived workplace stress and that they coped well with the stressors they faced. When categorized by years of experience on an IMT, members with less than 5 years of experience reported significantly less stress than members with 5 to 10 years of experience and those with more than 10 years of experience. Future studies may be required to better understand this finding.

The 4-year investigation into IMTs resulted in a much better understanding of the health and fitness of team members, the role that stress plays and the sources of stress, and how team members cope with stress. Additional studies carried out during an IMT assignment would provide a more longitudinal perspective on many of the issues identified in this research.

Palmer, C.G.; Gaskill, S.E. (both of the University of Montana); Miller, T.; Domitrovich, J.W. (both of MTDC). 2007 to 2009.

These studies were conducted under the Memorandum of Understanding between MTDC and the UM Lab.

Blisters

Foot care supplies, primarily for blisters, are common on any medical supply unit leader's list. Blisters occur when there is too much friction on skin (Athletic Training and Sports Medicine, 3rd Edition, 1997). This section discusses some ways to prevent blisters and what to do with a blister once it develops. These guidelines are based on information from the Mayo Clinic <http://www.mayoclinic.com> and the American Academy of Orthopaedic Surgeons <http://www.aaos.org>.

Prevention

Boots

Boots are critical equipment for most wildland firefighters. Purchase boots that fit comfortably and take the time to break them in. The best way is simply to wear them. Start slowly for short durations around the house and on flat surfaces. Slowly increase the time wearing the boots and begin hiking. Finally, add weight while hiking.

Socks

Wearing a pair of socks made of material that wicks moisture may help prevent blister formation. Blisters occur more frequently in damp conditions. Change socks regularly to keep your feet dry and clean. Avoid cotton socks because they retain moisture near the feet and increase friction. Be aware that synthetic socks should not be worn on the fireline; they can melt. Use powder on your feet to help keep them dry during the day and wear socks made of natural fibers (wool).

Tape and Moleskin

Tape and moleskin add an additional layer of protection to skin. At the first sign of a "hotspot," use only enough tape or moleskin to cover the area; additional material might come loose and create further problems. Cut off excess material. If tape is used, choose one that breathes and stretches. An example (believe it or not) is duct tape.

Treatment

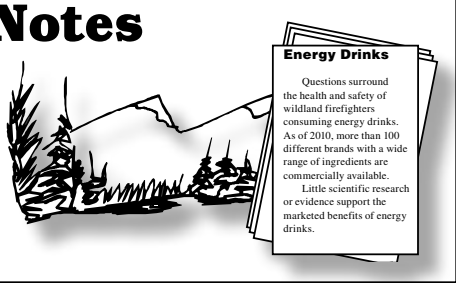
Treat blisters immediately. The best way to heal a blister is to leave it intact and keep weight off of it, which is not always possible on a fire. The next best method is to remove the fluid from the blister. Using a sterilized needle, clean the blister and make a small hole at the edge. If possible, open the blister at night so it can heal while you sleep. Drain the fluid as best you can without removing the skin (to help protect the underlying tissue).

After the blister is drained, use an antibiotic and cover the area with a sterile dressing. Avoid using an adhesive directly on the blister to prevent removing skin when the adhesive is removed. Cutting moleskin into a "doughnut" protects the blister without any adhesive on it and also allows the blister to breathe. When using tape, place a small piece of sterile dressing on the blister first to prevent adhesive from sticking to the blister. Keep the blister dry and protected until the skin comes off naturally, usually after 4 or 5 days. If the blister is bleeding, treat it like any other open wound. Cover the blister when you are active and remove any protection at night, allowing the blister to breathe. Reapply protection every morning or after the blister gets wet. Use powder to help keep your feet dry.

Key points:

- If you discover a hotspot, protect it from further irritation with moleskin or tape.
- If a blister occurs, gently clean the area and pierce the blister on an edge. Let it drain, but do not remove any skin. Add an antibiotic to prevent infection and cover it with a sterile dressing.
- Let the blister dry uncovered at night while you are sleeping.
- Seek medical help immediately if your blister is oozing or becomes infected.

Field Notes



Energy Drinks

Questions surround the health and safety of wildland firefighters consuming energy drinks. As of 2010, more than 100 different brands of energy drinks with a wide range of ingredients are commercially available. Energy drinks contain stimulants and additives, while sports drinks contain carbohydrates and electrolytes.

Little scientific research or evidence support the marketed benefits of energy drinks. Some of the more common ingredients include guarana (caffeine), bitter orange, ginseng, and taurine. The level of ingredients in energy drinks is far below levels recommended by researchers to receive the benefits reported by the manufacturers.

Energy drinks may contain levels of carbohydrate (sugar) beyond what the human body can absorb. This can lead to an upset stomach or gastrointestinal distress. An exercising individual can absorb about 60 grams per hour of carbohydrate from the gut. Some common energy drinks have about 55 to 65 grams of carbohydrate in an 8- to 8.4-ounce drink. This amount typically is consumed in a few minutes.

Comparing Energy Drinks to Sports Drinks

Energy drinks and sports drinks are not the same. Sports drinks are formulated using carbohydrates and tested to promote improvements in athletic performance. One study looked at the effect of a sugar-free energy drink and a placebo on run time to exhaustion and reported no differences in the time to exhaustion between the sugar-free energy drink and the placebo (Candow and others 2009).

There is a lot of debate about the safety and use of energy drinks (a topic to be discussed in an upcoming edition of the Wildland Firefighter Health and Safety Report). According to a Mayo Clinic review on energy drinks, individuals participating in exercise or working longer than 1 hour should not consume energy drinks (Higgins and others 2010). When developing a hydration and nutrition plan, remember that prior research on wildland firefighters shows that constant consumption of liquid or solid carbohydrates helps maintain immune function and blood glucose levels and improves performance. For wildland firefighters, sports drinks are a better source of carbohydrates and electrolytes.

Send Us Your Proposal (What should we study next?)

Every year, representatives from each region of the Forest Service meet to determine priorities for the National Technology and Development Program. Study ideas come from the field and from readers like you. If you have an idea for a study project, please submit a proposal. Proposal forms are available online at the Forest Service National Technology and Development Center's Web page or by contacting MTDC.

About the Author

Joe Domitrovich is an exercise physiologist at MTDC. His project work includes hydration, nutrition, employee health, stress, and fitness testing. He also is a wildland firefighter. Domitrovich received a bachelor's degree in kinesiology at Cal Poly San Luis Obispo in California. He has a master's degree in exercise physiology and an interdisciplinary studies Ph.D. with an emphasis in exercise science from the University of Montana. His recent Forest Service publications include "Heat Illness Basics for Wildland Firefighters" and "Hydration Strategies for Firefighters."

Library Card

Domitrovich, Joe. 2014. Wildland firefighter health & safety report: No. 14. Tech. Rep. 1351–2811–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 10 p.

The Featured Topic in this issue discusses changes in national nutrition contract shift food and wildland firefighter reactions to these changes. The Research section reviews project-related field studies on the effects of stress, including information on heat stress with different uniforms and workplace stress of incident management team members. The Risk Management section reviews common causes and effective treatments for blisters. The Field Notes section evaluates the effectiveness of energy drinks for wildland firefighters.

Keywords: blisters, energy drinks, fire fighting, firefighting, firefighting uniforms, first aid, food, Nomex, nutrition, safety at work, shift food, snacking, sports drinks, supplemental feeding, uniforms

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