A Publication of the
National Wildfire Coordinating Group

Fitness and Work Capacity

2009 Edition

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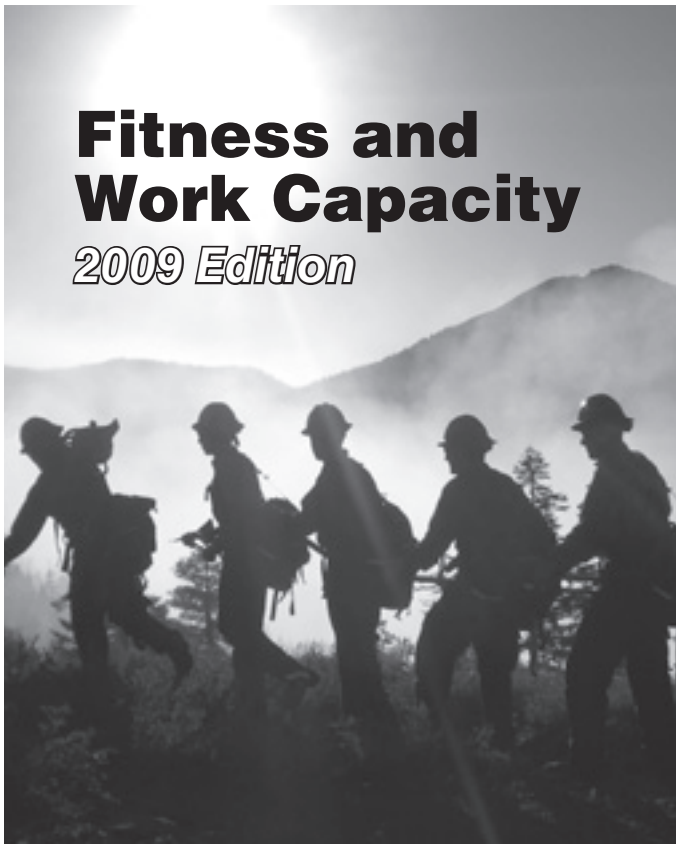
Dedication

To wildland firefighters, past, present and future—forest and grassland athletes who prepare themselves for physically demanding work in extreme environmental conditions.

A publication of the National Wildfire Coordinating Group

PMS 304-2 **December 2009**



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Chapter 1—Fitness and Health

> **"The daily habits of people have a great deal more to do with what makes them sick and when they die than all the influences of medicine."**
>
> *Lester Breslow, M.D.*

When men and women go to work during the 21st century, few engage in arduous muscular effort. Labor-saving devices have eliminated the need for muscular work at home and the automobile makes the task of getting to and from work physically effortless. Machines supplement or replace human effort in the forest and in mills, construction sites, factories, and mines.

Youth and adults engage in less physical activity each day, while they consume more calories than they burn. The consequences of these trends are obvious: the average worker can no longer deliver a full day's effort in a physically demanding job and degenerative diseases associated with inactivity and obesity, such as heart disease, hypertension, diabetes, and cancer, are epidemic.

Some jobs, such as wildland firefighting and forestry field work (such as trail construction and maintenance) have not been mechanized. These jobs require muscular strength and endurance. Workers need specific conditioning to prepare them for the rigors of arduous field work.

The benefits of physical activity and fitness extend well beyond those related to job performance. Regular activity and improved fitness are associated with:

- Reduced risk of heart disease, hypertension, and stroke
- Reduced incidence of being overweight or obese
- Reduced incidence and severity of diabetes
- Reduced risk of certain cancers
- Reduced risk of osteoporosis
- Reduced risk of injury and illness
- Improved immune function and resistance to infection
- Stronger bones, tendons, ligaments, and muscles
- Increased energy, mobility, and longevity

Activity and fitness also confer psychological benefits, including:

- Reduced anxiety and depression
- Reduced tension and stress
- Reduced incidence of dementia (Alzheimer's disease)
- Enhanced self-concept and body image
- Improved appearance and performance
- Enhanced quality of life

Activity and fitness contribute to a longer life and a shorter period of debilitating illness that frequently precedes frailty and death. Active living extends the prime of life; it adds life to your years as well as years to your life (figure 1.1).

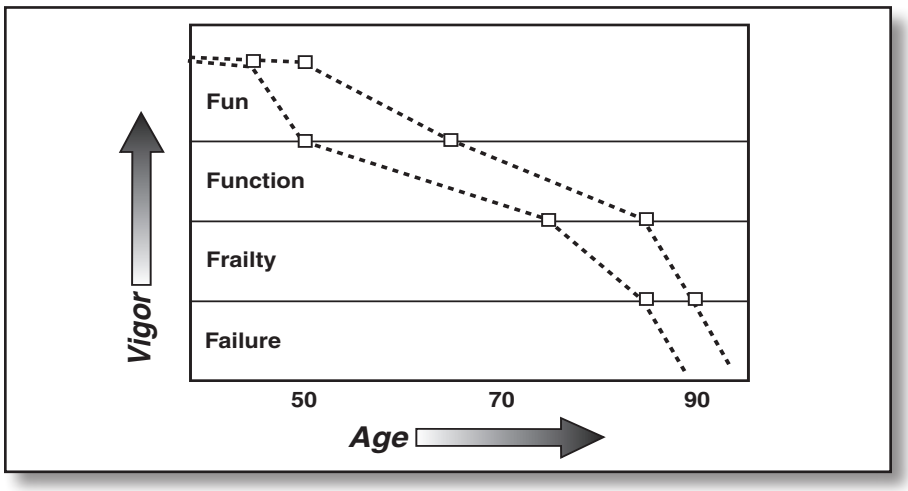

Figure 1.1—Vigor and the active life. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th edition. (Champaign, IL: Human Kinetics), 349.

The body doesn't wear out with use; it deteriorates with lack of use.

Use it or lose it!

The respiratory and cardiovascular systems are enhanced with activity and training. Tissues such as muscle and bone are strengthened. The best results come when activity and fitness are combined with good nutrition, adequate rest, stress management, safe habits (wearing seat belts), and avoidance of smoking and other drugs.

Fitness Index

A simple way to estimate fitness is to use the Fitness Index (table 1.1). Based on the relationship of physical activity to fitness, the index estimates aerobic fitness based on the intensity, duration, and frequency of your regular level of activity.

Table 1.1—Aerobic fitness index. Calculate your fitness index by multiplying the score in each category: Fitness Index = Intensity x Duration x Frequency. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th edition. (Champaign, IL: Human Kinetics), 9.

Category	Score	Activity
Intensity	5	Sustained heavy breathing and perspiration
	4	Moderately heavy breathing and perspiration
	3	Intermittent heavy breathing, as in recreational sports
	2	Moderate activity, as in brisk walking or volleyball
	1	Light activity, as in fishing, gardening, or easy walking
Duration	4	Longer than 40 minutes
	3	30 to 40 minutes
	2	20 to 30 minutes
	1	Less than 20 minutes
Frequency	5	Daily or almost daily
	4	Three to five times a week
	3	One to two times a week
	2	Less than once a week
	1	Once a month

Evaluation and Fitness Estimate

Score	Evaluation	Fitness Level
100	Very active and fit	High
80	Active and fit	
60 to 80	Active and healthy	Medium
40 to 60	Consider changes	
20 to 40	Improvement needed	Low
Lower than 20	Sedentary	

Wellness and Safety

Employee health and safety programs reduce injuries, the need for health care, and worker's compensation claims.

Workplace wellness programs emphasize prevention, individual responsibility, and cost-effectiveness. A good wellness program helps individuals identify and change unhealthy and destructive habits. Wellness programs improve employee morale and productivity, while reducing illness, absenteeism, and employee turnover. A dollar spent on a wellness program saves $3 or more in health care and other costs. A wellness or employee health program could include:

Health Risk Analyses—The health risk analysis is a computer-scored appraisal that identifies health risks and ways to reduce them.

Health Screenings—Screenings once or twice a year allow early detection of risk factors. Screenings include body weight, blood pressure, blood tests, the prostate specific antigen test, a dermatological exam, and more. These low-cost tests can be conducted in the workplace at a fraction of the cost of conducting them in a medical facility, and they reduce the need for visits to the doctor's office.

Health Education—Most programs include stress management, nutrition, weight control, back health, and smoking cessation. Some offer medical self-care, parenting, and prenatal classes.

Health-Related Fitness—All employees should take part in a health-related fitness program, including aerobic and muscular fitness. The program should be tailored to meet employee needs (see chapters 2 and 3).

Fitness and Safety

Some of the accidents in the workplace are caused by unsafe acts rather than unsafe conditions. It makes little sense to stress the importance of protective clothing or ergonomics while ignoring the physical and mental condition of employees. In general, individuals prone to on-the-job accidents are more likely to have unhealthy lifestyles (be inactive, overweight, or smoke) or have psychological problems. A high percentage of occupational accidents can be attributed to human factors. A good wellness program helps individuals change unhealthy habits and improve physical and mental health, contributing to a reduction in injuries and worker's compensation costs. Specific ways to reduce workplace injuries will be presented in chapter 12.

Fitness and Work Capacity

Work capacity is the ability to accomplish production goals without undue fatigue and without becoming a hazard to yourself or your coworkers. Work capacity is the product of a number of factors, including natural endowments, skill, intelligence, experience, and motivation, as well as nutrition, aerobic and muscular fitness, and acclimation. Even the most highly motivated workers may fail if they lack the strength or endurance required by the job, or if they are poorly fed, dehydrated, or not acclimated to environmental extremes. Fit workers are more productive, are absent fewer days, and are much less likely to develop job-related disabilities or retire earlier because of heart problems or other degenerative diseases. In addition, fit workers have a more positive attitude about work and life in general. For safety, health, productivity, and morale, fitness is good business.

Chapter 2—Health Assessments

The health benefits of regular, moderate exercise have been confirmed by many research studies. A number of medical and scientific organizations encourage the public to be physically active. The American College of Sports Medicine and the American Heart Association recommend that every American should have a total of 30 to 60 minutes of moderate intensity physical activity most days of the week. Even sedentary individuals can begin a moderate exercise program safely. If more individuals adopt an active lifestyle, public health will be enhanced.

Apparently healthy individuals who are under 45 years of age and have no symptoms, risk factors, or heart disease, can participate in more vigorous activity. Wildland firefighters who intend to train for the pack test and participate in arduous firefighting duties may need to take a medical evaluation required by their agency (table 2.1). Those training for other work capacity tests for moderate or light fire duties should check agency medical exam requirements, such as the health screening questionnaire, which helps to identify higher risk individuals. Higher risk individuals should consult with their physician before beginning training for work capacity tests or field duties.

The American College of Sports Medicine and the American Heart Association recommend that individuals complete a health screening questionnaire before they embark on a fitness program (figures 2.1a and 2.1b).

Table 2.1—Health screening requirements and recommendations.

Job	Work category	Requirement	Recommended
WLFF*	Arduous**	Medical exam***	-----
IMT****	Moderate	Health screening	See physician
IMT****	Light	Health screening	See physician
Field work	Varies*****	-----	Health screening
Employee	-----	-----	Health screening

*Wildland firefighters
**Type I firefighters (smokejumpers, hotshots, rappellers) have additional requirements.
***Follow the requirements of the agency having jurisdiction.
****Incident management team members.
*****Field work varies from light to arduous (for instance, trail work involves arduous effort).

USDA Forest Service/Department of the Interior FS-5100-31 (Rev 8/2009) OMB 0596-0164 (Expires1/2013)

WCT Level
__ Arduous
__Moderate
__Light

HEALTH SCREENING QUESTIONNAIRE (HSQ)

Assess your health needs by marking all true statements.

The purpose is to identify individuals who may be at risk in taking the Work Capacity Test (WCT) and recommend an exercise program and/or medical examination prior to taking the WCT.

Employees are required to answer the following questions. The questions were designed, in consultation with occupational health physicians, to identify individuals who may be at risk when taking a WCT. The HSQ is not a medical examination. Any medical concerns you have that place you or your health at risk should be reviewed with your personal physician prior to participating in the WCT.

Check 'Yes' or 'No' in response to the following questions:

[ ] Y [ ] N 1) During the past 12 months have you at any time (during physical activity or while resting) experienced pain, discomfort or pressure in your chest.

[ ] Y [ ] N 2) During the past 12 months have you experienced difficulty breathing or shortness of breath, dizziness, fainting, or blackout?

[ ] Y [ ] N 3) Do you have a blood pressure with systolic (top #) greater than 140 or diastolic (bottom #) greater than 90?

[ ] Y [ ] N 4) Have you ever been diagnosed or treated for any heart disease, heart murmur, chest pain (angina), palpitations (irregular beat), or heart attack?

[ ] Y [ ] N 5) Have you ever had heart surgery, angioplasty, or a pace maker, valve replacement, or heart transplant?

[ ] Y [ ] N 6) Do you have a resting pulse greater than 100 beats per minute?

[ ] Y [ ] N 7) Do you have any arthritis, back trouble, hip /knee/joint /pain, or any other bone or joint condition that could be aggravated or made worse by the Work Capacity Test?

[ ] Y [ ] N 8) Do you have personal experience or doctor's advice of any other medical or physical reason that would prohibit you from taking the Work Capacity Test?

[ ] Y [ ] N 9) Has your personal physician recommended against taking the Work Capacity Test because of asthma, diabetes, epilepsy or elevated cholesterol or a hernia?

Regardless whether you are taking the Work Capacity test at the Arduous, Moderate or Light duty level, a "Yes" answer requires a determination from your personal physician stating that you are able to participate.

I understand that if I need to be evaluated by a physician, it will be based on the fitness requirements of the position(s) for which I am qualified.

Signature:_____ Printed Name _____Date _____

Unit: _____ City _____State _____

Privacy Statement

The information obtained in the completion of this form is used to help determine whether an individual being considered for wildland firefighting can carry out those duties in a manner that will not place the candidate unduly at risk due to inadequate physical fitness and health. Its collection and use are covered under Privacy Act System of Records OPM/Govt-10 and are consistent with the provisions of 5 USC 552a (Privacy Act of 1974).

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Figure 2.1a—Health screening questionnaire.

USDA Forest Service/Department of Interior

FS-5100-30 (Rev 8/2009
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Work Capacity Test: Informed Consent

- **Pack Test- Arduous** The 3-mile test with a 45 pound pack in 45 minutes is strenuous, but no more so than the duties of wildland firefighting.
- **Field Test-Moderate** The 2-mile test with a 25 pound pack in 30 minutes is fairly strenuous, but no more so than the field duties.
- **Walk Test-Light** The 1-mile walk in 16 minutes is moderately strenuous, but no more so than the duties assig.

Risks

- There is a slight risk of injury (blisters, sore legs, sprained ankles) especially for those who have not practiced the test. If you have been inactive and have not practiced or trained for the test, you should engage in several weeks of specific training before you take the test. Be certain to warm up and stretch before taking the test, and to cool down after the test. The risk of more serious consequences (such as respiratory or heart problems) is diminished by completing the **(HSQ)** physical activity readiness questionnaire.

☐ **I have read the information on this form, the brochure "Work Capacity Test" and understand the purpose, instructions, and risks of the job related to work capacity test.**

☐ **I have read the information, understood, and truthfully answered the HSQ.**

Test to be Taken (check one) Pack test ☐ Field Test ☐ Walk Test ☐

Signature _____ Date _____

Printed Name _____

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Figure 2.1b—Work capacity test informed consent form.

Risks of Exertion

While physical activity generally is safe for most individuals, it increases the risk of muscle, joint, or more serious health risks. Risks are associated with exercise intensity (figure 2.2). Only about 10 percent of all heart attacks occur during exertion. Risk is associated with age (over 45 years), gender (male), being overweight or obese, and inactivity. The American Heart Association lists physical inactivity as a major risk factor for heart disease. The least active individuals are 50 times more likely to experience a serious problem during or soon after exertion than the most active individuals (American College of Sports Medicine and the American Heart Association 2007).

To minimize the risks of exercise, reduce heart disease risk factors (table 2.2) and have a medical examination or health screening before training, testing, or participating in strenuous work. If you have been inactive, walk regularly for 4 to 6 weeks before you begin strenuous training. When training, increase intensity and duration gradually, scheduling easier days to allow recovery. See chapters 8 and 9 for specific training advice.

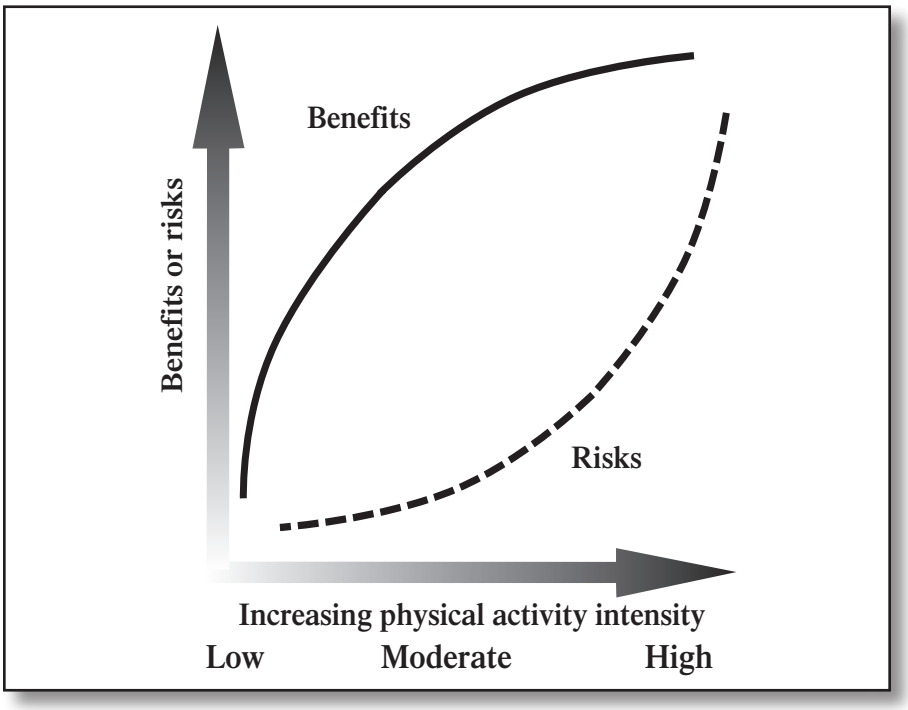

Figure 2.2—Benefits and risks of exercise. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 59.

Table 2.2—Heart disease risk factors. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 16.

Influenced by physical activity	May be influenced by physical activity	Not influenced by physical activity
Overweight and obesity	Electrocardiographic abnormalities	Family history of heart disease
Maintenance of blood glucose	Elevated uric acid and C-reactive protein	Gender (male has greater risk until age 55)
Elevated blood lipids	Pulmonary function (lung) abnormalities	Cigarette smoking
High blood pressure	Some cancers	Poor food choices
	Personality or behavior pattern (hard driving, time conscious, aggressive, competitive, hostile)	
	Psychic reactivity (reaction to stress)	

Chapter 3—Health-Related Fitness

All employees, not just those with a physically demanding occupation, should take part in a health-related fitness program. The program's goal is to improve the health and quality of life of all employees. Health-related fitness consists of the following:

Aerobic fitness—Aerobic activity engages large muscle groups in sustained activities such as walking, running, cycling, swimming, cross-country skiing, rowing, paddling, or similar activities. Ideally, the activity should serve a purpose.

Muscular Fitness—Fitness ensures that you have enough strength, muscular endurance, and flexibility to carry out your daily tasks with vigor and alertness, and with the capacity to meet unforeseen emergencies. All employees should engage in core fitness training to prevent back problems. Weight training should be used to prevent injuries and to provide the strength and endurance you need for your favorite activities (such as leg strength and endurance for mountain biking or skiing).

Meaningful Activity

Activity that serves a purpose has meaning. Walking makes good sense, whether you are having fun with family or friends, going to work, or exercising with your dog. Walking on a treadmill is less meaningful, unless it is used as a substitute for more meaningful walking during bad weather. Select activities you enjoy or that prepare you for upcoming events or seasons. Lifelong exercisers engage in meaningful activity almost every day of their lives; they are positively addicted to physical activity. They exercise for fitness and health, but more importantly, they do so for their own satisfaction. Their activity has purpose, and yours should too.

Body Composition—One way to reduce the risk of becoming overweight, or of developing heart disease or diabetes is to maintain a body mass index (BMI) from 19 to 25 (figure 3.1), a healthy waist-to-hip ratio (figure 3.2), and a waist circumference of less than 40 inches for men and 35 inches for women.

BODY MASS INDEX	HEIGHT																	
	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83
66	19	18	16	15	14	13	12	12	11	10	10	9	9	8	8	8	7	7
70	20	19	18	16	15	14	13	13	12	11	10	10	9	9	8	8	8	7
75	22	20	19	17	16	15	14	13	12	12	11	10	10	9	9	9	8	8
79	23	21	20	18	17	16	15	14	13	12	12	11	11	10	9	9	9	8
84	24	22	21	19	18	17	16	15	14	13	12	12	11	11	10	10	9	9
88	26	24	22	20	19	18	17	16	15	14	13	12	12	11	11	10	10	9
92	27	25	23	21	20	19	17	16	15	15	14	13	12	12	11	11	10	10
97	28	26	24	22	21	20	18	17	16	15	14	14	13	12	12	11	10	10
101	29	27	25	23	22	20	19	18	17	16	15	14	13	13	12	12	11	10
106	31	28	26	24	23	21	20	19	18	17	16	15	14	13	13	12	11	11
110	32	30	27	26	24	22	21	20	18	17	16	15	15	14	13	13	11	11
114	33	31	29	27	25	23	22	20	19	18	17	16	15	14	14	13	12	12
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132	38	36	33	31	29	27	25	23	22	21	20	19	18	17	16	15	14	14
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141	41	38	35	33	30	28	27	25	24	22	21	20	19	18	17	16	15	15
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150	44	40	27	25	32	30	28	27	25	24	22	21	20	19	18	17	16	15
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158	46	43	40	37	34	32	30	28	26	25	24	22	21	20	19	18	17	16
163	47	44	41	38	35	33	31	29	27	26	24	23	22	20	19	19	18	17
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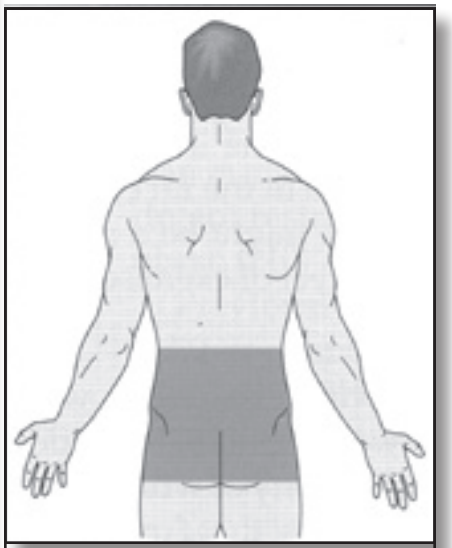
238	69	64	59	55	51	48	45	42	40	37	35	33	32	30	28	27	26	24
242	70	65	60	56	52	49	46	43	40	38	36	34	32	30	29	28	26	25
246	72	66	61	57	53	50	47	44	41	39	37	35	33	31	29	28	27	25
251	73	67	63	58	54	51	47	45	42	39	37	35	33	32	30	29	27	26
255	74	69	64	59	55	52	48	45	43	40	38	36	34	32	31	29	28	26
260	76	70	65	60	56	52	49	46	43	41	39	36	34	33	31	30	28	27
264	77	71	66	61	57	53	50	47	44	42	39	37	35	33	32	30	29	27
268	78	72	67	62	58	54	51	48	45	42	40	38	36	34	32	31	29	28
273	79	73	68	63	59	55	52	48	46	43	40	38	36	34	33	31	30	28
277	81	75	69	64	60	56	52	49	46	44	41	39	37	35	33	32	30	29
282	82	76	70	65	61	57	53	50	47	44	42	40	37	35	34	32	30	29
286	83	77	71	66	62	58	54	51	48	45	42	40	38	36	34	33	31	29
290	84	78	72	67	63	59	55	52	48	46	43	41	39	37	35	33	31	30
295	86	79	74	68	64	60	56	52	49	46	44	41	39	37	35	34	32	30
299	87	80	75	69	65	60	57	53	50	47	44	42	40	38	36	34	32	31
304	88	82	76	70	66	61	57	54	51	48	45	43	40	38	36	35	33	31
308	90	83	77	71	67	62	58	55	51	48	46	43	41	39	37	35	33	32
312	91	84	78	72	68	63	59	55	52	49	46	44	41	39	37	36	34	32

Underweight (under 19) | Desirable (19 to 25) | Increased health risk (26 to 29) | Obese (30 to 40) | Extremely obese (over 40)

Figure 3.1—Body mass index chart. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 242.

Energy Balance

Manage your weight by matching food intake to energy expenditure. Eat more when your energy expenditure is high—during the fire season, for instance. Eat less during the off season or increase physical activity to balance energy (caloric) intake with energy expenditure.



Waist-to-Hip Ratio

The waist-to-hip ratio (WHR) indicates visceral fat, which carries a greater risk of heart disease. To calculate, measure the waist at the level of the navel and hips at the greatest circumference. Measure to the nearest 0.25 inch or 0.5 centimeter, then divide the waist measurement by the hip measurement. WHR values above 0.85 to 0.9 for men and 0.75 to 0.8 for women exceed safe limits.

Figure 3.2—Waist-to-hip ratio. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 249.

A health-related fitness program can be pursued at the work site, in a commercial health club, or wherever the employee chooses. Health fairs and periodic tests can help keep employees motivated. While some organizations use incentives to encourage participation, long-term involvement depends on your intrinsic motivation, exercising because it is meaningful and essential for your health and quality of life.

Physical Activity and Health

Researchers at the Human Population Laboratory of the California Department of Health published a list of habits associated with health and longevity, including:

- Regular physical activity
- Adequate sleep
- A good breakfast
- Regular meals
- Weight control
- Abstinence from smoking and drugs
- Moderate use of (or abstinence from) alcohol

The study found that men could add 11 years to their lives and women could add 7 years by following any six of the seven habits.

Activity Recommendations

In 1995 the American College of Sports Medicine and the Centers for Disease Control recommended that every American should accumulate 30 to 60 minutes of moderate intensity physical activity most days of the week. Nine years later (2004) the Institute of Medicine extended this recommendation to 60 or more minutes of moderate activity in order to increase caloric expenditure and slow the growing epidemic of obesity. Now two-thirds of the adult population in the United States is overweight or obese.

The 2008 Physical Activity Guidelines for Americans, published by the U.S. Department of Health and Human Services, provides the following recommendations (*http://www.health.gov/paguidelines/faqs.aspx#Question5*).

- Adults should do 2 hours and 30 minutes a week of moderate-intensity, or 1 hour and 15 minutes (75 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic physical activity. Aerobic activity should be performed in episodes of at least 10 minutes, preferably spread throughout the week.
- Additional health benefits are provided by increasing to 5 hours (300 minutes) a week of moderate-intensity aerobic physical activity, or 2 hours and 30 minutes a week of vigorous-intensity physical activity, or an equivalent combination of both.
- Adults should also do muscle-strengthening activities that involve all major muscle groups performed on 2 or more days per week.

Those who use a pedometer should get at least 10,000 steps per day to meet the minimum activity recommendation. See appendixes A, B, G, H, and I to help you get started on a lifelong activity program.

Core Training

Core training focuses on the central portion of the body, providing a solid foundation for performance and health. Strong and balanced trunk muscles (abdominal, back, chest, shoulder, and hip muscles) allow workers to transfer power better when they're using their arms and legs. Well-trained core muscles distribute the forces of hard work, reducing the risk of injury. All employees should engage in a core training program (see appendix G for core training exercises).

Chapter 4—Wildland Firefighting

> **"In order that people may be happy in their work, these three things are needed: They must be fit for it. They must not do too much of it. And they must have a sense of success in it."**
>
> ***John Ruskin***

Many factors can make work difficult and stressful, such as the concentration required of air traffic controllers, the balance and agility required of steelworkers, or the ability to withstand the endless repetition required of assembly line workers. Energy expenditure and muscular requirements define physically demanding occupations, such as forestry field work and wildland firefighting. The energy demands of these occupations are classified as hard, very hard, or extremely hard work (table 4.1).

See table 4.1 for the energy requirements of firefighting tasks.

The muscular requirements of firefighting, as defined by the National Wildfire Coordinating Group (2009), include lifting more than 50 pounds. Firefighters carry loads up to 45 pounds (hose packs, water bags) and loads over 50 pounds (pumps). Smokejumpers may have to carry loads heavier than 100 pounds. The muscular demands of firefighting range from heavy to very heavy (table 4.2).

Long work shifts and the demands of the working environment combine to make wildland firefighting an extremely demanding occupation.

Table 4.1—Classifying work by energy expenditure.

Classification	Caloric cost (kcal/min)	Oxygen cost (L/min)	Examples
Light	less than 2.5	less than 0.5	Desk work
Moderate	2.5 to 5.0	0.5 to 1.0	Chores, repairs, walking
Hard	5.0 to 7.5	1.0 to 1.5	Using a chain saw, shoveling
Very hard	7.5 to 10.0	1.5 to 2.0	Chopping wood, digging
Extremely hard	More than 10.0	More than 2.0	Hiking uphill with a pack, jogging

Adapted from Dictionary of Occupational Titles, U.S. Department of Labor 1968 and Astrand and others 2003.

Table 4.2—Classifying muscular work.

Work classification	Lifting lb (kg)	Carrying lb (kg)
Very light	up to 10 (4.5)	Small objects
Light	up to 20 (9.1)	up to 10 (4.5)
Medium	up to 50 (22.7)	up to 25 (11.3)
Heavy	up to 100 (45.0)	up to 50 (22.7)
Very heavy	over 100 (45.0)	over 50 (22.7)

Adapted from Dictionary of Occupational Titles, U.S. Department of Labor 1968 and Astrand and others 2003.

The Worker

In 1960 men averaged 5 feet 8 inches tall and women averaged 5 feet 3 inches tall. Today, men are 1½ inches taller on average and women are 1 inch taller. The average weight of men increased from 166.3 pounds in 1960 to 191 pounds in 2002. The average weight of women increased from 140.2 to 164.3 pounds during the same time period. The average Body Mass Index (BMI), a ratio of weight to height, increased from 25 in 1960 to 28 in 2002. A BMI higher than 25 is considered overweight. A BMI higher than 30 identifies obesity, unless the waist measurement is under 40 inches for men and 35 inches for women. Recent data shows that 66 percent of adults over 20 years of age are overweight or obese. (National Center for Health Statistics: *http://www.cdc.gov/nchs/nhanes.htm*).

Hats or Caps

During the catastrophic fires of 1910, a seasoned ranger phoned Elers Koch in Missoula to request some firefighters. When Koch asked how many, the ranger replied:

"Send me 10 men if they wear hats, and if they wear caps, I'll need 30."

The respectable lumberjack always wore a felt hat, whereas the pool hall boys and general stew bums (hobos) usually wore caps and shoved their hands deep in their pockets (from "Year of the Fires" by Stephen Pyne 2001).

Aerobic Fitness

Also called maximal oxygen intake or VO_2 max, aerobic fitness is defined as the ability to take in, transport, and use oxygen. It can be reported in liters of oxygen per minute (liters per minute) or as milliliters of oxygen per kilogram of body weight (milliliters per kilogram-minute). Table 4.3 shows the average aerobic fitness for men and women.

Table 4.3—Average aerobic fitness (milliliters/kilogram-minute) for men and women from 20 to 69. Reprinted, with permission, from B.J. Sharkey and P.O. Davis, 2008, Hard Work (Champaign, IL: Human Kinetics), 15.

Men				
Age	Mean	+1 SD	+2 SD	+3 SD
20–29	43	50	57	64
30–39	42	49	56	63
40–49	40	47	54	61
50–59	36	43	50	57
60–69	33	40	47	54
Women				
Age	Mean	+1 SD	+2 SD	+3 SD
20–29	36	43	50	57
30–39	34	40	46	52
40–49	32	38	44	50
50–59	29	34	40	46
60–69	27	32	37	42

*SD or standard deviation is a measure of variability around the mean (average). Plus one standard deviation (+ 1 SD) includes 34 percent of the population, + 2 SD includes 47.5 percent, and + 3 SD includes 49.5 percent of the population. Men or women who are below average (-1, -2, or -3 SD) would not be fit enough for hard work.

Fitness Testing—Since 1975, wildland firefighters and fire managers have

been required to pass a work capacity test before the fire season. The current test is the Pack Test, a 3-mile hike with a 45-pound pack, which predicts aerobic fitness. Performance on the test is also correlated with muscular fitness. Firefighters must complete the hike in 45 minutes, predicting an aerobic fitness score of 45 milliliters/kilogram-minute. The energy demands of wildland firefighting exceed the capacity of the average man or woman. Applicants for firefighting jobs must be above average in aerobic fitness to meet the job requirement or they must train to improve their fitness by up to 25 percent or more.

Factors That Influence Aerobic Fitness

Several factors influence aerobic fitness, including heredity, age, gender, and training.

Heredity

Studies indicate heredity accounts for half of the variance in maximal aerobic fitness among individuals. The remaining variation is accounted for by environmental factors such as training and nutrition. The capacity of muscle to respond to training is also inherited, with improvements in aerobic fitness ranging from 5 percent to more than 30 percent for a given amount of training. Other inherited factors such as physique and body composition influence the potential to perform. Genes influence potential, but they don't assure it. The 30,000 genes that form the blueprint of the human body are subject to the influence of the environment and behavior. Genetic potential can only be realized when genes are switched on by training. The only way to realize your aerobic potential is to engage in training.

Age

Table 4.3 shows the decline in aerobic fitness with age. At age 60 the VO_2 max is about 75 percent of the level at age 20. The rate of decline approaches 8 to 10 percent per decade for inactive individuals, regardless of their initial level of fitness. Those who decide to remain active can cut the decline in half (to 4 to 5 percent per decade). Those who engage in fitness training can cut that rate in half (to 2 to 3 percent per decade, see figure 4.1).

Figure 4.1—Age and aerobic fitness. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 80.

Gender

The average aerobic fitness of young women is 10 to 20 percent lower than the average for young men. The VO_2 max and performance of highly trained young female endurance athletes are only 10 percent below elite males. One reason for the difference between genders may be women's lower hemoglobin levels. Hemoglobin is the oxygen-carrying compound found in red blood cells. The average hemoglobin levels for women are 2 grams per deciliter of blood below those of males. Total hemoglobin is correlated to VO_2 max and endurance. Other reasons for the differences between genders may be that women are smaller and have less muscle mass and more body fat on average than men.

A portion of the difference in fat between genders is sex-specific fat that is essential for reproductive function and health. For these and other reasons (such as the risk of developing osteoporosis), women shouldn't try to become too thin. We raise the issue only to explain why the average male has some advantage over the average female in aerobic fitness.

Studies and distance races show that women are well suited for fat-burning endurance events. Some women tolerate heat, cold, pain, and other indignities as well as or better than men. Although the average man has a small advantage in aerobic fitness, women can overcome that difference with training. The

physical demands of wildland firefighting are not related to age or gender, so the work capacity requirement does not change for firefighters of different ages or genders.

Factors That Influence Muscular Fitness

In 1980, MTDC conducted a large field study to analyze the relationship between muscular fitness and performance of firefighting tasks. Measures of strength and muscular endurance, as well as lean body weight, were significant predictors of work performance. Factors that influence muscular fitness include age, gender, and lean body weight.

Age—Strength peaks in the early 20s and declines slowly until about age 60. The rate of decline usually accelerates after age 60, but it doesn't have to. When strength is used, it hardly declines, even into the 60s.

Gender—Until 12 to 14 years of age, boys are not much stronger than girls. Afterward, the average male gains an advantage that persists throughout life. Studies show that untrained females have about half the upper body strength and two-thirds the lower body strength of males. The average male has 10 times more testosterone, an anabolic (growth-inducing) steroid, than the average female. Testosterone helps muscles get larger and stronger.

Body Size—Body size is a factor in hard work. Physically demanding occupations often require absolute capacities and performances. Absolute demands, such as being able to lift and handle heavy loads, place someone with a smaller lean body weight at a disadvantage. In wildland fire suppression, no mechanical aids assist the worker. To perform effectively, smaller firefighters may have to work harder than a larger employee, leading to fatigue and the potential for injury. Firefighters must be able to meet the physical demands of their occupation in a safe, effective, and appropriate manner to avoid risk to themselves, coworkers, and the public.

Lean Body Weight—Lean body weight or fat-free weight is the body weight minus fat weight. Lean body weight reflects an individual's muscle mass. Studies of wildland firefighters indicate that lean body weight is positively associated with performance of firefighting tasks and is associated with performance in lifting tasks. Individuals with a lower lean body weight may have to engage in muscular fitness training before the fire season.

Body Fat—Two-thirds of the adult population is classified as overweight or obese. Excess body fat does not contribute to work performance or strength, and it decreases aerobic fitness, endurance, and heat tolerance.

Small but Fit

After several seasons on a district fire crew, Rebecca, a 40-year-old mother of two, earned a spot on a hot shot crew. She was 4 feet 10 inches tall and weighed 95 pounds. On one fire, when the wind picked up and the crew was ordered to a safety zone, she had to jog to keep up with her long-legged coworkers. Fortunately, her excellent aerobic fitness kept her from slowing the crew's escape to safety. A less fit worker would have slowed the crew and increased the threat posed by the fire.

Lean body weight is significantly related to performance in lifting tasks. Those with more muscle can lift more. A weight training program will add pounds of muscle. Both weight training and aerobic training will help pare away excess fat.

The Available Workforce

The energy and muscular demands of wildland firefighting exceed the capacities of many untrained individu-

als. The national epidemic that has left so many persons overweight or obese further narrows the pool of available workers. Some applicants have no experience in physically demanding work or sport. To qualify for firefighting positions, many applicants will have to engage in muscular and aerobic training, lose excess body fat, and become hardened to the rigors of this physically demanding occupation. Crew bosses will have to teach work skills and help new firefighters gradually adapt to long work shifts.

"Send me 10 men if they wear hats, and if they wear caps, I'll need 30."

Chapter 5—Fitness for Firefighting

This chapter shows how muscular and aerobic fitness are related to performance in firefighting. We explain each component of fitness and describe how training improves work performance and reduces the risk of injury.

Aerobic Fitness

Studies of firefighters and other field workers confirm the link between aerobic fitness and performance. Fit workers accomplish more with less fatigue, and they perform better in hot environments. They cope with and recover faster from long shifts and reduced rest, and they miss fewer days of work because of illness and injury. In short, aerobic fitness is an important factor in prolonged arduous work. Table 5.1 shows the energy costs for common firefighting tasks.

Table 5.1—Energy costs of common wildland firefighting tasks. The energy costs are estimates for someone weighing 150 pounds. Add or subtract 10 percent for each 15 pounds above or below 150 pounds.

Wildland Firefighting Tasks	Energy Cost	
	cal/min	mL/kg • min
Using a handtool (for instance, digging or chopping with a Pulaski, combi tool, McLeod, or brush hook)	7.5	22.5
Lifting and carrying light loads (examples are clearing loose brush or trees, deploying or repositioning hose, throwing dirt with a shovel, firing operations, or structure protection)	6.8	20.0
Chain sawing (felling, bucking, limbing)	6.2	18.0
Packing heavy loads (pumps, hose packs, 5-gallon water bags)	7.5 (flat) 10.0 (hill)	22.5 29.4
Hiking with light loads (field pack and tools)	6.5	19.0
Performing under adverse conditions (including long work shifts; rough, steep terrain; heat, cold, altitude, smoke; insufficient food, inadequate fluid replacement, lack of sleep)	6.5–10+	19–30
Emergency responses (fast pull-out to safety zone, rescue, or evacuation assistance to others)	10.0+	29.4+
Chopping wood	7.5	21.4
Tree felling (ax)	8.5	25.0
Stacking wood	5.8	17.0
Shoveling	6.8	20.0

The body metabolizes fat and carbohydrate when producing energy during long periods of hard work. Aerobic fitness is defined as the maximal capacity to take in, transport, and use oxygen.

Aerobic fitness indicates the maximal capacity of the respiratory system (taking in oxygen), the circulatory system (transporting oxygen), and the muscles (using oxygen). Although the maximal oxygen intake (VO_2 max) is usually measured with a laboratory treadmill test, it can be estimated with simple field tests (see chapters 6 and 8).

When the body can't meet the energy demands of strenuous work with aerobic metabolism, it begins to use the limited supplies of anaerobic energy. Continued reliance on anaerobic energy rapidly leads to fatigue.

The two ways to measure aerobic fitness are aerobic capacity (liters per minute) and aerobic power (milliliters per kilogram-minute). Aerobic capacity is related to performance in cycling and rowing, while aerobic power is a better measure of performance when workers are carrying their own body weight, such as when they are hiking and climbing hills. But when workers are carrying a heavy load (70 pounds), performance is more related to aerobic capacity (VO_2), which defines the size of the engine. Now let's consider two additional dimensions of aerobic fitness: the first and second lactate thresholds.

Lactate Thresholds—Lactic acid is both an energy carrier and a metabolic byproduct of intense effort. Its accumulation is a sign that you are using energy faster than it can be produced aerobically. Too much lactic acid interferes with the muscles' capabilities. Lactic acid and the high levels of carbon dioxide produced during vigorous effort are associated with labored breathing, fatigue, and discomfort.

Blood lactate is a byproduct of anaerobic glycolysis. In a progressive treadmill test, going from a walk to a jog to a run—lactate rises slowly at first, then more rapidly (figure 5.1). The transition from slow oxidative muscle fibers to fast glycolytic fibers is associated with the increase in lactic acid.

The first lactate threshold (LT1) occurs at about 50 percent of your VO_2 max. The first threshold defines a level of exertion that can be sustained for several hours to all day, depending on its level. As you go from a jog to a run, you involve additional fast-twitch strength muscle fibers and produce more lactate.

The second lactate threshold (LT2) defines the upper reaches of aerobic metabolism. It is highly correlated to performance in competitive events (such as a 10-kilometer run) lasting from 30 minutes to 3 hours (Sharkey and Gaskill 2006).

VO_2 Max Test

Before taking the test, the subject should fill out a health screening questionnaire (see figure 2.1) and sign an informed consent form. The subject is fitted with electrocardiograph electrodes and a breathing valve that directs exhaled air to a metabolic analyzer. The test is conducted on a treadmill after a warmup at a speed dictated by the subject's level of fitness. The inclination of the treadmill is increased until the subject cannot continue or the subject's oxygen intake levels off. The maximal oxygen intake, or VO_2 max, measured in liters of oxygen per minute, indicates the subject's maximal aerobic capacity. Body size can be adjusted for by dividing VO_2 max by the subject's weight (in kilograms). This measure, in milliliters of oxygen per kilogram of body weight, is called aerobic power. It is correlated to the ability to perform arduous work.

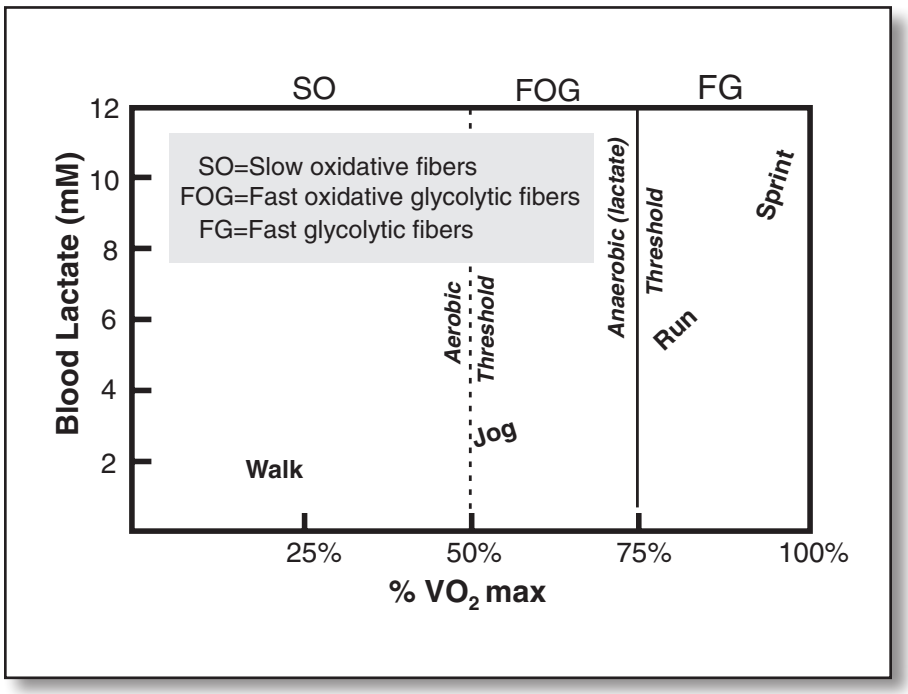


Figure 5.1—Lactate thresholds. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 73.

Training can raise VO_2 max and both lactate thresholds. Eventually the VO_2 max will plateau, but the lactate thresholds will continue to improve (figure 5.2). As training improves the muscle's oxidative capacity, more work can be done without an increase in lactic acid. The first lactate threshold defines the ability to perform prolonged arduous work. Individuals with an improved LT1 can sustain 50 percent or more of their VO_2 max for 8 hours or longer. If a worker has a VO_2 max of 50 milliliters/kilogram-minute, and his LT1 is 50 percent of his max, his VO_2 at LT1 is 25 milliliters/kilogram-minute.

Studies in the workplace indicate that LT1 defines work output in some physically demanding occupations. In a study by Gaskill and others (2002), wildland firefighters were divided into two groups: those with higher and those with lower levels of LT1. The firefighters were fitted with electronic motion sensors to determine work activity and sent out to work for 9 days on an actual fire. Those with a high LT1 had an average of 43.7 milliliters/kilogram-minute VO_2, while those with a lower LT1 had an average of 34.6 milliliters/kilogram-minute VO_2. Those with the high LT1 performed more work throughout the day. They sustained a higher work rate without feeling more fatigued (figure 5.3).

Sustainable Fitness—Steve Gaskill calls the VO_2 at LT1 "sustainable fitness." It defines the workload a firefighter can sustain throughout the working day. You can train sustainable fitness (LT1) by gradually increasing the duration of time spent at or somewhat above LT1. Of course, the training should involve the actual work or a close approximation.

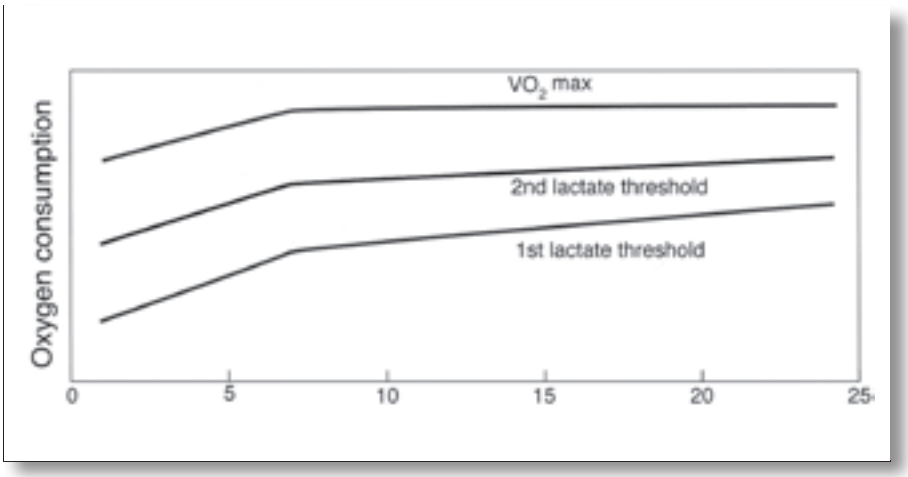


Figure 5.2—Improvements in VO_2 max and lactate thresholds.

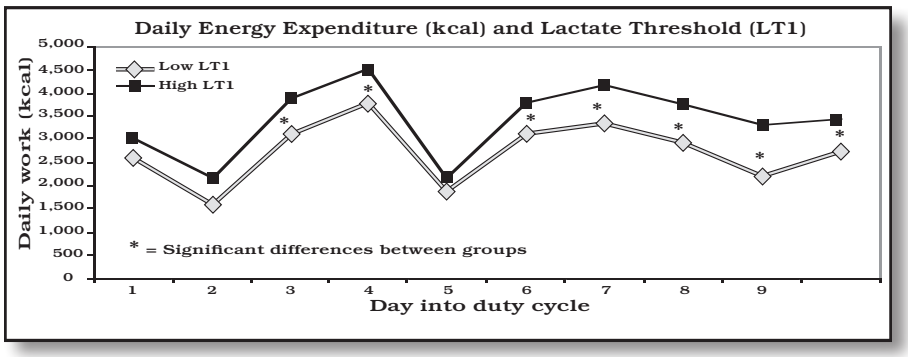


Figure 5.3—This graph shows the work (kilocalories per day) done by a hotshot crew over a 9-day period. The crew was divided into fit and less fit groups. The fit group did more work per day than the less fit group.

Dimensions of Aerobic Fitness

Aerobic fitness has several dimensions. Although each dimension has its own value, all of them can be determined in a single treadmill test.

Table 5.2—Measuring aerobic fitness.

Dimension of fitness	Measures	Best related to
VO_2 max (L/min)	Intensity	Aerobic capacity—short (5 to 15 min) cycling, rowing, or work with heavy loads
VO_2 max (mL/kg-min)	Intensity	Aerobic power—short (5 to 15 min) running, hiking
Second lactate threshold	Short duration	30-min to 3-h events (10 k to marathon)
First lactate threshold	Long duration	Prolonged work or sport (8 h or longer)

The first lactate threshold defines the level of effort that can be sustained for prolonged periods. Expressed as a percentage of VO_2 max, the lactate thresholds may be low or high, depending on the level of activity and training. All dimensions of fitness can be increased by training using the principles presented in chapter 7.

In the field, sustainable fitness is measured with sustained work. Wildland firefighters must pass the Pack Test, a 3-mile (4.8-kilometer) hike with a 45-pound (20.5-kilogram) pack, completed within 45 minutes. The energy cost of the test is the same as the work of wildland firefighting, so firefighters are asked to demonstrate the ability to sustain the workload for the time it takes to complete the 3-mile hike. Those who complete the test in less than 45 minutes demonstrate the ability to sustain a higher work rate. Completing the test in 45 minutes predicts a VO_2 max of 45 milliliters/kilogram-minute.

Efficiency—Another factor that has a significant impact on work capacity is a worker's efficiency or economy of motion. Efficient workers use less energy to accomplish a given task, allowing them to work at a lower percentage of their maximum capacity. Efficiency conserves energy and prolongs performance. With appropriate instruction and practice, workers can learn to use tools and accomplish tasks with a minimum of wasted motion. Efficiency can help compensate somewhat for differences in VO_2 max or the lactate thresholds. The ideal worker has a high VO_2 max and lactate thresholds combined with skill and economy of motion.

Muscular Fitness

Firefighters with more strength and muscular endurance are better able to carry the loads and use wildland firefighting tools than those who are not as fit. Muscular fitness protects against lower back and other overuse injuries and the accidents and hazards found in dangerous environments like the fireline. Muscular fitness also contributes to everyday life, allowing workers to perform their daily tasks with vigor and a greater margin of safety.

Muscular fitness is an essential part of the total health and fitness program. It:

- Maintains the muscle mass needed to burn fat
- Prevents or reduces the risk of lower back and other overuse injuries
- Maintains performance, mobility, and independence well into the retirement years
- Maintains bone density and reduces the risk of osteoporosis

The primary components of muscular fitness are strength, muscular endurance, power, and flexibility.

All these components contribute to work capacity. We will focus on explaining how strength, endurance, power, and flexibility aid work performance while lowering the risk of overuse and other job-related injuries.

Muscular strength is the ability to lift heavy objects; muscular endurance is the ability to lift smaller objects repeatedly, and power is the ability to do work rapidly, for instance, when swinging an ax.

Muscular Strength

Strength, the maximal weight that can be lifted by a specific muscle group, is highly related to the cross-sectional area of the muscle. While strength is influenced by heredity, it improves with training. Although strength declines slowly with age, it declines more slowly when muscles are used regularly. Strength training yields results, regardless of age.

The average woman has about half the arm and shoulder strength and three-fourths the leg strength of the average man. Part of this difference can be attributed to the difference in body weight between the average man and the average woman. When strength is expressed per unit of body weight, strength differences between the genders are reduced. Workers who need additional strength can safely engage in strength training to improve their ability to carry out field tasks. Women can reduce the "strength gap" by engaging in a systematic weight training program.

Strength is the primary factor limiting work capacity when heavy lifting is involved, when using heavy tools, or when heavy loads must be transported. Strength, muscular endurance, and aerobic fitness combine to set limits on work capacity for repeated lifting, when working with handtools, or when moderate loads are involved. Figure 5.4 illustrates how strength and aerobic fitness interact. The curves on the figure show combinations of work rate, workload, and aerobic fitness that can be sustained for prolonged work shifts.

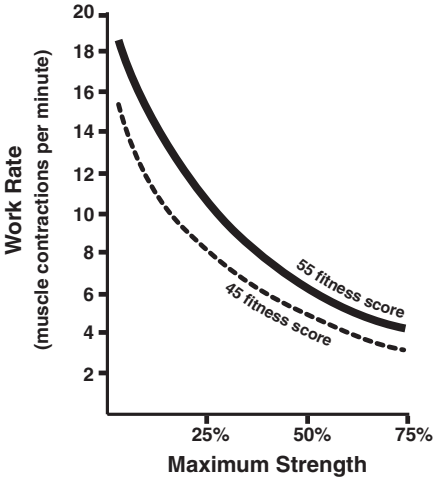


Figure 5.4—Relationship of strength and aerobic fitness. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 321.

For stronger individuals, a given workload constitutes a lower percentage of their maximum strength, allowing improved performance. The ideal combination involves above-average strength and aerobic fitness. For example, a worker with a VO_2 max of 55 can lift a loaded shovel using just 20 percent of maximal strength and will be able to sustain a work rate of more than 10 contractions (shovel loads) per minute. A worker with a VO_2 max of 45, for whom a loaded shovel constitutes 50 percent of maximum strength,

will be able to sustain less than five contractions per minute. Field studies of wildland firefighters verify these predictions.

Some workers may have high levels of aerobic fitness but relatively low muscular strength. They may compensate by lifting a lighter load more often. Similarly, strong workers compensate for low aerobic fitness by lifting heavier loads more slowly. Skillful workers use less energy to accomplish a task. The best production rates are accomplished by workers who possess above-average strength and muscular endurance, along with aerobic fitness, skill, efficiency, and experience.

How Much Strength?

How much strength do you need? For prolonged work, strength should be at least five times more than the load encountered on the job. Stated another way, the load shouldn't exceed 20 percent of maximal strength. For example, to wield a loaded shovel (10 pounds) for an extended period, firefighters should possess about 50 pounds of strength in the muscles being used. Once that level of strength is achieved, work capacity can be further enhanced by improving strength, muscular endurance, aerobic fitness, and skill (efficiency).

Muscular Endurance

Endurance is an essential component of work capacity. It defines the ability to keep working and is measured by the muscle's ability to lift a load repetitively. For many forestry field tasks, repetitive work with handtools is the name of the game. Training improves muscular endurance by improving the aerobic energy capabilities of the muscles used. Training enhances the action of aerobic enzymes and the capillary supply of specific muscle fibers. Training to improve work capacity must be specific to the task and muscles used (table 5.5).

Most work tasks require more endurance than strength. Once an individual has the strength needed to accomplish a task, training should focus on endurance. Endurance is developed with training that emphasizes repetitions. You'll find training advice in chapter 7.

Flexibility

Flexibility is the range of motion our limbs can move through. Skin, connective tissue, and conditions within joints restrict this range. Injuries can occur when a limb is forced beyond its normal range. Improved flexibility can reduce

Table 5.5—The strength-endurance continuum. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 153.

	Strength	**Short-term (anaerobic) endurance**	**Intermediate endurance**	**Long-term endurance**
For	Maximum force	Brief (2-3 min) persistence with heavy load	Persistence with intermediate load	Persistence with lighter load
Prescription	4-8 RM* (slow) 3 sets rest > 3 min	15-25 RM 3 sets rest 1-3 min	30-50 RM 2 sets rest < 1 min	Over 100 RM 1 set
Improves	Contractile protein ATP** and CP*** Connective tissue	Some strength and anaerobic metabolism (glycolysis)	Some endurance and anaerobic metabolism Slight improvement in strength (for untrained individuals)	Aerobic enzymes Mitochondria Oxygen and fat utilization
Doesn't improve	Oxygen intake Endurance	Oxygen intake		Strength

*RM = Repetitions maximum

**ATP = Adenosine triphosphate

***CP = Creatine phosphate

the potential for injury. While excessive flexibility isn't necessary, a certain amount helps workers get over, under, and around obstacles, lessening the risk of injury in most forms of vigorous activity.

Range of motion increases when joints and muscles are warm, so do some general physical activity before stretching. A few minutes of dynamic stretching (see appendix H) before work or sport improves flexibility and performance, reduces soreness, and could lower the risk of injury. Stretching won't prevent muscle soreness, but it does help reduce soreness. Use gentle stretching movements. Avoid vigorous bobbing, which tightens muscles as it invokes a reflex contraction in the muscle you are trying to stretch. Contracting the muscles briefly before a stretch allows more complete relaxation and a better stretch.

Stretching is important to maintain the range of motion during training. Lack of flexibility in the back and hamstring muscles contributes to lower back problems. Stretching may reduce the risk of repetitive trauma injuries. Attention to flexibility must be a lifelong pursuit if you are to maintain range of motion and avoid problems in your lower back.

Specificity of Exercise—Exercise and the effects of a particular kind of training are specific to the muscles and metabolic pathways used in the training. Firefighting and many field tasks require prolonged work with the arms. It is essential to train the muscles that will be used on the job. Untrained arm muscles may fatigue, even through a worker has a high VO_2 max based on a leg test and leg training. A high VO_2 max ensures the cardiovascular and respiratory capacity for work, but does not ensure specific training of the arm and trunk muscles used to perform prolonged arduous work with handtools. Athletes recognize the importance of specificity and follow general off-season training with sport-specific training as the season approaches. The same principles apply to firefighters and forestry field workers who should engage in job-specific tasks (shoveling, wood cutting) to prepare for work.

Muscle Soreness

The delayed onset muscle soreness that begins about 24 hours after your first exposure to vigorous effort may be due to microscopic tears in the muscle membrane or tissue. The soreness peaks several days after the first day of activity, then diminishes slowly. It can reduce strength and influence performance for 1 or 2 weeks. It is accompanied by swelling and leakage of enzymes from the muscle, but not by the accumulation of lactic acid, which is gone within an hour of exercise. Soreness is more likely after eccentric exercise, where the contracting muscle is stretched (lowering weights, downhill running). Soreness can be minimized with a gradual transition to weightlifting, starting with light weights. Static stretching of the affected muscles and the use of an anti-inflammatory drug can help relieve soreness. Soreness only occurs when you begin a new activity, but it may reoccur if you lay off for many weeks or do lifts with new muscle groups.

Muscle Fiber Types

Muscles have two primary fiber types, the slow-twitch fibers needed for endurance and the fast-twitch fibers needed for strength and power. Endurance athletes have more slow-twitch fibers, while strength or power athletes have more fast-twitch fibers. Firefighting requires both types of fibers. Slow-twitch fibers use energy and oxygen efficiently for sustained energy output. These fibers contract more slowly than fast-twitch fibers, producing less power. Wildland firefighting sometimes requires both strength and endurance (see table 5.6).

Table 5.6—Characteristics of slow-twitch and fast-twitch muscle fibers. Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2007, Fitness & Health, 6th ed. (Champaign, IL: Human Kinetics), 46.

Characteristics	Slow oxidative (SO)	Fast oxidative glycolytic (FOG)	Fast glycolytic (FG)
Average fiber percentage	50%	35%	15%
Speed of contraction	Slow	Fast	Fast
Force of contraction	Low	High	High
Size	Smaller	Large	Large
Fatigability	Fatigue resistant	Less resistant	Easily fatigued
Aerobic capacity	High	Medium	Low
Capillary density	High	High	Low
Anaerobic capacity	Low	Medium	High

The characteristics of these two fiber types are quite different. The optimal muscle for endurance can never be maximally strong or powerful. Likewise, the muscle fibers that produce the most force are not optimal for endurance. Training will tend to move muscle characteristics toward one type or the other. The fibers are quite different in their characteristics and how they respond to training. This difference in the fibers' characteristics requires specific training so wildland firefighters can develop adequate strength and the capacity for long-duration effort. In addition, firefighters need adequate strength and power for times when it is needed, such as when dragging a charged hose or when a smokejumper packs out 110 pounds of gear.

Fiber Types

Endurance Fibers—Slow-twitch fibers are smaller in diameter than strength fibers. The short distance between the capillaries, which carry oxygen, and the mitochondria, where oxygen is used, allows oxygen to be used efficiently. The network of capillaries is extremely well developed around the endurance fibers, further enhancing oxygen delivery. Endurance fibers have a high density of mitochondria where fuels are oxidized to form energy for contractions. Mitochondria are not packed as densely in strength muscle fibers, making energy production less efficient.

It's easier for endurance fibers to use fat as an energy source than for strength fibers to do so. Because fat is our primary source of stored energy for long-duration work, endurance fibers' ability to burn fat is a great advantage for wildland firefighters. Endurance fibers tend to burn carbohydrates fully, producing little lactic acid and enabling work to continue as long as carbohydrates and fats are available. Lactic acid is a byproduct of high-intensity work that, along with other factors, can limit the duration of work.

Strength Fibers—Fast-twitch fibers are larger because they have more contractile proteins. Their large diameter makes them stronger and more powerful than endurance fibers, allowing the fibers to shorten more rapidly. Because the size of the fibers makes it more difficult to deliver oxygen to the mitochondria, these muscle fibers produce more of their energy without oxygen (anaerobically). These fibers also do not metabolize fat very well because it takes a lot of oxygen to oxidize fat. Because fast-twitch fibers do not have enough mitochondria to fully use the lactic acid they produce, lactic acid builds up, limiting fast-twitch fibers' ability to keep contracting. While wildland firefighters may occasionally need strength and power, they couldn't work all day using strength fibers. The focus of training for wildland firefighters should be adequate strength with excellent endurance.

Fast Oxidative Fibers

When fast-twitch fibers undergo prolonged systematic endurance training they adapt metabolically, improving their ability to oxidize fat and carbohydrate. These hybrid fast-twitch fibers are called fast oxidative glycolytic fibers. However, fast-twitch fibers do not change into slow-twitch fibers.

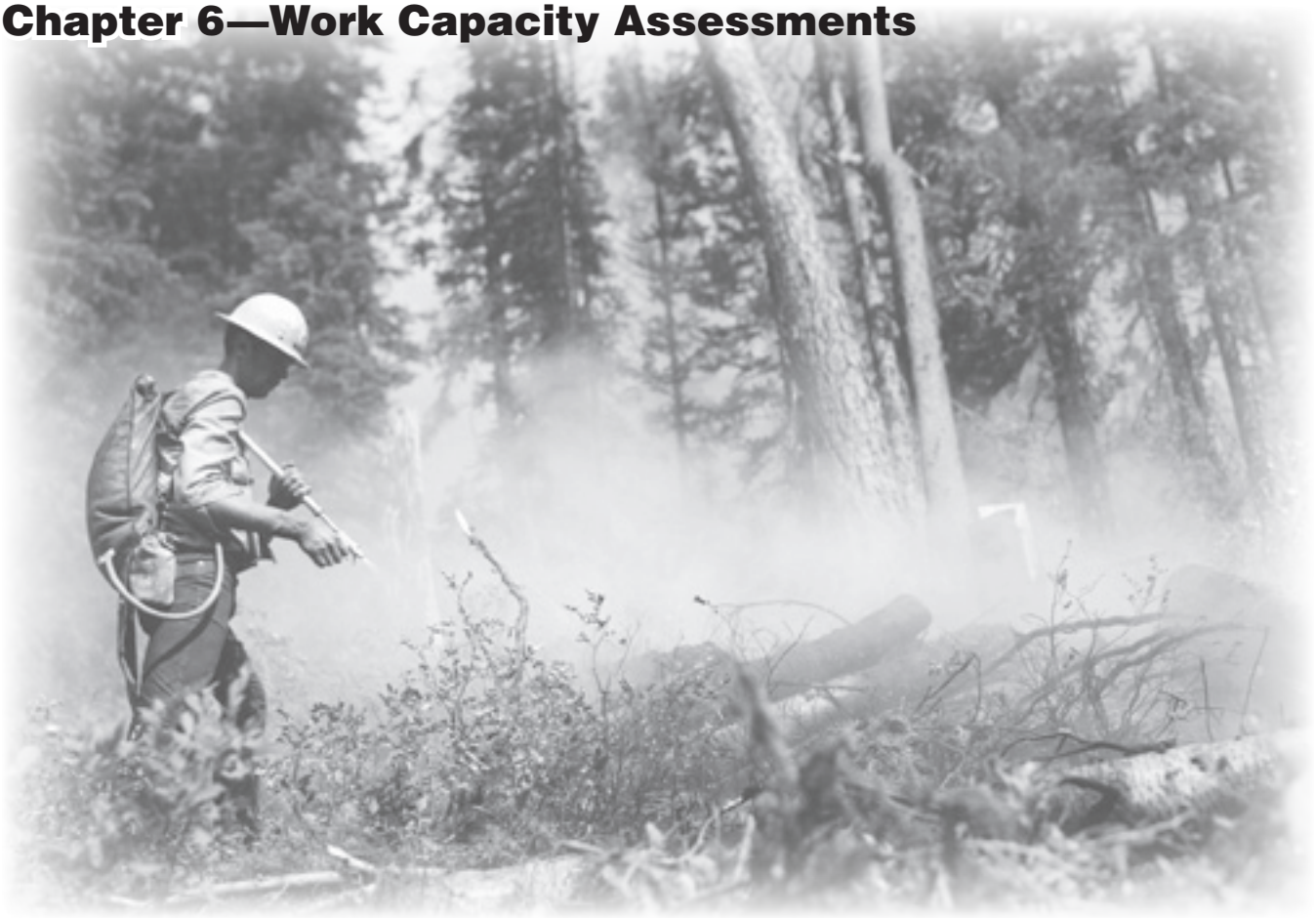
Muscle Proteins—The proteins actin and myosin allow muscles to contract. These proteins are more pronounced in the strength (fast-twitch) muscle fibers. Enzyme proteins in the mitochondria are needed for endurance. These enzyme proteins, which enhance the oxidation of carbohydrate and fat, are more pronounced in the slow-twitch muscle fibers. Strength training increases the contractile proteins in both types of fibers. Endurance training improves enzyme protein and the fibers' ability to produce energy from the oxidation of fat and carbohydrate. Since adaptations only take place in the fibers actually used in training, specific training is required for the tasks you will perform in the field.

Don't Call it Cardio!

Back in the 1950s, our knowledge of fitness was limited to the effect of training on the heart. Training led to a reduction in the resting and exercise heart rates, so it was called cardiovascular fitness. Then we began to understand the effect of training on oxygen intake and oxygen transport, so it was called cardiorespiratory fitness. And in 1967, a study of the effects of training on skeletal muscle fibers showed that training doubled oxidative enzymes and the muscle's ability to use oxygen. Since then, we have defined fitness as the maximal ability to take in, transport, and use oxygen.

The term 'cardio' describes one portion of aerobic fitness, but it ignores the important effects of training on muscle fibers. You don't become fit by raising the heart rate. Fitness training involves the systematic exercise of large muscle groups, not exercise just to raise the heart rate. Heart rate is sometimes used in training as a measure of oxygen utilization or exercise intensity. But skeletal muscle is the target of training; the role of the heart is to supply trained muscles with oxygen and energy.

Chapter 6—Work Capacity Assessments



> **"That a man must be physically sound for his work we know, but a standard of soundness has never been defined . . . It is urgent that a simple but effective method be used by all employing officers to ensure the rejection of the clearly unfit."**
>
> *Coert Dubois,*
> *U.S. Forest Service, 1914*

Work capacity is the employees' ability to accomplish production goals without undue fatigue and without becoming a hazard to themselves or to coworkers. Work capacity is a complex composite of aerobic and muscular fitness, natural abilities, intelligence, skill, experience, acclimation, nutrition, and motivation. For prolonged arduous work, fitness is the most important determinant of work capacity.

Work Capacity

Years ago, crew bosses assessed a worker's capability by observing performance in preseason training. Those who measured up made the crew; those who didn't were reassigned or let go. Today a series of employment laws and regulations (Federal Uniform Guidelines on Employee Selection Procedures) have emerged. Minimum work capacity standards were developed to ensure physical qualifications for the job (Wildland Firefighter Health and Safety Report No. 4, Sharkey 2001). Based on extensive laboratory and field tests, the National Wildfire Coordinating Group has approved work capacity standards (NWCG 2009) for personnel involved in arduous, moderate, and light duties. The duties include:

Arduous—"Duties involve field work requiring physical performance calling for above average endurance and superior conditioning. These duties may include an occasional demand for extraordinarily strenuous activities in emergencies under adverse environmental conditions and over extended periods. Requirements include running walking, climbing, jumping, twisting,

bending, and lifting more than 50 pounds; the pace of work typically is set by the emergency condition."

Moderate—"Duties involve field work requiring complete control of all physical faculties and may include considerable walking over irregular ground, standing for long periods, lifting 25 to 50 pounds, climbing, bending, stooping, squatting, twisting, and reaching. Occasional demands may be required for moderately strenuous activities in emergencies over long periods. Individuals usually set their own work pace."

Light—"Duties mainly involve office-type work with occasional field activity characterized by light physical exertion requiring basic good health. Activities may include climbing stairs, standing, operating a vehicle, and long hours of work, as well as some bending, stooping, or light lifting. Individuals almost always can govern the extent and pace of their physical activity."

Since 1975 firefighters have been required to take a work capacity test that determines minimum qualifications for wildfire suppression. Field tests now are used to assess work capacity (table 6.1).

Test performance is correlated to the aerobic and muscular demands of each category.

Table 6.1—Work capacity tests.

Category	Test	Distance (miles)	Pack (pounds)	Time (minutes)
Arduous	Pack	3	45	45
Moderate	Field	2	25	30
Light	Walk	1	0	16

The required work capacity standards for wildland firefighters, incident management personnel, field workers, and agency personnel are listed in table 6.2. Where no requirement exists, recommendations for aerobic and muscular fitness are provided also.

Instructions for administering the Pack, Field, and Walk Tests may be found in the Work Capacity Test Administrator's Guide (Whitlock and Sharkey 2003). Before the fire season, firefighters should train to meet the required and recommended levels of performance.

Table 6.2—Work capacity requirements and fitness recommendations.

Req. Required test Rec. Recommended test	Pack Test[1]	Field Test[1]	Walk Test[1]	3-Mile Packout Weight[2]	1.5-Mile Run Time	10 RM[3] Leg Press	10 RM[3] Bench Press	Pullups	Pushups	Situps
Wildland Firefighters										
Hotshots	Req.			Rec-60	Rec-10:30	2.5 x BW [4]	1.0 x BW	2	25	45
Rappellers	Req.			Rec-85	Rec-10:30	2.5 x BW	1.0 x BW	4	25	45
Smokejumpers	Req.			Req 110	Req 11:00	2.5 x BW	1.0 x BW	7	25	45
Other Hand Crews	Req.			–	Rec-11:40	2.0 x BW	0.8 x BW	5 mod.[5]	10	30
Incident Management[6]										
Arduous	Req.			–	Rec-11:40	1.5 x BW	0.8 x BW	4 mod.	10 mod.	25
Moderate		Req.		–	Rec-12:30	1.2 x BW	–	3 mod.	7 mod.	20
Light			Req.	–	–	1.0 x BW	–	–	5 mod.	15
None			Rec.	Health-related fitness recommended—see chapter 6						
Field Workers[7]			–	–	Rec-11:40	1.5 x BW	0.7 x BW	5 mod.	10	25
Agency Personnel[8]			Rec.	Health-related fitness recommended—see chapter 6						

1 - Pack, Field, and Walk tests - See Table 6.1

2 - The weight refers to the weight in a backpack that it is recommended (required for smokejumpers) that you are able to carry for 3 miles within 90 minutes.

3 - RM refers to "Repetition Maximum." The weights refer to a resistance that you are able to lift 10 repetitions. Multiply your body weight (BW) times the multiplier to determine your recommended standard.

4 - BW refers to body weight.

5 - Modified pullups.

6 - For classification see PMS 310-1 (National Wildfire Coordinating Group 2009).

7 - Field workers, such as trailworkers. Recommendations depend on the nature of the position. Compare with above categories.

8 - It is recommended that all agency personnel meet health-related fitness standards.

Wildland firefighting can be hazardous, with long shifts performed in difficult environmental conditions. When emergencies arise, a firefighter must be able to escape to a safety zone and may have to help others do so. Field studies show a high correlation (0.87) between aerobic fitness and the time it takes to reach a safety zone. The higher the level of fitness, the more rapid the escape (Ruby and others 2003). Pack Test performance predicts aerobic fitness; completing the test in 45 minutes predicts an aerobic fitness score of 45 milliliters/kilogram-minute.

Pack Test

Field studies of firefighters showed that performance carrying a load was highly correlated to performance on other firefighting tasks. Lab studies indicated that the energy cost of packing a 45-pound load was equivalent to the energy cost of firefighting tasks. A time of 45 minutes on a 3-mile test predicted an aerobic fitness score (max VO_2) of 45 milliliters/kilogram-minute, the minimum standard for wildland firefighters. In addition, performance on the Pack Test is significantly related to muscular fitness, including measures of upper and lower body strength. Finally, field studies of the test demonstrated that it did not discriminate—scores are not adversely influenced by gender, ethnicity, age, height, or weight. For more about the test development process, visit MTDC's Web site at *http://www.fs.fed.us/t-d/* Username: t-d, Password: t-d (see Wildland Firefighter Health & Safety Report No. 4, Sharkey 2001b).

Chapter 7—Principles of Training

> **"You have to do more than you are currently doing to get a training response."**
>
> ***Steve Gaskill***

Our muscles, bones, and connective tissues adapt to the stresses and loads that we put on them. This adaptability is a fundamental characteristic of tissues in general. In exercise physiology we refer to the acute (short-term) changes that occur during exercise as responses. For instance, heart rate and blood pressure respond to running. The long-term changes after many days, weeks, and years of training are called adaptations—genes in muscle fibers are 'turned on" to produce new proteins, the building blocks for new muscle tissue, or to produce enzymes for energy production.

No training plan can be designed that works for everybody. However, if you understand the basic principles of aerobic and muscular fitness training, you will be able to adapt the training programs outlined in chapter 8 and appendixes A through H to fit your needs and goals.

Overload and Recovery—We increase the load on a system (such as a muscle) to elicit a training response. The increased load (or overload) turns on genes in the cell to produce proteins, a form of adaptation. The adaptations seem to occur most rapidly during periods of recovery. Training (overload) must be coupled with periods of recovery. Training is a period of stress, recovery, and adaptation.

Overload—Overload can be from increased duration, intensity, or frequency of training. Because wildland firefighting assignments may require 14 or more days of long-duration effort, with occasional periods of high-intensity exertion, the programs in chapter 8 focus on developing muscular

strength and endurance to handle the rigor of wildland firefighting.

Recovery: Periods of lighter work and recovery are vital to effective training and are also important during extended periods of work. During periods of lighter work and recovery, adaptations occur.

Overtraining

If wildland firefighters don't take the time to recover after periods of extreme overload, their fitness, health, and work capacity may decrease. Additionally, they may become more susceptible to illness, become irritable, sleep poorly, and lose weight rapidly. These are signs of the overtraining syndrome first diagnosed in athletes. A simple morning "fatigue index" test can help monitor recovery. This test is described in appendix I. Firefighting crews might want to take a bathroom scale to fire assignments so they can monitor members' morning weights every few days. Rapid weight loss may be due to dehydration or overwork.

Patience—You can't get ready for the fire season in a few weeks. Preparation takes a sustained effort over several months, starting with training for muscular strength and moving toward increased endurance. The level of training and the time needed for preparation depend on each person's level of fitness. Regardless of your level of activity during the off-season, it takes at least several weeks to move from general fitness to the job-related fitness required for firefighting.

Specificity—How you train will determine your results. Fitness is specific to the muscles used, the speed at which they are used, the movements that are practiced, and the resistance and duration of the activities. There is no perfect substitute for a particular activity other than the activity itself. Digging line for long periods of time, extended hiking in rugged terrain with your line gear, chain sawing or swamping, laying hose and moving pumps, all require specific muscles, patterns of movement, adequate strength in specific areas, and endurance. Additionally, job-specific work hardens the body in other ways (work hardening) by toughening skin and strengthening supporting muscles (such as muscles in the body's core and finger flexors). In general, the training programs in appendixes A through H start with general training to improve muscular and endurance fitness and progress toward more task-specific fitness.

Most tasks in wildland firefighting require high endurance during job-specific tasks. The body must be able to take in and transport oxygen to the muscles and to use the oxygen in the muscles being trained. The only way to optimally develop the endurance of muscles is to train them by doing the activity.

Although the principle of specificity is a major component of training, we recognize that it is not possible to train specifically for wildland firefighting year around. Few of us can cut trees and dig line to train throughout the year, and those activities might not be appreciated should you try. Instead, the fitness programs recommended here start with general training, then move to more specific imitations of firefighting tasks. During the early fire season, training becomes very specific, gradually increasing the duration of tasks as firefighters become work hardened.

Reversibility—When we become less active, we lose the benefits of training. Different components of fitness are lost at different rates. A week in bed with the flu will result in a substantial loss in blood plasma volume, but little change in mitochondrial enzyme concentration and little change in capillary density. When you get back on your feet, a couple of training sessions will return blood volume and cardiac function to normal.

However, if you take 3 months off from physical activity while performing a

desk job during the off-season, you will lose much of the fitness gained during the previous months of training. If you are highly fit at the end of a fire season and don't maintain your fitness for 6 months, it may take another 6 months to regain it. Training adaptations are transient and depend on continued overload, recovery, and adaptation to maintain fitness. There is some evidence that people who have been highly fit and take a break seem able to return to high levels of fitness faster than those who have not been highly trained before.

Individual Responses—Training programs are usually designed for the average person. But heart size, muscle mass, bone density, muscle fiber type, fat distribution patterns, responses to training, and other factors vary from individual to individual. If a group shares the same exercise program, there will be large differences in their responses to the individual workouts and the overall training program. Some will improve their fitness by as much as 40 percent, while others will see minimal improvements. The same is true for wildland firefighters. Reasons for individual responses include genetics, maturation, nutrition, general health, and more. For instance, up to 50 percent of aerobic endurance may depend on genetics.

Some wildland firefighters can do very little training for 3 to 6 months, train for a few weeks, and be ready to go. Others are "slow responders" who seem to lose gains quickly and take many weeks to get back into firefighting shape. Some trainees can tolerate intense training to reach peak fitness. Others cannot tolerate the same workload, but reach similar performance levels if they intersperse more rest days. Here are some guidelines to help you adapt a training program, such as one of the programs in chapter 8, for you:

- Understand what training does to your body. Pay attention to what seems to be working, and what isn't. Know how your engine works. This will help you evaluate the effectiveness of different approaches to training.
- Pay attention to how you are feeling. On days when you are tired, listen to your body and give yourself time to recover. If you feel like you need to push harder, go for it—but, if you feel an activity is too hard, back off on the intensity.
- Learn and practice good technique for the tasks that you will be performing. The closer you get to the fire season, the more specific your training should become. Optimizing your technique will allow you to perform longer and more efficiently with less risk of injury.
- Keep a record of what you do and how you feel! A notebook and pencil are often good enough. Keep track of the results by testing yourself periodically (see chapter 6). If you keep records and adjust the programs in this book based on your results, you will have your own personal prescription for success.

The Training Plan

Training plans follow the "Frequency, Intensity, Time, and Type" (FITT) model for each workout. Successive workouts are planned to gradually increase the overload (progression) with daily, weekly, and seasonal variations. Training plans should follow the training principles: overload and recovery, patience, specificity, reversibility, individual response, and progression.

We have to do something extra to get a training response. Applying the overload principle regularly is the basis of a training program. How we overload is specified in terms of intensity of exercise, duration of effort, and frequency of effort. Once you specify the type of training activity, you have the

major components of a training program. Based on your current fitness and genetic makeup, you will have a training threshold; an intensity, duration, or frequency of effort that elicits a training response.

Generally, the minimum threshold for aerobic fitness is considered to be a heart rate about 60 percent of one's maximal heart rate: (220 – your age) x 0.6. For improving strength, the minimal threshold is about 66 percent of your current maximal strength.

Progression—As we become more fit, the minimum training threshold increases. We need to progressively overload. For instance, to prepare for the arduous work capacity (pack) test, the progression might include: walk 1 mile at a speed you can comfortably handle, increasing the distance over time to 3 miles. During this time you might have increased your frequency from twice per week to three times per week. Next, increase your walking speed to 4 miles per hour in 1 mile increments until you can walk 3 miles at this speed. Finally, start walking with progressively heavier packs until you can complete the 3 miles in 45 minutes with a 40-pound pack.

Does this mean that every training session should be above your training threshold and that you should increase the overload each workout? The answer is an absolute No! Training needs to be varied daily, weekly, and seasonally to allow for individual recovery. This principle of variability, which we call periodization, is important; individuals who ignore it may develop overtraining or overuse injuries. Activity below the training threshold is important to allow recovery and time for training adaptations to occur.

Varying Your Training

While athletes often use complex strategies to vary their training, some commonsense methods are easy to apply. Remember that periodization is variation in training, but the principle of progressive overloading still applies. Figure 7.1 shows gradual increases in overload with daily, weekly, and seasonal variations.

Daily Variation—The simplest form of periodization is to alternate hard days (overload above the minimum training threshold) with easy days (below the training threshold). The easy days are for recovery and to allow time for improvements in muscle strength (contractile proteins) or endurance (enzyme proteins).

Weekly Variation—It makes sense to alternate harder weeks with easier weeks. At the end of a hard week, you should feel tired. At the end of an easy week, you should feel rested.

Seasonal Variation—Each season will have a different training focus.

Recovery Period—This is a period of active recovery after the fire season. A number of research studies have shown that it is beneficial to take some time off from formal training after a long period of work or competition. This appears to be true for wildland firefighters and is a normal response to a

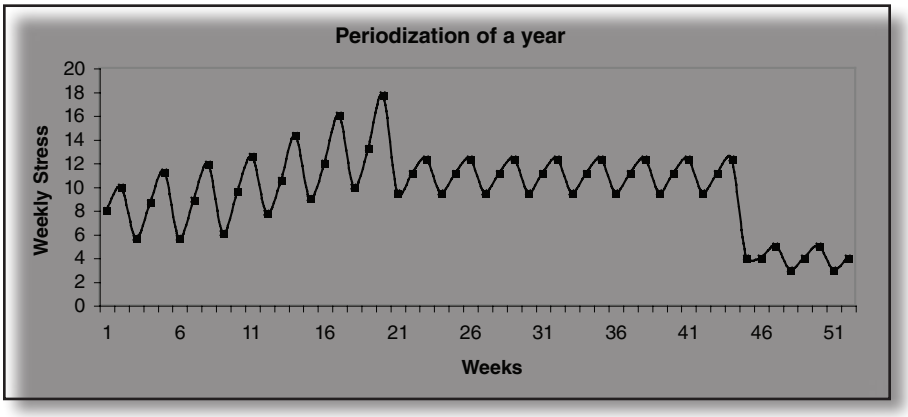


Figure 7.1—A generalized schematic of periodizing training before the fire season. Weeks 1 to 20 are shown as the training period. During this time there is a gradual increase in overload but with weekly variation. Within each training week a firefighter should also have easier and harder days. During the fire season the average work intensity will be lower than during the final weeks of training and, if possible, there should be daily and weekly variations in physical stress. After the fire season, physical activity may be reduced for several weeks of recovery before a new year begins.

long fire season. The duration of this period may vary, but is generally 2 to 3 weeks. This period allows your body time to recover, but won't be long enough to lose long-term fitness gains. During this time, most wildland firefighters will continue to participate in recreational activities that help maintain general endurance and muscular fitness.

After you have recovered, focus on maintaining and gradually increasing your fitness. We suggest moderate physical training 3 to 4 days a week. If you need to increase muscular strength or muscular endurance, this is a good time to start.

Preseason Period—This is the time to begin preparing for the upcoming fire season. The length of this season depends on the level of fitness you maintained during the off-season. In general, we suggest a 4-week period during which you gradually build both endurance and muscular fitness, beginning with nonspecific activities and moving toward physical training that is task oriented to prepare you to perform your job successfully.

Early Fire Season—This period includes the time when your crew is gathered together and begins formal physical training. Training will be task specific and include both physical and technical training. The length of this period varies greatly across crews, regions, and agencies. However, in all cases, crewmembers are expected to arrive with adequate endurance and muscular fitness to begin job-specific training. During this period, you will have extended periods of "work hardening" to prepare for the long, hard days of the coming fire season.

Fire Season—The duration of this period depends on the length and severity of the fire season, crew assignments, and agency policies. Maintenance of fitness and health during this period is discussed in chapter 9.

Chapter 8—Fire Season Fitness

The training programs in this chapter follow the principles of training discussed in the previous chapter, and are based on current research, including studies involving wildland firefighters.

The programs are designed to meet the fitness needs of all wildland firefighters, from incident management team members to line personnel. Because every individual has different needs, different fitness levels, and responds differently to training, programs should be adjusted to each individual's needs.

To simplify the organization of the training programs, we start with overall goals for five groups of firefighters with similar fitness needs, then briefly discuss seasonal goals and training programs for each group within the wildland firefighting community. Training program details are found in appendixes A through H.

Fitness and Work Capacity Goals

Each group of firefighters has overall fitness and work capacity goals (table 8.1) and specific goals for four periods of the year (table 8.2).

Table 8.1—Fitness goals for wildland firefighters.

Group	Fitness tests*	Fitness and work capacity goals
Personnel not required to pass a work capacity test	None required.	Maintain health, body weight, and fitness to carry out daily tasks with vigor and alertness, with ample energy to enjoy leisure pursuits, and to meet unforeseen emergencies.
Incident management team members	Safely complete the required work capacity test for your category (Walk, Field, or Pack Tests).	Maintain health, body weight, and fitness to carry out daily tasks with vigor and alertness, with ample energy to enjoy leisure pursuits and to meet unforeseen emergencies.
Supervisory personnel who work on or near the fireline	Pass moderate or arduous work capacity (Field or Pack Tests) and other fitness assessments (recommended).	Hiking endurance (with pack). Maintain health, body weight, and fitness to carry out daily tasks with vigor and alertness, with ample energy to enjoy leisure pursuits and to meet unforeseen emergencies.
Type II firefighter and other field personnel (such as trail crew members)	Pass arduous work capacity Pack Test (required for WLFF) and other fitness assessments (recommended).	Fitness for job-specific tasks, including upper and lower body endurance and strength. Basic tasks include line digging, cutting, swamping; hiking with pack; pump and hose work; mopup and related activities.
Type I firefighters: smokejumpers, rappellers, and hotshots	Pass arduous work capacity Pack Test (required) and other assessments required or recommended in table 6.2.	Fitness for job-specific tasks, including upper and lower body endurance and strength plus crew-specific needs such as jumping; let down; pack-out; line digging, cutting, and swamping; hiking with pack; pump and hose work; mopup and related activities.

*For complete fitness test requirements and recommendations see table 6.2.

Table 8.2—Seasonal fitness goals for wildland fire personnel.

Group	Recovery	Preseason	Early fire season	Fire season
Personnel not required to pass a work capacity test	Maintain health, body weight, and the fitness to carry out daily tasks with vigor and alertness, with ample energy to enjoy leisure pursuits and to meet unforeseen emergencies.			
Incident management team members	Meet activity goals for health and weight management.	Gradually improve fitness to safely pass required work capacity tests and for health and weight management.	Continue fitness, health, and weight management programs.	Maintain fitness for health and weight management. Develop healthy fire camp eating habits.
Supervisory personnel who work on or near the fireline	Meet activity goals for health and weight management, and for muscular and aerobic fitness.	Improve fitness to meet job requirements and pass work capacity tests. Focus on the ability to hike with a moderate pack.	Longer hikes in hills and rough terrain. Job-specific fitness training for tasks that you expect to perform.	Maintain fitness through job-related tasks, and if necessary, through physical training. Monitor health, fatigue, and body weight.
Type II hand crews and field workers (such as trail crewmembers)	2 to 4 weeks of unstructured activity to recover from the previous fire season. Then resume training, moving from general to more specific tasks as the season approaches.	Increase hiking and long-duration activities with some specificity. Begin resistance training specific to job tasks that you will perform (appendix F). Begin preparation for the arduous work capacity Pack Test.	This period involves crew training, moving toward job-specific tasks and increasing the duration of the tasks, including hiking with a pack, line digging, saw work, swamping, and pump and hose work.	Maintain fitness through job tasks and periods of recovery. If possible, work days should be varied with an easier day after every 1 to 3 hard days. Monitor health and fatigue. If necessary, include job-specific training or project work to maintain fitness.
Type I firefighters: smokejumpers, rappellers, and hotshots	2 to 4 weeks of unstructured activity to allow recovery from the fire season. Resume training, moving from general to more specific tasks as the season approaches.	Increase hiking and longer duration activities with some specificity. Begin resistance training activities specific to the job tasks that you will perform. Before the early season, engage in tasks including line digging, chain saw work, swamping, and focus on the strength tasks (such as self rescue from tree landings for smokejumpers).	This period may involve 1 to 2 hours a day of physical training for job-specific tasks, gradually increasing the time spent on tasks such as hiking with a pack, line digging, saw work, swamping, and pump and hose work. Muscular fitness training should be continued with a core training program (appendix G).	Maintain fitness through job tasks and periods of recovery. If possible, work days should be varied with an easier day after every 1 to 3 hard days. Monitor health and fatigue.

Where To Begin?

Inactive individuals are more than 50 times as likely to experience a heart problem during exertion as individuals who have been active. Anyone who intends to take any of the work capacity tests or begin fitness training should become active before they begin training. Inactive individuals should undertake a 4- to 6-week walking program, slowly increasing the distance and their pace until they can walk 3 miles in 45 minutes. Those who are older or have been inactive for a long time may need to walk for more than 4 to 6 weeks before becoming more active. See your physician or complete a health screening questionnaire before beginning vigorous activity (see figure 2.1). Then use the Walk, Walk-Jog, and Jog-Run Tests to determine your fitness level. Read through the tests and decide which program is appropriate for you (appendix A).

Walk Test—Walk at a brisk pace (3.5 to 4 miles per hour) for 10 minutes.

- If you cannot walk at a brisk pace for 5 minutes, begin with the Red Walking Program.
- If you can walk for 5 minutes but can't walk for 10 minutes, begin with the third week of the Red Walking Program.
- If you walk the full 10 minutes but are somewhat tired, start with the White Walk-Jog Program.
- If 10 minutes is easy, and you have done some jogging, wait a day after trying the Walk-Jog Program and take the Walk-Jog Test.

Walk-Jog Test—Alternately walk 50 steps (left foot strikes the ground 25 times) and jog 50 steps for 10 minutes.

- If you can't complete 10 minutes, begin with week three of the White Walk-Jog Program.
- If you can complete 10 minutes but feel tired and winded, begin with week four of the White Walk-Jog Program.
- If you complete the Walk-Jog Test comfortably, you can take the 1.5-mile Run Test or start the Blue Jogging Program.

1.5-mile Run Test—This test is a 1.5-mile run, pacing yourself as fast as possible for at least 1 mile, but preferably for the entire distance.

On a track, complete a warmup by walking and jogging until you feel ready to go. When ready, start the 1.5-mile run test (figure 8.1).

- If you can complete 4 laps (1 mile) under 11:45 (11 minutes and 45 seconds), start the Blue Jogging Program at week 4.
- If you can complete 6 laps (1.5 miles) under 17:36, start the Blue Jogging Program at week 6.
- If you can complete 6 laps (1.5 miles) under 17:30, begin any of the following programs:

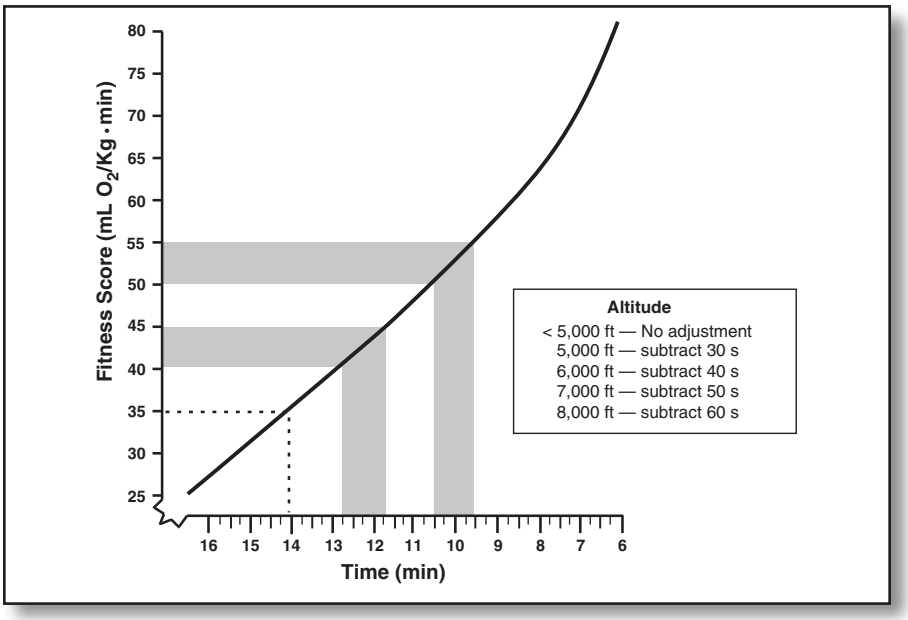


Figure 8.1—The 1.5-mile Run Test.

- Training for the work capacity tests (Walk, Field, or Pack).
- General fitness for incident management team members.
- General off-season maintenance program for all fireline personnel.

Once you have completed the tests, you can determine the appropriate training program for each season of the year, based on your fitness level and job requirements. See the appendixes to select the appropriate training programs.

Muscular Fitness Training

Wildland firefighting is primarily an endurance activity with occasional short periods of high-intensity work. Muscular fitness training focuses on developing muscular endurance rather than large increases in strength. However, many firefighters will need to improve strength as well as muscular endurance. Early in the off-season, begin strength training two to three times per week. Increase weight while reducing repetitions to between four and eight. Have a spotter help when you are lifting heavy weights.

The recommendations are based on the idea of repetition maximum (RM). The RM is the number of repetitions you can do with a weight before you are unable to continue in good form. A 12-RM set is a series of 12 repetitions with the 11th and 12th repetitions becoming very difficult. Table 8.3 shows general guidelines for muscular fitness training.

Specific exercises for resistance training are listed in appendix F. Core training exercises are listed in appendix G.

Table 8.3—Guidelines for muscular fitness training.

Desired Outcome	RM[1]	Rest[2]	No. Sets	Speed[3]	Frequency[4] (per week)
Muscular fitness[5]	10-15	1-2	2-3	Moderate	2-3
Strength	1-6	>3	2-3	Slow	3-4
Power	8-12	>3	2-3	Fast	2-3
Muscular endurance	15-30	<1	2-3	Moderate	2-3

[1]RM stands for repetition maximum, the number of repetitions that can be completed in a set before you are unable to continue in good form.

[2]Rest is minutes of rest between sets.

[3]Speed is speed of movement. Heavier weights are generally moved slowly. The development of power requires fast movements and moderate weights. Often, specialized equipment is required.

[4]Frequency is the number of sessions each week. Be sure to rest at least 1 day between sessions.

[5]Maintenance program.

To Gain Weight

Some workers can improve work performance and safety by following an off-season strength and weight-gain program designed to add muscle, not fat. These workers will focus on strength training while cutting back on aerobic training. They should make sure they get enough energy and high-quality protein in their diet. We recommend consuming 750 calories more than normal on weight training days, and an extra 250 calories on nontraining days. This plan could lead to a weight gain of almost 1 pound per week. If you try to gain weight more rapidly, much of it will be in the form of fat.

For more information on aerobic and muscular fitness training, see "Fitness and Health" (Sharkey and Gaskill 2007), "Sport Physiology for Coaches" (Sharkey and Gaskill 2006), and the Fire Fit Program (*http://www.nifc.gov/firefit/fitness.htm*).

Flexibility

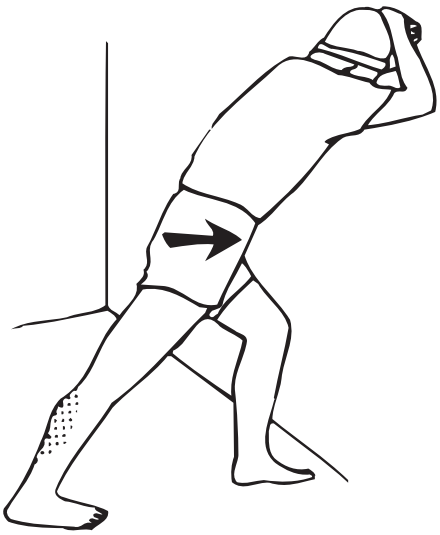
Flexibility enhances sustained work capacity and reduces the risk of injury. Flexibility decreases with age and inactivity. Some work-related injuries may be more likely with decreased flexibility. Lower back problems are associated with poor flexibility, especially problems related to the hamstrings and weak abdominal muscles.

For effective stretching, warm up a bit with light exercise or calisthenics. Finish the warmup with more vigorous effort, such as jogging, before stretching. During the fire season, stretch after hiking to the fireline and again at the end of the work shift before you cool down.

Static stretching involves a slow movement to reach the point of stretch, holding the position (5 to 10 seconds), and relaxing. The stretch may be repeated, and very light bobbing may be employed.

Contract/relax is a variation of the static stretch. Do a static stretch, relax, then contract the muscle for a few seconds. Repeat the static stretch. When performed on muscles like those in the calf, the technique seems to help the muscle relax so you can better stretch the tendon.

Dynamic stretching involves stretching in work-specific motions. It improves range of motion in movements related to the job. Dynamic stretching may reduce the risk of injury.



Do your stretching routine when training or firefighting. Specific exercises for flexibility can be found in appendix H.

Chapter 9—Maintaining Fitness and Health

Field work and firefighting are not without risks. We must do all we can to prevent illness and injuries, to treat firefighters properly if they are injured or ill, and to ensure the firefighters' successful return to work. This chapter will help firefighters prepare for the fire season and maintain their fitness and health during the fire season.

Maintaining Fitness

Staying fit during the fire season requires working or training to maintain the strength and endurance for normal tasks, with adequate reserve to meet extraordinary demands such as escape. Some firefighters, such as incident management team members and fire camp personnel, may face special challenges when trying to maintain their fitness for specific jobs.

Incident Management Team and Camp Personnel

For overhead crews and those primarily stationed in a fire camp, the fitness challenge during the fire season is scheduling daily activities to manage stress and to maintain basic fitness, health, and weight control. This may be especially challenging given the large servings at the catering trailer, hot weather, busy schedules, and uninviting conditions for physical activity.

Team members must find time to walk briskly, accumulating 60 minutes a day of moderate activity equivalent to brisk walking. Exercise periods can be as short as 10 minutes and don't require changing into training clothes. A walk around the camp every hour or two will do, as would 15-minute walks in the evening after dinner or during breaks. Research studies show that short activity breaks improve productivity and promote healthy hearts.

Fire camp personnel should consider using one of the training programs in appendix A to maintain their fitness. While a more formal aerobic program will require dedicated fitness time, it may be possible to stay fit by performing tasks around the fire camp that require physical labor or by hiking or jogging.

Supervisory Personnel Who Work on or Near the Fireline

If your job requires hiking in the fire area, you need to maintain fitness throughout the fire season so you can hike effectively while carrying line gear. If you spend a lot of your time driving while working at a fire, you may become less fit for your duty at future fires, where arduous hiking may be required. You also need to maintain a fitness reserve in case you need to escape or help others do so.

There is no substitute for hiking. Sometimes you may have to supplement your standard hikes with jogging 2 to 3 days a week. Or you may have to hike in the hills more than your duties require. To maintain reasonable aerobic fitness, spend 30 to 40 minutes 3 days each week hiking briskly, walking at an easier pace the rest of the week.

Type II Hand Crews and Other Outdoor Work Crews

During most duty cycles, your work will maintain or even increase your fitness and improve your ability to keep working. However, you may have assignments that don't require heavy labor or you may have a number of weeks between fire assignments. To maintain your aerobic and muscular fitness, find some time for physical training, including running and upper body work. The startup program in appendix A works well.

The simplest way to maintain fitness is to be sure that you find a job that you would classify as moderately hard to hard or train for 40 to 60 minutes every other day. The more job specific the task, the better. Many fit individuals have lost their fitness during light fire seasons.

Type I Crews, Including Smokejumpers, Rappellers, and Hotshots

The optimal way to maintain fitness is to alternate 1 to 3 days of hard work with 1 to 2 days of lighter work. If you work extended hard shifts for too many days in a row, your body may begin to break down. Your fitness and performance (as well as your safety) will suffer. If you have too many light days in a row, your fitness will also suffer.

In many ways, smokejumpers have the perfect job for optimal fitness. When smokejumpers perform initial attack, they work long, hard days for 2 to 4 days, then come back to the smokejumper base for a few days off before the next fire jump. During slow periods, they have time for physical training.

For all Type I crewmembers, maintaining fitness specific to the job is vital. Crew bosses need to cycle the work, whenever possible, making sure that their crews have an easier day or two after 2 to 3 days of hard work. When crews have extended periods of light work, crewmembers need to do physical training or find jobs to maintain their fitness. The ability of the human body to adapt is amazing: fitness is lost when work decreases and regained when work increases.

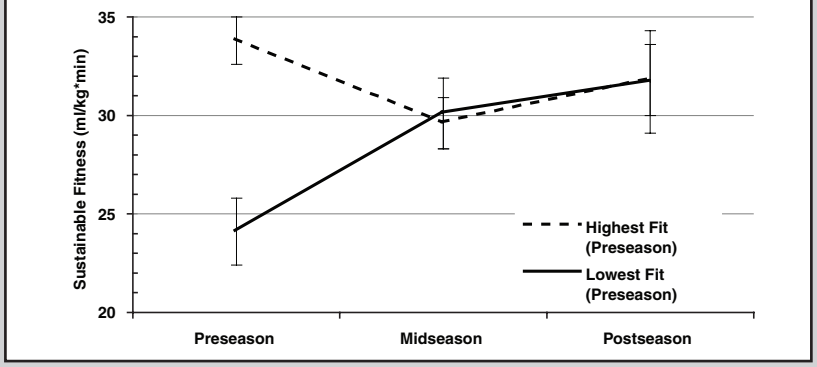


Figure 9.1—A study that followed a Type I crew over the course of a fire season showed that the fittest members of the crew actually lost aerobic fitness over the first half of the season, while the least fit members improved, until all crewmembers had reasonably similar levels of fitness. One of the last fires of the season required greater fitness with lots of steep hiking, line digging, and long days. Many members of the crew regretted they were not as fit then as they had been earlier in the season (sustainable fitness is the maximum day-long work rate).

Maintaining Health

Hard, Then Easy

While it is rarely possible to control work duties on a fire, whenever possible the duties should be cycled so crewmembers have an easier recovery day for every 1 to 3 days of hard work. Crew leaders, division supervisors, and incident management team members should try to cycle work intensity to maintain crew safety, function, and health. Studies show that crews who practice this principle have missed fewer days of work and have been more effective than crews who become overfatigued.

Figure 9.2 shows the complex relationship between daily work and increases in the fatigue index (resting + exercise + recovery heart rates) between the fitter firefighters (dark dashed line) and the less fit group (dark solid line). Activity monitors worn throughout the period allowed the total energy expended each day to be estimated. Energy expenditure was very high (more than 3,800 kilocalories per day) for 5 days out of 6.

The fatigue index on the morning of day 6, after the easier activity on day 5 (1,800-kilocalorie energy expenditure), was just slightly elevated in both groups (lower and higher fitness), suggesting that the crew had recovered overnight. Both groups had high fatigue indexes on the 9th morning, after high-intensity work on days 6, 7, and 8, showing that they had not recovered.

Activity was moderate on day 9 (2,850 kilocalories). The following morning, the fitter group had nearly recovered to baseline levels on the fatigue index, while the less fit group appeared to remain fatigued. The less fit group also had significantly depressed levels of salivary IgA on the morning of day 10.

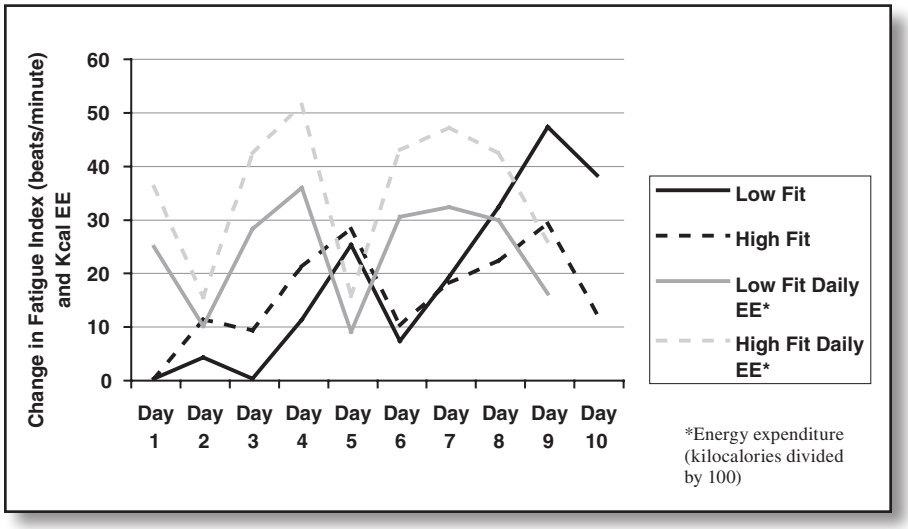


Figure 9.2—Fatigue index and energy expenditure (EE).

Eating and Hydration

Supervisors can make food and drink available, but the firefighters themselves are responsible for making sure they eat and drink enough. Firefighters who aren't doing so can be a hazard to themselves and their coworkers. Supervisors should schedule fluid replacement every 30 minutes during hot conditions and workers should eat frequently. On very hot days, firefighters may need to drink up to a quart of water an hour. When firefighters are drinking a lot of water, it's best if they drink an occasional sport drink containing electrolytes.

The old adage "Drink Often" should be replaced with the new adage "Eat and Drink Often." MTDC studies, as well as military studies, have shown that workers who eat regularly (about 40 to 100 kilocalories every hour) are able to do as much as 35 percent more work during the last 2 hours before lunch and at the end of the day (and recover better before the next shift), think clearly (and presumably be safer), maintain their blood sugar and immune function—and they feel better (figure 9.3).

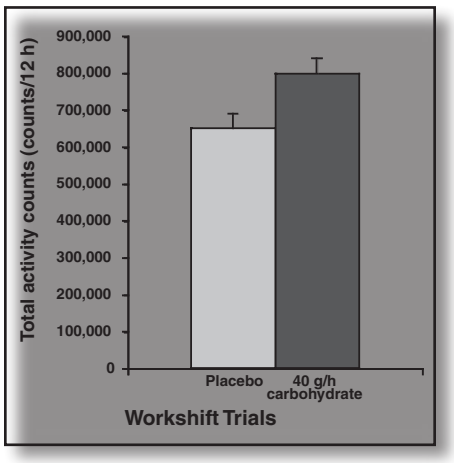


Figure 9.3—Firefighters who eat regularly during the day are able to consistently work harder during the few hours before lunch and late in the day. This figure shows the total work activity (measured by activity counts) for the entire day with and without regular snacking. Total daily work increased the equivalent of 1.75 extra hours each day when firefighters received 40 grams of carbohydrate per hour.

Fitness

Workers with higher aerobic fitness do more work (figure 9.4), recover more quickly, and are better able to handle their jobs without compromising their immune function. Proper preparation during the off-season will reduce injury and illness.

Maintaining Weight—While most fire crews and incident management teams do not bring a bathroom scale with them, checking weight each morning is a good way to ensure that firefighters are maintaining hydration. Gradual weight loss during fire assignments can indicate the firefighters are not eating enough or that they're not drinking enough fluid.

Check the color of your urine in the morning. If the urine is dark, you need to drink more. If your urine is normal and you're losing weight, eat more, especially during the shift. Rapid weight loss almost always indicates dehydration.

Fatigue—Exhaustion makes firefighters more susceptible to upper respiratory infections. To prevent fatigue, maintain fitness, eat enough, keep hydrated, take frequent breaks, and get enough sleep.

Hand Washing, Water Bottles, and Cleanliness

When you are living in a crowded fire camp, or even when you are spiked out with your crew, be careful not to spread germs. Wash your hands before meals or before handling food. Don't share water bottles. If you share water, pour the water from one water bottle to another. Studies have found high concentrations of bacteria and other micro-organisms in water bottles that are not regularly washed. Firefighters who use sipping hydration systems need to wash the reservoirs, hose, and mouthpiece. To avoid encouraging the growth of micro-organisms, never mix flavored beverages containing sugar in sipping hydration systems (see "Hydration Strategies for Firefighters," Domitrovich and Sharkey 2008).

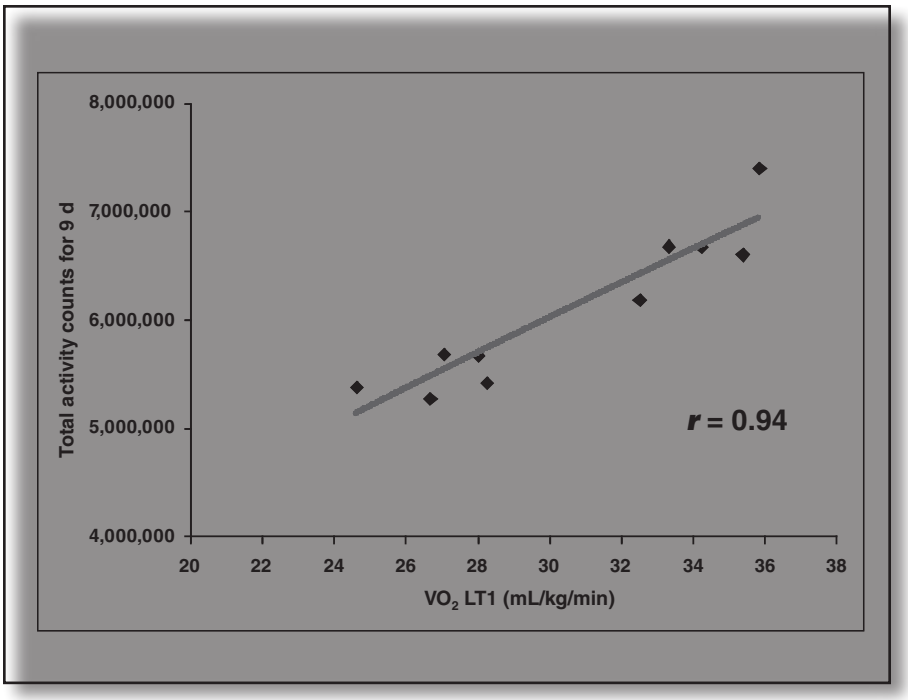


Figure 9.4—Aerobic fitness (VO_2 LT1) and work output (measured by activity counts). The firefighters' first lactate threshold (LT1) is an indication of sustainable fitness.

Preventing Illness and Injury

Work Hardening

Work hardening uses a gradual progression of work-specific activities to bring you to the job ready to deliver a good day's work. While training provides the foundation for fitness, training is no substitute for job-specific work hardening. Work hardening ensures that the muscles and connective tissues used on the job are tough and ready to go. Feet are hardened when you hike and work in the boots you'll use in the field.

Hike up and down hills and on sidehills at the pace you'll use on the job. Do some extended hikes with a loaded pack to prepare your back and shoulders for carrying loads. Test legs and boots on steep uphill climbs.

Feet, hands, back, joints, and muscles need to adjust to prolonged arduous field work. The early season training programs in chapter 8 incorporate examples of work-specific training. Using tools frequently during the off-season will improve your readiness. Blisters, sprains, strains, and muscle soreness are indications that you need more work hardening.

If you will be building fireline, do some work with a handtool like the Pulaski to prepare trunk and upper body muscles for prolonged work in the position the tool demands. This work will also toughen your hands so you won't get blisters the first day on the job. Come to the job hardened and ready to go, but be prepared to treat blisters and other problems that hinder performance.

Crew Bosses—Make Time for Work Hardening

When crews report for duty at the start of the season, crew bosses should plan time for job-specific work hardening as suggested in the early fire season training goals (chapter 8). Schedule training and project activities that prepare workers for the job and the environmental conditions they will face. Gradually increase work rate and duration.

Take frequent breaks. Provide instructions on tool use during the breaks. Change tools often to avoid fatigue and to cross train workers on your crew. Watch for signs of overuse injuries, heat stress, or other early-season problems. During this period, you can focus on developing good habits—including safety awareness, hydration, and nutrition—while building crew morale, cohesion, and teamwork.

During the fire season, crew bosses should pay attention to signs of fatigue in each crewmember. Try to vary each member's work so they have at least 1 easier day for every 1 to 3 days of extended hard work. Fit workers tend to recover faster and experience less fatigue, but they may also work harder. Vary the work, the duration, and the intensity whenever possible.

Blisters

Blisters are a major cause of discomfort and lost work time. Blisters form when friction separates layers of skin, allowing fluid to accumulate between them.

For feet

- **Fit new boots to your feet (some firefighters put on a new pair of boots, get them thoroughly wet, and wear them until they dry out).**
- **Wear boots often before the season starts.**
- **Use bag balm to lubricate potential hot spots.**
- **Wear two pairs of socks or double-layer socks.**
- **Use moleskin or a skin protector to cover hot spots.**

For hands

- **Harden your hands with light work.**
- **Wear gloves that fit.**
- **Use moleskin or a skin protector to cover hot spots.**

Work and Rest

Fatigue can cause accidents. Breaks—short or long—are one defense against fatigue, sleep is another. To perform well at tough jobs like wildland fire-fighting, workers need to average 1 hour of sleep for every 2 hours of work. This rest-to-work ratio means that a 14-hour work shift is about as long as crews can work and still get the sleep and rest they need. The shift should allow time for eating, showering, and getting ready for work. Sleeping conditions should be quiet, warm, and dry. Night crews need protection from noise, light, dust, and other conditions that interfere with restful sleep during the day.

Return to Work

After a short illness or injury resulting in absence from work, an employee may return to duty under these conditions:

- Physician approval (if needed)
- Absence of fever for 24 hours without use of antifever drugs (such as aspirin)

After prolonged illness, a worker should follow a gradual transition to full work activity or be reassigned temporarily to less arduous duties.

Neck Check

Should you train or work with an upper respiratory infection? Dr. Randy Eichner recommends the neck check. If symptoms are above the neck, such as a stuffy nose, sneezing, or a scratchy throat, try exercising at half your normal pace.

If you feel better after 10 minutes, you can increase the pace and finish the workout. If symptoms are below the neck, with aching muscles or coughing, or if you have a fever, nausea, or diarrhea, take the day off.

You can return to training when the fever is gone for at least 24 hours without the use of aspirin or other fever medications.

Chapter 10—Nutrition and Performance

> **"An army marches on its stomach."**
> ***Napoleon Bonaparte***

Recent research has identified nutritional strategies that will improve the health, safety, and performance of wildland firefighters. The right food sources, properly timed, provide energy and nutrients that help sustain work and maintain the immune system. Supplemental high-energy foods delay fatigue and enhance immune function while helping firefighters maintain their ability to think and make decisions during periods of hard work.

To ensure their health and performance, firefighters need to eat like endurance athletes. Firefighters require twice as many calories as normal—or more—when they are working on the fireline. This chapter is for wildland firefighters, incident management team members, support personnel, and those interested in good nutrition for health and performance. The chapter includes information on energy and nutrient needs, the timing of food intake, vitamin and mineral supplements, and weight management. Intermittent feeding (shift food) maintains blood glucose, work output, immune function, mood, and the ability to make decisions throughout the work shift. We'll deal with hydration in chapter 11, "Environment and Performance."

Energy for Work: Calories

Firefighting is a physically demanding occupation, with energy requirements as high as 6,000 kilocalories per day. Firefighters who do not consume enough calories will become fatigued and lose body weight and muscle. Consuming too few calories during a busy fire season can impair immune function and lead to illness.

Firefighters should check their weight every 2 weeks during the season. The best time is in the morning before breakfast (but after urination). The energy for work comes from carbohydrate, fat, and protein.

Carbohydrate

Carbohydrates are digested, converted to glucose, and stored in your liver and muscle as glycogen (branched chains of glucose molecules). Muscle glycogen fuels the muscles during work; liver glycogen maintains blood glucose, the primary fuel for the brain and nervous system. When blood glucose levels drop during extended physical activity, carbohydrates from the food we eat can provide blood glucose. If your diet does not include enough carbohydrate, the body will make blood glucose from muscle protein, a poor alternative because muscle is needed for the work at hand.

Long hours of strenuous fireline work increase a firefighter's daily carbohydrate requirements. Each gram of carbohydrate provides 4 kilocalories of energy (table 10.1). Carbohydrate needs are based on body weight (in kilograms) and work rate.

Determine your weight in kilograms by dividing your weight in pounds by 2.2. For a 154-pound firefighter:

154 pounds/2.2 = 70 kilograms

Hard Work: 5 to 7 grams (0.18 to 0.25 ounces) of carbohydrate is required per kilogram of body weight per day.

5 to 7 grams x 70 kilograms = 350 to 490 grams (12.35 to 17.3 ounces) of carbohydrate required per day

Harder Work: 7 to 10 grams (0.25 to 0.35 ounces) of carbohydrate is required per kilogram of body weight per day.

7 to 10 grams x 70 kilograms = 490 to 700 grams (17.3 to 25.7 ounces) of carbohydrate required per day

For ultraendurance sports or very hard work, the carbohydrate requirement could be even higher.

Carbohydrate-rich foods include whole-grain products, beans, rice, corn, peas, potatoes, fruit, fruit juice, milk, yogurt, energy bars, and sports drinks. So-called energy drinks contain little carbohydrate.

Table 10.1—The carbohydrate content of common foods.

Food	Grams (ounces) of carbohydrate	Kilo-calories
1 slice bread	12 (0.42)	48
1 cup beans	48 (1.69)	192
1 cup rice	37 (1.30)	148
1 cup corn	41 (1.45)	164
1 medium apple	21 (0.74)	84
1 energy bar	27 (0.95)	108
1 cup sports drink	15 (0.53)	60
1 cup milk	12 (0.42)	48
1 cup yogurt	14 to 44 (0.49 to 1.55)	56 to 176

During work, firefighters need 40 grams (1.41 ounces) of carbohydrate each hour from snacks and sports drinks. An energy bar may contain 25 grams (0.88 ounces) of carbohydrate, and 1 cup of sports drink may contain 15 grams (0.53 ounces), for a total of 40 grams (1.41 ounces) of carbohydrate (40 grams x 4 kilocalories per gram = 160 kilocalories of energy). Field studies of firefighters show that carbohydrate energy supplements improve work output, immune function, blood glucose, and mood.

Fat

Fat should provide 20 to 35 percent of daily calories with a minimum recommended amount of 1 gram of fat per kilogram (0.035 ounces per pound) of body weight. No more than one-third of the fat should come from saturated and trans fats such as butter, lard, dairy fat, and some processed fats—read the labels. The balance of fat should come from monounsaturated and polyunsaturated fats (such as olive, canola, and peanut oils or nuts such as almonds and hazelnuts). If a firefighter needs 4,000 kilocalories per day when fighting fire, one-quarter of those calories (1,000 kilocalories) can come from fat. Because each gram of fat has about 9 kilocalories, 111 grams of fat would provide about 1,000 kilocalories. Firefighters doing light work (2,200 kilocalories) only need 56 grams of fat per day.

Protein

Athletes and wildland firefighters require 1.2 to 1.8 grams of protein per kilogram of body weight (0.042 to 0.064 ounces per pound)—1.2 grams for moderate work and 1.8 grams for prolonged hard work under adverse conditions and for recovery. For this example, we will use a 154-pound (70-kilogram) firefighter needing 1.5 grams of protein per kilogram (0.053 ounces per pound) of body weight:

70 kilograms x 1.5 grams = 105 grams (3.7 ounces) of protein per day

Table 10.2 shows the amount of protein in some food choices.

Shift Food

During prolonged endurance events, athletes eat throughout the event. Field studies of firefighters show that intermittent feeding throughout the shift maintains blood glucose and work output. Firefighters consuming shift food performed more work, especially during the last 4 hours of the shift, compared to firefighters who had a traditional sack lunch.

Table 10.2—Content of protein in common foods.

Food	Portion	Grams (ounces) of protein
Almonds	¼ cup	5 (0.18)
Beans	½ cup cooked	8 (0.28)
Beef	4 ounces	35 (1.23)
Cheese	1 ounce	7 (0.25)
Chicken	4 ounces, no skin	37 (1.30)
Chili	1 cup	20 (0.70)
Corn	½ cup cooked	3 (0.11)
Egg	1	6 (0.21)
Fish	4 ounces	31 (1.09)
Hamburger patty	4 ounces	20 (0.70)
Milk	1 cup	8 (0.28)
Peanut butter	1 tablespoon	4 (0.14)
Pizza	1 slice	10 (0.35)
Pork	4 ounces lean	35 (1.23)
Rice	½ cup cooked	2.5 (0.09)
Sunflower seeds	¼ cup	8 (0.28)
Tofu	1 cup	6 to 9 (0.21 to 0.32)
Veggie burger	4 ounces	5 (0.18)

Nutrients: Vitamins and Minerals

Nutrition needs: Determine your caloric and nutrient needs by using the Web site *http://www.mypyramid.gov/*. This site suggests daily caloric and micronutrient (mineral and vitamin) needs based on your age, gender, and level of physical activity. Remember, the protein and carbohydrate requirements underestimate the needs of wildland firefighters. Click on the food group for additional information. Table 10.3 shows daily food requirements for light and for arduous work.

Table 10.3—Daily food requirements for light and for arduous work.

Food	Light work	Arduous work
Daily requirements	**2,200 kilocalories**	**4,400 kilocalories**
Fruit	4 servings (2 cups)	12 servings (6 cups)
Vegetables	4 to 5 servings (2 to 2 ½ cups)	8 servings (4 cups)
Whole grains*	6 servings	12+ servings
Milk or yogurt	1 to 2 cups	5 cups
Meat, fish**	6 ounces	10 ounces

*Whole grains and enriched or whole-grain products.
**Meat, fish, or meat substitute.

Firefighters do not need vitamin and mineral supplements if their diets include a variety of nutrient-rich foods and beverages and provide enough energy to maintain body weight.
For more information on vitamin and mineral needs, see "Wildland Firefight-

er Health and Safety Report: No. 9" on the MTDC Web site (*http://www.fs.fed.us/t-d/pubs/htmlpubs/htm05512803* Username: t-d, Password: t-d).

Related Issues

The following issues are related to energy, nutrition, and weight management.

Immune Function—Psychological stress, exhaustion, smoke exposure, sleep deprivation, and dehydration can degrade immune function. A well-balanced diet with adequate calories, meat, shellfish, fruits, and vegetables enhances immunity. Research has demonstrated that adding carbohydrate energy supplements during work helps maintain the immune function of wildland firefighters.

Ergogenic Aids—Ergogenic aids are products that are thought by some to improve performance. Few have been proven effective, especially in a long season of arduous work. Some (ephedra) have caused death. Others (anabolic steroids) can harm the heart. Use good food choices and fitness training to meet performance goals. For information on ergogenic aids, consult a registered dietitian—not Internet sites.

Special Needs of Incident Management Team Members—Incident management team members do less arduous work than wildland firefighters. Dietary recommendations are based on the daily energy expenditure required to maintain the body mass index (BMI) in the normal range (19 to 25). Use the *http://www.mypyramid.gov/* Web site to determine nutritional needs. Review the BMI chart (see figure 3.1).

Weight Management —When fire season is over, eat less because your energy needs will be lower. To lose weight during the off season:

- Increase physical activity.
- Decrease calorie intake by eating less sweets and fats.
- Decrease portions of all foods.

Weigh yourself every 2 weeks to monitor your progress.

Begin the fire season physically fit, with a sound nutritional base.

Chapter 11—Environment and Performance

> **"No athlete is crowned but in the sweat of his brow."**
> ***St. Jerome***

A number of environmental factors influence work output. This chapter focuses on heat stress, altitude, and smoke, the ways these factors affect performance and health, and what firefighters can do to minimize their impact.

Heat Stress

Wildland firefighting is hot, physically demanding work, so it is vital that you understand heat illnesses, how they affect you, and what you can do to prevent or treat them.

Field workers suffer heat stress when the air temperature, humidity, radiant heat, and lack of air movement combine with hard work and protective clothing to raise the body temperature (figure 11.1). Evaporation of sweat is the body's main line of defense against heat. As sweat evaporates, it cools the body. When water lost by sweating is not replaced, the body's heat controls break down and body temperature climbs dangerously. When our bodies can't cope with this added heat, we experience heat illnesses, including heat cramps, heat exhaustion, and heat stroke.

Heat Cramps—Painful muscle cramps sometimes strike workers who perform prolonged strenuous effort in the heat. Treatment involves electrolyte drinks (tomato juice, sport drinks, lightly salted water) or electrolyte tablets and stretching to relieve the cramps. The risk is minimized when fluid intake is adequate, when sport drinks are available to replace electrolytes lost in sweat, and when the diet includes bananas, oranges, and salt (sodium) with meals.

Heat Exhaustion—This disorder is characterized by weakness; fatigue; dry, hot, and flushed skin; headache; nausea; and, sometimes, collapse. Heat exhaustion is caused by inadequate fluid intake, sodium depletion, or both. Fluid loss leads to a drop in blood volume

Relative Humidity (%) \ Temperature (˚F)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders With Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Figure 11.1—Heat index. Locate temperature (top) and relative humidity (side). Intersect readings to find the apparent temperature, what the temperature feels like. (National Weather Service: *http://www.crh.noaa.gov*)

that severely limits the muscles' work capacity. Treatment includes rest in a cool place with legs elevated and electrolyte drinks. Prevention includes improved aerobic fitness and acclimation to the heat.

Heat Stroke—Most persons experiencing heat stroke have sweat-soaked and pale skin, hyperthermia (body temperature above 104 degrees Fahrenheit), and central nervous system disturbances. When metabolic heat produced by muscles outpaces the body's ability to dissipate the heat, the core temperature rises to levels that disrupt organ function. The symptoms of heat stroke include disorientation, confusion, dizziness, irrational or unusual behavior, inappropriate comments, and loss of balance and muscle function.

Heat stroke is a life-threatening medical emergency that requires immediate cooling of the whole body. The most rapid cooling involves immersion in cold or ice water. Ice packs, mists, and fanning are less effective than immersion. The patient should be monitored during initial treatment, transport, and medical treatment. Following recovery, the worker should refrain from exercise for at least 1 week. When workers are cleared for a return to activity they should begin gradually, allowing 2 weeks to acclimate and 2 to 4 weeks of training before returning to work.

Hydration

Fluid needs vary from person to person and change with environmental stress. Wildland firefighters should drink enough water throughout the day to maintain their body weight within 2 percent of their weight before beginning work. The U.S. Army and the American College of Sports Medicine recommend drinking up to 1 liter (1.06 quarts) of fluid for every hour of hard work to maintain blood volume and to enhance the body's ability to keep cool by sweating.

Wildland firefighting generates about 400 kilocalories of heat per hour, with another 180 kilocalories of heat being generated by the environment and the fire (400 + 180 = 580 kilocalories of heat gain per hour). Complete evaporation of 1 liter (1.06 quarts) of sweat removes 580 kilocalories of heat.

How to Stay Hydrated

Before work	**1 to 2 cups of fluid**
During work	**1 cup every 15 minutes (1 quart per hour)**
After work	**Replace fluid deficit**

Monitor your body weight to determine fluid deficit. Drink 2½ cups of fluid for each pound of weight loss.

For information on heat and hydration, see Wildland Firefighter Health and Safety Report No. 3 (Sharkey 2000a) on MTDC's Web site: *http://www.fs.fed.us/t-d/pubs/html-pubs/htm01512817/* Username: t-d, Password: t-d.

There are wide individual differences in sweat rate and fluid loss. Daily fluctuations in weight can be monitored (monitor hydration by weighing in the morning after urinating and before eating or drinking).

Electrolytes are minerals (such as sodium and potassium) that are important for nerve and muscle function, and for the body's fluid and acid/base balances.

To replace electrolytes lost in sweat:

- Use the saltshaker at meals.
- Eat salty foods (pickles, olives, jerky) when you're sweating during work.
- Drink carbohydrate/electrolyte drinks (sport drinks) during work.
- Drink milk at breakfast or after work.

Sport Drinks—Carbohydrate/electrolyte drinks (sport drinks) help maintain blood glucose, work output, immune function, improved mood, and the ability to make decisions. The electrolytes help to maintain blood volume. Lightly flavored sport drinks encourage drinking. For more information on sport drinks, see Wildland Firefighter Health and Safety Report No. 8 on MTDC's Web site: *http://www.fs.fed.us/t-d/pubs/htmlpubs/htm04512802/* Username: t-d, Password: t-d.

Urine Color

In a series of studies, Dr. Lawrence Armstrong confirmed the relationship of urine color to measures of hydration. Urine that is pale yellow or straw color indicates hydration, but darker colors indicate dehydration (Armstrong 2000).

Preventing Heat Stress

While it's important to know how to recognize and treat heat disorders, it's best to prevent them. Your actions in the months, weeks, and days before exposure to heat stress are as important as anything you do when you are being stressed.

Fitness—Achieving and maintaining a high level of aerobic fitness is one of the best ways to protect yourself against heat stress.

- The fit worker has a well-developed circulatory capacity, as well as increased blood volume. Both are essential to regulate body temperature in the heat.
- Fit people start to sweat at a lower body temperature, so they have a lower body temperature and heart rate while working.
- Fit workers adjust or acclimate to work in the heat twice as fast as unfit workers (in 4 days compared to 8). Fit workers lose acclimation more slowly and regain acclimation more quickly than unfit workers.
- Unfit, overweight workers are unsuited for work in the heat. They carry more weight and don't have a corresponding increase in surface area for evaporative cooling.

Fittest Workers

In a study conducted in the University of Montana Human Performance Laboratory's heat chamber, the fittest worker finished a 2-hour work test with a heart rate of 118 beats per minute, while the least fit labored at a rate of 164 beats per minute. All subjects were working at the same rate and grade on the treadmill. There was a highly significant inverse relationship between aerobic fitness and the working heart rate (r = -0.91).

Acclimation—The worker who is acclimated to work in the heat runs less risk of heat stress. The body adjusts to hot work in 4 to 8 days by:

- Starting to sweat at a lower body temperature
- Increasing sweat production
- Decreasing skin and body temperature
- Improving blood distribution
- Decreasing heart rate

About 1½ hours of work a day is enough to acclimate workers to a specific combination of work and heat, providing partial acclimation for more severe conditions. Fitness training activities also provide partial acclimation. Adjust to hot weather activity gradually. Set a sensible pace, take frequent breaks, replace fluids, and don't expect full production for the first several days.

Acclimation persists for several weeks, especially with regular physical training. Fatigue, sleep loss, and alcohol consumption lead to some loss of acclimation.

Work Habits

Pace yourself. Be aware that individuals may have large differences in heat tolerance. If you push too hard to keep up with others, you may not last the whole work shift. When possible:

- Avoid working close to heat sources.
- Do the hardest work during cooler morning or evening hours.
- Change tools or tasks to minimize fatigue.
- Take frequent short (30-second) rest breaks.

Individual Differences

Individuals differ in their response to heat. Some will always be at greater risk for heat disorders because of inherited differences in heat tolerance (such as perspiration rate, variations in body composition, nutrition, hydration, or fatigue). Illness, drugs, and medications also can influence your body's response to work in a hot environment. If you are using medications or have medical conditions, ask your physician whether they pose a threat. Monitor your response to heat and watch out for signs of heat stress. When possible, weigh yourself in the morning (after urinating, but before breakfast) to watch for dehydration. If your weight is down, rehydrate before you return to work. Take your heart rate when you wake up to see if you are dehydrated, overtired, or have a fever. A heart rate 10 percent above your average could indicate a problem. Finally, always work or train with a buddy who can provide help if you become disoriented or disabled with a heat disorder.

Rest Periods—Work/rest cycles must be adjusted to prevent progressive fatigue. Shorter work periods and frequent rest periods in a cool, shaded area minimize heat buildup. Experience shows that heat stress is unlikely when your heart rate is less than 100 beats per minute after 3 minutes of rest.

Protective Clothing—Modern fire-resistant garments, designed to protect against sparks, embers, and brief exposure to direct flame, do so at a price in terms of heat stress. The fabric that provides protection reduces airflow and evaporative cooling. Wear cotton T-shirts and underwear to help sweat evaporate. Do not wear synthetic undergarments. They can melt on your skin when exposed to flame or intense heat. Wear loose-fitting garments to enhance air movement. Avoid extra layers of clothing that insulate and restrict air movement, because they can contribute to heat stress.

Cold

Exposure to low temperatures and high winds can lead to frostbite, hypothermia, and even death. The body cuts off blood flow to the extremities when you're cold, leading to discomfort and loss of dexterity. Shivering helps maintain body temperature, but

physical activity using large muscles is far more effective than shivering in restoring heat and blood flow. Because large muscle activity takes considerable energy, anyone exposed to cold weather must maintain a cypothermia and possible death.

Windchill—Windchill describes the effect of windspeed on heat loss (figure 11.2). A 10-degree Fahrenheit reading is equivalent to -25 degrees Fahrenheit when the windspeed is 20 miles per hour. If you must face the wind on a cold day, be sure to cover exposed flesh and be on the lookout for frostbite.

Frostbite—Frostbite is damage to the skin from cold exposure. The skin appears pale and feels numb. Rewarm frostbitten skin with warm (not hot) water, but do not massage. Protect sensitive areas (nose, ears, and toes) to avoid frostbite and the pain that occurs during rewarming.

Hypothermia begins when the body loses heat faster than it can be produced. The problem can be compounded by fatigue, energy depletion, and rapid cooling from snow, rain, wind, and evaporation. When the brain itself cools, the body begins to shut down. This is a medical emergency and the victim should be transported to a medical facility as quickly as possible. Hypothermia often occurs at temperatures above 30 degrees Fahrenheit.

To avoid problems during cold weather:

- Dress in layers, wearing wicking garments underneath a weatherproof parka.
- Take layers off as you heat up and put them on as you cool off.
- Wear a hat that protects your ears.
- Maintain your energy level and avoid exhaustion.
- Acclimate to the cold to minimize discomfort.

While cold air will not freeze tissues in the lungs, even at subzero temperatures, it may make vigorous exercise difficult for those prone to airway constriction. Slow down and use a mask or scarf to minimize the effect of cold air on airways.

Windspeed (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
(Windspeeds higher than 40 mph have little additional effect)	Frostbite Times																	

Frostbite Times: 30 min, 10 min, 5 min

Figure 11.2—Wind chill chart (National Oceanic and Atmospheric Administration 11/01/01).

Altitude

Field work and firefighting often take place at moderate altitude. Elevations below 5,000 feet (1,500 meters) have little noticeable effect on healthy workers. But at elevations above 5,000 feet, available levels of atmospheric oxygen decline. With less oxygen available, altitude always reduces work capacity. Even highly fit workers will be affected by the diminished oxygen supply.

Altitude Acclimation

Altitude affects our ability to take in, transport, and use oxygen. Work at altitude leads to acclimation by:

- Increased air intake (better ventilation)
- Improved oxygen transport (increase in red blood cells)
- Improved utilization of oxygen in muscles (increased capillaries)

These adjustments reduce—but never eliminate—the effect of altitude on aerobic fitness. While it takes several weeks to make a good adjustment to work at a higher elevation, athletes have learned that they can improve with a week of altitude training for every 1,000 feet (300 meters) above 5,000 feet elevation.

If your crew works at an elevation above 5,000 feet, take it easy for the first few days, Take frequent breaks and avoid excessive fatigue. Plan more time to recover after hard work. Eat lots of carbohydrates for added energy. Take special care to maintain hydration because altitude hastens fluid loss. As with heat stress, individuals differ in altitude tolerance. Above 8,000 feet (2,400 meters), a few workers may begin to experience mild symptoms of acute mountain sickness (AMS), characterized by headache, fatigue, and lack of appetite. They will require more time to adjust, possibly including recovery time at a lower elevation.

Health Hazards of Smoke

Concern for the health hazards of smoke from prescribed fires and from wildfires is longstanding. The 1987–1988 fire seasons intensified interest and prompted study of the problem. The increasing intensity of fires has contributed to concerns regarding the health hazards of smoke.

Employee Exposure

Studies of air samples collected from the breathing zone of wildland firefighters and workers involved with prescribed burning indicate some potential for hazardous exposure to respirable particulate, carbon monoxide, formaldehyde, and acrolein (table 11.1). Exposures seldom exceed the permissible exposure limits (PEL) or short-term exposure limits (STEL) mandated by the Occupational Safety and Health Administration (OSHA). Exposures exceed OSHA standards less than 5 percent of the time on prescribed fires and even less frequently on wildland fires.

Respirable particulate is composed of particles of airborne soot small enough to find their way to the lungs. These particles irritate and burden airways and may carry carcinogens into the lung.

Benzene is a product of hydrocarbon combustion by the internal combustion engines that power chain saws and pumps.

Carbon monoxide is a colorless, odorless product of incomplete combustion that combines with hemoglobin, reducing the oxygen-carrying capacity of blood.

Acrolein is a strong aldehyde that stings and burns eyes and irritates the airways.

Formaldehyde is a strong irritant and potential carcinogen found in the smoke of forest fires.

Vegetative smoke contains many more compounds, including formic acid, sulfur dioxide, and low levels of polynuclear aromatic hydrocarbons. Workers using gasoline-powered tools, such as chain saws or pumps, risk additional exposure to benzene.

Table 11.1—Permissible exposure limits and average wildland firefighter workshift exposure values (in parentheses) for health hazards of smoke. This table is taken from Reinhardt and Ottmar (2000). TWA = time-weighted average; STEL = short-term exposure limit; ceiling = level not to be exceeded; PPM = parts per million.

	Respirable particulate (mg/m^3)	Benzene (ppm)	CO (ppm)	Acrolein (ppm)	Formaldehyde (ppm)
TWA	5 (1.47)	1 (0.004)	50 (2.8)	0.1 (0.001)	0.75 (0.006)
STEL	—	5	—	0.3	2.0
Ceiling	—	—	200	—	—

Monitoring Exposure

Data from the Forest Service's Pacific Northwest Research Station and Rocky Mountain Research Station, Missoula Fire Sciences Laboratory show that carbon monoxide is highly correlated to other toxins in smoke. Because of these relationships, carbon monoxide can be used to monitor firefighter exposure to other hazards in smoke (such as respirable particulate, formaldehyde, and acrolein). A carbon monoxide time-weighted average (TWA) of 25 parts per million helps keep exposure to other gases and particulates within permissible limits. This carbon monoxide level, which is below the OSHA permissible exposure limit of 50 parts per million or the NIOSH (National Institute for Occupational Safety and Health) standard of 35 parts per million accounts for altitude; long, strenuous work shifts; and variability in particulate and formaldehyde levels (figure 11.3).

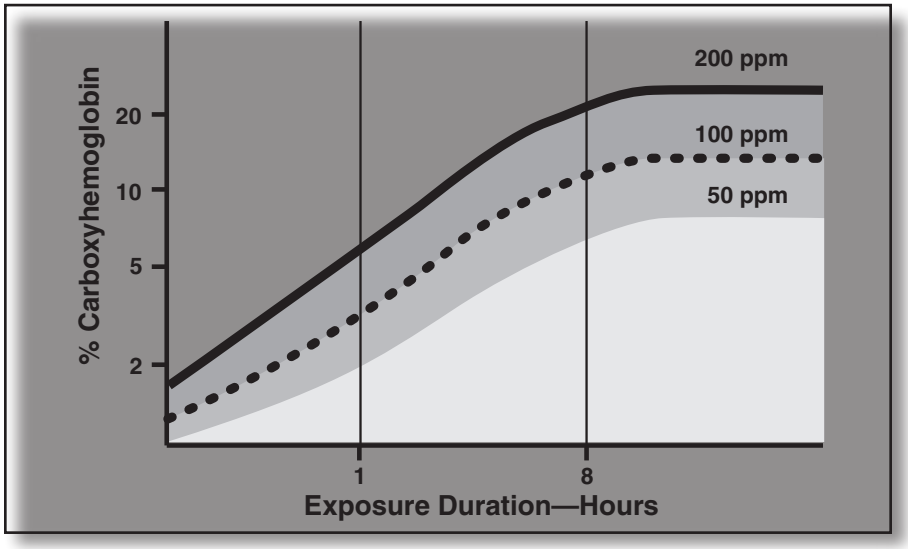


Figure 11.3—Effects of carbon monoxide concentration and exposure duration on blood carboxyhemoglobin (COHb) levels (Sharkey 1997). OSHA's goal is to keep COHb levels below 5 percent (cigarette smokers' COHb levels range from 5 to 10 percent).

Health Effects

Smoke exposure may cause short-term, intermediate, and long-term problems.

Short-term exposure causes eye irritation and coughing, and can cause respiratory problems. Studies of the effect of smoke exposure on firefighters have shown small but statistically significant daily and seasonal declines in pulmonary function. However, declines over a work shift usually have disappeared by the following day, and declines over a season disappear after a period free from exposure. With enough recovery time, the human lung is remarkably capable of cleansing itself.

Intermediate exposure (days or weeks) to smoke reduces the effectiveness of the mucociliary escalator, which sweeps particulate trapped in mucus so it can be spit out or swallowed. When particulate is not removed effectively, the risk of bronchitis is increased. Prolonged continuous exposure to smoke may compromise the effectiveness of the immune system.

Long-term exposure risks from years of firefighting have not been established. Although the constituents of smoke have the potential to increase the risk of heart disease, chronic lung disease, and cancer, there is no evidence that the intermittent exposure of wildland firefighters to low levels of smoke from forest fires has increased these risks.

Chapter 12—Preventing Injuries and Illness

Wildland firefighting and field work can be dangerous occupations. We must take steps to prevent injuries and illnesses, to treat injuries and illnesses that do occur, and to ensure a worker's successful return to work.

Prevention

Prevention begins long before the field season; it includes physical preparation, good nutrition, and work hardening. A firefighter should begin the fire season well rested.

Fitness—Fit workers are less likely to be injured, and they're likely to recover more quickly after an injury. Debilitating back and repetitive trauma problems are less common in workers with adequate muscular fitness. Workers who engage in core training (see appendix G) improve performance and experience fewer back problems.

Training—Training involves more than physical fitness. Firefighters need to learn and practice proper lifting techniques to avoid back problems. Training in the efficient and effective use of tools also is essential. Workers should be cross trained to reduce the likelihood of repetitive trauma disorders. Simply changing jobs or tools now and then will reduce the repetitive strains and trauma associated with certain tasks.

Safety

Safety awareness and training are important, as are the examples set by crew leaders and managers. Workers respond to safety messages that are communicated by action and deed. Workers need to understand and appreciate the values and limitations of protective equipment and become proficient in its use and care.

Ergonomics—Ergonomics implies selecting the right tool for the job as well as the right person for the tool. Our studies show that certain tools, such as the combi tool, are more effective and less fatiguing than the Pulaski and that some workers are more capable with certain tools. Field work and firefight-

ing in remote sites limit the use of power tools, increasing the importance of workers' fitness and skill with handtools. Because we can't adapt the job to the worker, we must adapt the worker to the job.

On the Job

Warmup—Workers, like athletes, need to warm up before strenuous effort. A gradual increase in muscle and body temperatures improves metabolic and neuromuscular efficiency. Warm muscles and stretched tissues are less susceptible to injury. Stretching also helps relieve soreness. Use stretching and a gradual transition to work to ease into the workday.

Work and Rest—Fatigue often is a cause of accidents; make sure that you get enough rest. Breaks, short or long, are a defense against fatigue. Sleep is another. To perform well at tough jobs like wildland firefighting, workers need to average 1 hour of rest for every 2 hours of work. This rest-to-work ratio means that a 14-hour work shift is about as long as crews can work and still get the sleep and rest they need. The shift should allow time for eating, showering, and getting ready for work. Sleeping conditions should be quiet, warm, and dry. Night crews need protection from noise, light, dust, and other conditions that interfere with restful sleep during the day.

Field studies by the University of Montana and the Missoula Technology and Development Center show that firefighters' immune systems fully recover after 14-hour shifts but not after 21-hour shifts. Crew bosses should follow hard days with easier ones to allow time for recovery.

Energy and Hydration—Workers are responsible for maintaining their energy and fluid intake. Supervisors can make sure adequate food and drink is available, but the workers themselves are responsible for taking the time to eat and drink. Failing to do so makes workers a hazard to themselves and their coworkers. Supervisors should schedule breaks every 90 minutes, especially late in the shift. Fluids should be replaced regularly, with firefighters drinking every 15 to 30 minutes during hot conditions.

Injuries

No job is worth an injury, yet job-related injuries do occur. Slips, trips, and falls are common in field work. Firefighters experience ankle, knee, and back injuries. How can we limit these injuries and speed employees' return to work?

Treatment

For soft-tissue injuries that are not severe, appropriate treatments minimize the extent of the injury and ensure a quick and complete recovery. Most soft-tissue injuries are treated with RICESS (Rest, Ice, Compression, Elevation, Stabilization, and Stretching).

This simple treatment plan, if followed properly, has a dramatic effect on recovery. Use ice as often as possible in the first few days after the injury. Use compression to avoid swelling. Elevate the leg as necessary to control swelling. When pain and swelling are controlled, stabilizing the ankle allows a return to limited activity and rehabilitation.

Rehabilitation

Firefighters with serious injuries should receive rehabilitation under the guidance of an athletic trainer or physical therapist. Rehabilitation involves a progressive program designed to restore muscle strength and endurance, range of motion, and full functional use. The ability to perform under field conditions should test the employee's readiness to return to work. Physician approval will be required after recovery from serious injuries.

Well-designed rehabilitation programs return workers to full activity in the shortest possible time. With physician approval, workers may return to work with the aid of protective taping or bracing. Leg, back, wrist, and other braces are becoming common in the workplace, but there is little proof that they prevent new or recurring injuries. Braces are no substitute for training or rehabilitation. Workers should not return to work until they can do so

Treating a Sprained Ankle Using RICESS

Rest—Rest is used to relieve swelling and to allow treatment (ice and elevation). Otherwise, some mobility is desirable, so long as discomfort and swelling are controlled.

Ice—Ice (which could be a cold pack, a frigid mountain stream, or snow in a plastic bag) is the treatment of choice for acute soft tissue injury. Cold slows metabolism, reduces bleeding and swelling, reduces pain, and limits the extent of the injury. Apply ice for 20 to 30 minutes several times a day for best results. Continue for several days or until the swelling and pain are gone.

Compression —An elastic wrap soaked in cold water provides compression and cooling shortly after the injury. A dry wrap continues compression between cold treatments.

Elevation—Elevating the limb limits the swelling after an injury. A badly swollen sprained ankle should be elevated above the heart as much as possible during the 24 hours following the injury.

Stabilization—Workers can use tape or ankle supports to stabilize the ankle.

Stretching—While stretching may be viewed as part of rehabilitation, gentle stretching may begin shortly after the injury. Flexion and extension exercises can be done while applying ice, compression, and elevation.

safely, without becoming a hazard to themselves or to their coworkers.

Return to Work

Before firefighters are allowed to resume firefighting, they should be able to pass the job-related test they passed before being hired. For example, a firefighter should be able to pass the test used to establish job-related work capacity. This will demonstrate recovery from the injury as well as the fitness for duty. If no test is available for the job classification, performance of key elements of the job will provide some assurance of job readiness. Because of the risk of subsequent injury, smokejumpers require a more demanding test. Dr. Michael Schutte, an orthopedic surgeon and specialist in sports medicine, has used a jumping test to evaluate a jumper's readiness for return to work.

Workers want to rejoin their crew and return to work as quickly as possible. Medical clearance and an appropriate field evaluation will ensure their readiness for work without undue risk of subsequent injury.

Illness

When living with a large number of people in a fire camp or even when spiked out with your crew, take care to avoid the spread of bacteria and viruses. Wash your hands before meals or handling food. Don't share water bottles. If you need to share water, pour the fluid from one bottle to another.

An ongoing study has found high concentrations of bacteria and other microorganisms in water containers that were not regularly washed. Firefighters who use sipping hydration systems need to wash the reservoirs, hose, and mouthpiece occasionally. Flavored beverages containing sugars should not be used in sipping hydration systems.

Immune Function

The human immune system is a complex arrangement of organs, tissues, and cells that protect the body from infectious microbes (including viruses, bacteria, fungi, and parasites). Up to 50 percent of the visits to fire camp medical tents are for upper respiratory problems, including coughs, colds, and sore throats. Factors in the firefighting environment known to compromise immune function include: fatigue, exhaustion, stress, inadequate energy

and nutrition, dehydration, smoke, sleep deprivation, and environmental extremes. Wildland firefighting presents a challenge to immune function and health.

The secretory immune system of the mucosal tissues of the upper respiratory tract is considered the body's first line of defense against infiltration by pathogens. Salivary immunoglobulin A (sIgA), the major component of that system, inhibits pathogens from attaching themselves and reproducing, preventing them from entering the body. Numerous studies have shown that sIgA decreases significantly after a bout of prolonged, intense effort, such as a marathon run. Up to 25 percent of the finishers in the marathon will experience an upper respiratory tract infection within 2 weeks afterward (the percentage is more than 50 percent after longer events).

This decline in sIgA after arduous effort allows viruses and bacteria to gain a foothold, increasing the likelihood of infection.

Carbohydrate supplementation during long shifts of arduous firefighting enhances maintenance of immune function, improves recovery, and allows firefighters to accomplish more (fig 12.1). The mechanism for the improved immune function may be related to a decrease in cortisol, a stress hormone that causes immune function to decline. Carbohydrate minimizes the production of cortisol.

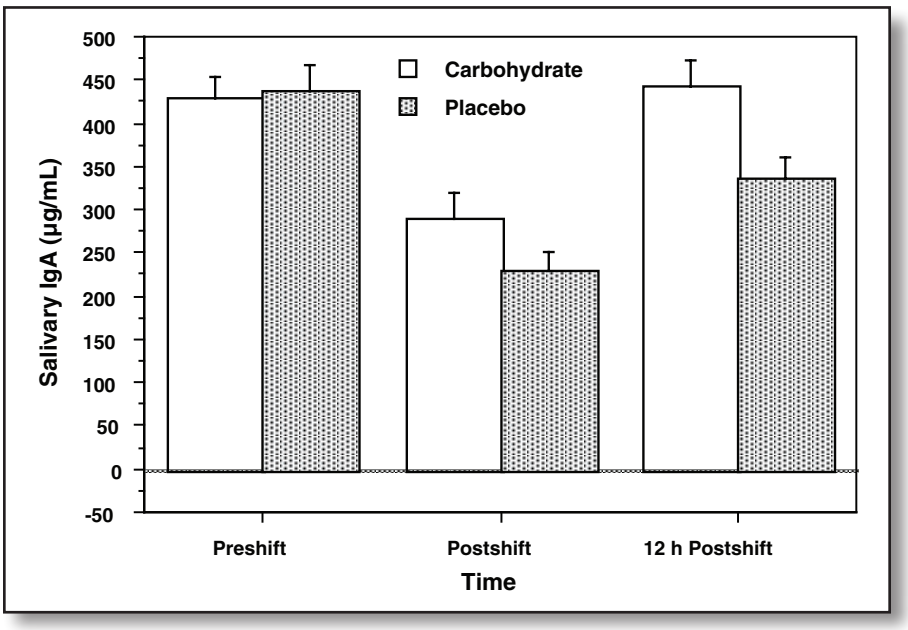


Figure 12.1—Immune function decline and recovery after hard work, with and without carbohydrate supplementation (Harger and others 2004).

Studies also show that sIgA decreases even more after very long work shifts, which may require a day or two of relative rest for recovery. The immune function of wildland firefighters becomes depressed after hard work (more than 3,000 kilocalories), especially after a number of days of hard work (figure 12.2). The fatigue index, using a simple standardized step test, appears as sensitive as sIgA in identifying patterns of fatigue and immune depression. Although these data suggest that physically fit wildland firefighters can sustain arduous duty cycles, days of lighter activity should be interspersed to maintain immune function and avoid accumulative fatigue (see appendix I for more information on the fatigue index). In figure 12.2:

- Bars represent relative work during each shift. Bars at the height of the horizontal line represent about 4,000 kilocalories of energy expenditure.
- The light line represents the percent change in the fatigue index.
- The dark line represents change in sIgA (measured in milligrams per milliliter).

Larger fatigue index values represent fatigue. Values that return to 0 percent reflect recovery. Negative sIgA values indicate immune function suppression. (Gaskill and Ruby 2004).

Recovery—Time for rest and recovery should be included during training and during work. Failure to provide time for recovery could lead to suppressed

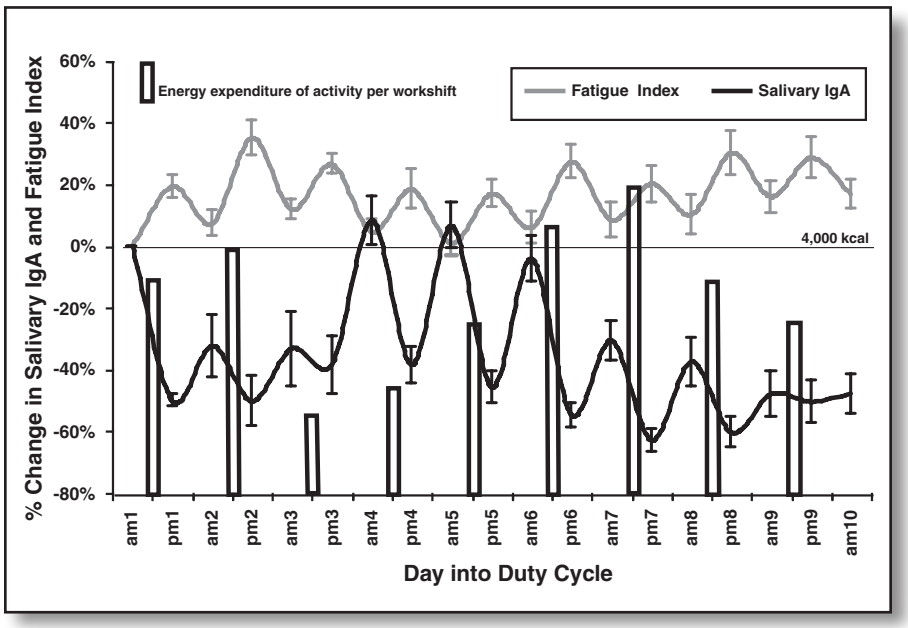


Figure 12.2—Changes in salivary IgA and fatigue index after days of variable energy expenditure.

immune function and an increased risk of respiratory infection. Recovery must consider all the factors that affect immune function, including exhaustion, inadequate rest, poor nutrition (not enough energy, fruits, and vegetables), dehydration, stress, and smoke exposure. Smoke depresses immune function and deadens the actions of the cilia in the lung. Cilia sweep particulate up and out when it is entering the lung. When the cilia stop their work, particulate can slide deeper into the respiratory tract. Prolonged smoke exposure can lead to bronchitis or even pneumonia. Schedule rest days in a smoke-free environment to ensure recovery.

See appendix J for warning signs and medical issues related to training, testing, and performance of physically demanding work.

Firefighting and the Immune System

While the smoke from forest fires is not considered immediately dangerous to life and health, it does cause unpleasant symptoms (production of phlegm, coughing, wheezing, sore throat, burning eyes) and sometimes leads to respiratory illness. A number of factors in the firefighting environment reduce immune function and increase the body's susceptibility to respiratory and other illnesses.

Stress—Stress is a response to events that are perceived to be physically or psychologically threatening. The body's endocrine system responds by producing hormones for the fight-or-flight response. However, prolonged exposure to these hormones can lead to immune suppression and increased susceptibility to infection and illness.

Fatigue—Prolonged exertion and exhaustion lead to suppression of the immune system, vulnerability to upper respiratory infections, and slow healing of wounds, as well as poor performance, muscle soreness, irritability, sleep disturbances, and psychological problems, such as depression.

Nutrition—Just as certain nutrients (Vitamins C, E, and Beta-carotene) help maintain a healthy immune system, poor nutrition can weaken it. See the section on nutrition for more information on this subject.

Smoke—Chronic exposure to the smoke from cigarettes reduces immune function, influences the response to other agents (such as carcinogens) and increases the risk of heart disease, lung cancer, chronic respiratory problems, and other ailments. Prolonged exposure to the smoke from wildfires has the potential to cause some of these effects. However, firefighting is seasonal, exposure is episodic, exposures seldom exceed allowable limits, and the health implications of these exposures have not been determined. While smoke is a threat to the immune system, stress, fatigue, and poor nutrition also lead to poor immune function and increased risk of upper respiratory and other problems.

To maintain a healthy immune system and minimize the risk of respiratory illness, avoid prolonged exposure to smoke, manage stress through communication and training; improve fitness, use rest and labor-saving tools to minimize fatigue, and eat a variety of vegetables, fruits, and other immune friendly foods.

References

American College of Sports Medicine and the American Heart Association. 2007. Exercise and acute cardiovascular events: placing the risks into perspective. Medicine & Science in Sports & Exercise. 39(5): 886-897.

Armstrong, Lawrence E. 2000. Performing in extreme environments. Champaign, IL: Human Kinetics. 344 p.

Astrand, Per Olaf; Rodahl, Kaure; Dahl, Hans; Stromme, Sigmund B. 2003. Textbook of work physiology. Champaign, IL: Human Kinetics. 656 p.

Domitrovich, Joe; Sharkey, Brian. 2008. Hydration strategies for firefighters. Tech Tip 0851–2324P–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 6 p. Available online at http://www.fs.fed.us/eng/pubs/htmlpubs/htm08512324/.

Gaskill, S. E.; Ruby, B. G.; Heil, D. P.; Sharkey, B. J.; Hansen, K.; Lankford, D. E. 2002. Fitness, workrates and fatigue during arduous wildfire suppression. Medicine & Science in Sports & Exercise. 34(5): s195.

Gaskill, S.; Ruby, B. 2004. Relationship of work to salivary IgA and fatigue. In: Wildland Firefighter Health and Safety Report No. 8. Tech. Rep. 0451–2802–MTDC. U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center.

Harger, S.; Gaskill, S.; Ruby, B. 2004. Effects of carbohydrate supplementation on salivary immunoglobulin A during long duration arduous work. Medicine & Science in Sports & Exercise. 36: S320.

Haskel, William L.; Lee, I-Min; Pate, Russell R.; [and others]. 2007. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Medicine & Science in Sports & Exercise. 39(8): 1423-1434.

National Wildfire Coordinating Group Incident Operations Standards Working Team. 2009. National interagency incident management system wildland fire qualification system guide. PMS 310-1. Boise, ID: National Wildfire Coordinating Group. 166 p. Available online at http://www.nwcg.gov/pms/docs/pms310-1.pdf.

Pyne, Stephen J. 2001. Fire: a brief history. Seattle, WA: University of Washington Press. 224 p.

Reinhardt, Timothy E:, Ottmar, Roger D. 2000. Smoke exposure at western wildfires. Res. Pap. PNW–RP–525. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 72 p.

Ruby, B. C.; Ledbetter, G. W.; Armstrong, D. W.; Gaskill, S. E. 2003. Wildland firefighter load carriage: effects on transit time and physiological responses during escape to safety zone. International Journal of Wildland Fire. 12(1): 111-116.

Sharkey, Brian. 1997. Tech. Rep. 9751–2835–MTDC. Health hazards of smoke: recommendations of the consensus conference April 1997: Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 84 p.

Sharkey, Brian. 2001a. Wildland Firefighter Health and Safety Report No. 3. Tech. Rep. 0151–2817–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 12 p.

Sharkey, Brian. 2001b. Wildland Firefighter Health and Safety Report No. 4 Tech. Rep. 0151–2840–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 14 p.

Sharkey, Brian J.; Davis, Paul O. 2008. Hard work: defining physical work performance requirements. Champaign, IL: Human Kinetics. 256 p.

Sharkey, Brian J.; Gaskill, Stephen E. 2006. Sport physiology for coaches. Champaign, IL: Human Kinetics. 320 p.

Sharkey, Brian J.; Gaskill, Stephen E. 2007. Fitness & health. Champaign, IL: Human Kinetics. 440 p.

U.S. Department of Labor. 1968. Selected characteristics of occupations by worker traits and physical strength. Supp. 2 to the Dictionary of Occupational Titles, 3d ed. 1968. Washington, DC: U.S. Department of Labor.

Whitlock, Chuck; Sharkey, Brian. 2003. Work capacity test: administrator's guide. Boise, ID: National Interagency Fire Center. 29 p.

Appendix A—Startup Programs

These programs are for persons who have been sedentary before training for the work capacity tests or undertaking a weight loss or fitness program. All of the programs are based on the "average" individual. You may have to adjust the times, your rate of progression, and how much you do on any particular day. It is okay to do more or less depending on how you are feeling. We strongly recommend that you follow the general flow of each program and exercise the rule of patience. Progress modestly and you will maintain your health and improve your fitness.

These programs are from the President's Council on Physical Fitness and Sport (*http://www. fitness.gov*).

Red Walking Program

Week	Activity (Every other day at first)
1	**Walk at brisk pace for 5 minutes, or less if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Walk briskly for another 5 minutes or until you become uncomfortably tired.**
2	**Same as week 1, but increase the pace as soon as you can walk 5 minutes without soreness or fatigue.**
3	**Walk briskly for another 8 minutes, or less if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Walk briskly for another 8 minutes, or until you become uncomfortably tired.**
4	**Same as week 3, but increase the pace as soon as you can walk 8 minutes without soreness or fatigue.**

When you've completed week 4 of the Red Walking Program, begin week 1 of the White Walk-Jog Program.

White Walk-Jog Program

Week	Activity (Four times a week)
1	**Walk briskly for 10 minutes, or less if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Walk briskly for another 10 minutes, or until you become uncomfortably tired.**
2	**Walk briskly for 15 minutes, or less if you become uncomfortably tired. Walk slowly or rest for 3 minutes.**
3	**Jog for 10 seconds (25 yards). Walk for 1 minute (100 yards). Do this 12 times.**
4	**Jog 20 seconds (50 yards). Walk for 1 minute (100 yards). Repeat 12 times.**

When you've completed week 4 of the White Walk-Jog Program, begin week 1 of the Blue Jogging Program.

Blue Jogging Program

Week	Activity (Five times a week)
1	Jog for 40 seconds (100 yards). Walk for 1 minute (100 yards). Repeat nine times.
2	Jog for 1 minute (150 yards). Walk for 1 minute (100 yards). Repeat eight times.
3	Jog for 2 minutes (300 yards). Walk for 1 minute (100 yards). Repeat six times.
4	Jog for 4 minutes (600 yards). Walk for 1 minute (100 yards). Repeat four times.
5	Jog for 6 minutes (900 yards). Walk for 1 minute (100 yards). Repeat three times.
6	Jog for 8 minutes (1,200 yards). Walk for 1 minute (100 yards). Repeat.
7	Jog for 10 minutes (1,500 yards). Walk for 1 minute (100 yards). Repeat two times.
8	Jog for 12 minutes (1 mile or 1,760 yards). Walk for 1 minute (100 yards). Repeat.

Once you have completed the Blue Jogging Program, or if you are able to complete two 1-mile jogs (1,760 yards) interspersed with a 1-minute walk, you are ready to begin the off-season fitness program for your crew or the basic programs in appendix C or D to prepare for the work capacity tests. If you are an office employee or are interested in a physical activity program to maintain health or normal body weight, see the programs and suggestions offered in appendix B.

Measuring energy expenditure

Appendix B—Physical Activities for Health And Weight Control

These suggestions are for individuals with sedentary office jobs who would like to maintain normal weight and reduce their risk for chronic diseases including heart disease, stroke, diabetes, hypertension, high cholesterol, and a number of other illnesses.

We often hear that individuals do not have enough time for a training program or to be physically active. However, millions of individuals have learned to change a few behaviors and find time for short periods of physical activity over the course of every day. You can change your life and long-term health outlook dramatically by changing small behaviors.

A healthier life begins with 30 minutes of daily vigorous activity. Walking 1½ to 4 miles a day doesn't require one long walk. Walks can be as short as 10 minutes. You can keep track of your exercise by purchasing an inexpensive pedometer (step counter) and accumulating 10,000 steps a day. Include some stair climbing and brisk walking several times a week.

Light or moderate activity is recommended for weight loss. To lose weight, you need to accumulate 60 minutes or more of walking a day and eat slightly less. Walking or jogging a mile burns around 100 kilocalories. To lose a pound of fat you must burn 3,500 kilocalories—easily accomplished with a 35-mile walk!

Don't be discouraged; increase physical activity and eat less to achieve a caloric deficit of 500 kilocalories per day (caloric deficit means you burn more calories than you consume). With a daily 500-kilocalorie deficit, you will lose 1 pound per week.

You could achieve a 500-kilocalorie deficit by increasing physical activity 250 kilocalories (walking 2½ miles), combined with a dietary reduction of 250 kilocalories (one candy bar). To lose 2 pounds a week, walk 5 miles a day to burn 500 kilocalories (5 miles) and consume 500 fewer kilocalories for a caloric deficit of 1,000 kilocalories. You should not try to lose more than 2 pounds per week, and you should not have a daily caloric deficit of more than 1,000 kilocalories. For more information on weight control, see "Fitness & Health" (Sharkey and Gaskill 2007).

Appendix C—Training for the Work Capacity Tests

These fitness programs are based on the average individual. You may have to adjust the times, your rate of progression, and how much you exercise on a given day. We recommend that you follow the general flow of the program. Progress modestly and you will maintain your health while you improve your fitness.

Begin training at least 4 to 6 weeks before your test. Most of the training will simulate the activity of the test, gradually increasing the distance and the weight carried. Wear the same footwear during training that you will wear during the test.

Training for the work capacity test is no substitute for training for the job of wildland firefighting.

Preparing for the Walk Test

If you have completed the White Walk-Jog Program (appendix A), you are ready to prepare for the Walk Test (1-mile hike in 16 minutes). If you have not been physically active, we suggest that you start training by taking the Walk and Walk-Jog Tests (see chapter 8). Begin the Red, White, or Blue fitness program at the appropriate week based on your test results. To prepare for the Walk Test, complete at least the White Walk-Jog Program. Begin training 2 weeks before the test.

You will need to find a measured mile—a ¼-mile (400-meter) track at a local school or park will do.

Week 1

Day 1—Walk one ¼-mile lap to warm up. After the warmup lap, time yourself walking briskly for one lap. Your target time is 4 minutes or less. Walk slowly for one-half lap, then briskly walk another lap. Repeat five times.

Day 2—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for 1½ laps. Your target time is 6 minutes or less. Walk slowly for one-half lap, then walk briskly for another 1½ laps. Repeat three times.

Day 3—Hike or walk continuously for 25 to 30 minutes at a comfortable pace. This is an easy day.

Day 4—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for two laps. Your target time is 8 minutes or less. Walk slowly for one-half lap, then walk briskly for two laps. Walk slowly for another one-half lap.

Day 5—Hike or walk continuously for 30 to 35 minutes at a comfortable pace. This is an easy day.

Day 6—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for 2½ laps. Your target time is 10 minutes or less. Walk slowly for one-half lap, then briskly for 2½ laps. Walk slowly for another one-half lap, then briskly for another 2½ laps. Finish by walking slowly for one-half lap.

Day 7—Hike or walk continuously for 30 to 35 minutes at a comfortable pace. This is an easy day.

Week 2

Day 1—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for three laps. Your target time is 12 minutes or less. Walk slowly for one-half lap, then time yourself walking briskly for two laps with a target time of 8 minutes or less.

Day 2—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for 3½ laps. Your target time is 14 minutes or less. Walk slowly for one-half lap, then time yourself walking briskly for another 1½ laps with a target time of 6 minutes or less.

Day 3—Hike or walk continuously for 30 to 35 minutes at a comfortable pace. This is an easy day.

Day 4—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for four laps. Your target time is 16 minutes or less. If you can do this, you have met the requirements for the Walk Test. We suggest that you continue training for another 3 days to help assure that you pass the Walk Test.

Day 5—Hike or walk continuously for 30 to 35 minutes at a comfortable pace. This is an easy day.

Day 6—Walk one lap to warm up. After the warmup lap, time yourself walking briskly for five laps or as far as you can, up to eight laps (2 miles). Maintain a pace of 4 minutes or less per lap.

Day 7—Hike or walk continuously for 30 to 35 minutes at a comfortable pace. This is an easy day.

You are ready for the Walk Test. If it is not scheduled right away, maintain your training with 30 to 60 minutes of moderate walking on most days. Pace yourself at 4 minutes or less per lap for 1 to 2 miles at least twice a week.

Preparing for the Field Test

If you have completed the Blue Jogging Program, you are well qualified to prepare for the Field Test (a 2-mile hike in 30 minutes carrying a 25-pound pack). If you have not been physically active, we suggest that you start by taking the Walk and Walk-Jog Tests (see chapter 8) and begin the Red, White, or Blue Programs at the appropriate week, based on your test results. To prepare for the Field Test, complete at least week 4 of the Blue Jogging Program. At that point, you should be ready to begin specific training for the Field Test, using the following progression. Expect to take 2 to 3 weeks to prepare after reaching the midpoint of the Blue Jogging Program.

You will need to find a measured 2-mile trail. Mile markers on a road will work if the road has a wide shoulder. A track at a local school or park also works well.

- Briskly hike a 2-mile flat course without a pack. Do this every other day until you can hike the course in less than 30 minutes. On days between hikes continue the Blue Jogging Program.
- Wear a pack weighing 12 to 15 pounds on your training hikes. Continue to hike on alternate days until you can complete the 2-mile course with the light pack in less than 30 minutes. Continue to progress in the Blue Jogging Program, or stay active in other ways, on alternating days.
- Gradually increase the weight in the pack for your training hikes. Adding 2 to 3 pounds each hike while maintaining the 30-minute pace for 2 miles will get you to your target within three to five sessions (1 to 1½ weeks). On the days between hikes, consider hiking hills (with your pack) to build leg strength and endurance, jogging, or participating in other physical activities. If you will be doing specific firefighting tasks, the days between your training hikes are a good time to begin practicing those activities.

Preparing for the Pack Test

If you have completed the Blue Jogging Program, you are well qualified to prepare for the arduous Pack Test (a 3-mile hike in 45 minutes carrying a 45-pound pack). If you have not been physically active, we suggest that you start by taking the Walk and Walk-Jog Tests (see chapter 8) and begin the Red, White, or Blue Programs at the appropriate week, based on your test results. To prepare for the Pack Test, you should complete the Blue Jogging Program, which requires a similar level of aerobic fitness as the Pack Test, and prepares you for the specific training needed to complete the Pack Test. Expect to take 2 to 4 weeks to prepare after completing the Blue Jogging Program. You will need to find a measured 3-mile trail. Mile markers on a road will work if the road has a wide shoulder. A track at a local school or park also works well.

Briskly hike a 3-mile flat course without a pack. Do this every other day until you can hike the course in less than 45 minutes. On the days between hikes, continue the walk and jog workouts in the Blue Jogging Program and begin task-specific job training outlined for specific crews.

Wear a pack weighing about 20 to 25 pounds during your training hikes. Continue hiking on alternate days until you can complete the 3-mile course with the light pack in less than 45 minutes. On alternate days begin hiking in hills, continue with job-specific training, or enjoy other physical activities.

Gradually increase the weight in the pack, adding 3 to 5 pounds each hike. Maintaining the 45-minute pace for 3 miles will get you to your target within five to seven sessions (1½ to 2 weeks). On the days between training hikes, take longer hikes in hills (wearing your pack) to build leg strength and endurance for the fire season, jog, or participate in other physical activities (such as mountain biking). Continue to train for specific fire tasks your crew will perform, such as line digging, brushing, sawing, and similar activities.

Appendix D—Fitness for Incident Management Team Members

You may have to adjust the times, your rate of progression, and the amount of exercise on any day. It is okay to exercise more or less, based on how you are feeling. We strongly recommend that you follow the general flow of each program and remain patient. Progress modestly and you will maintain your health and improve your fitness.

The weekly routines that follow will help you maintain general aerobic fitness by incorporating the requirements for health and weight management. They alternate easier days with harder days. This is a 2-week program starting with an easier week followed by a harder week. Alternate these weeks, starting with the easier week and gradually increasing toward the harder week until you find a level that balances the time you have available and your fitness needs. Most of the days will not require you to change into special clothing for exercise because the activities are moderate or light.

If you are currently sedentary, start first with the Red and White Programs (appendix A). Begin with the "Easier Week," alternating with the "Harder Week," and adjusting the duration and intensity of training to fit how you are feeling and your individual fitness level.

Whenever walking—walk briskly.

Easier Week

Monday
Aerobic: 60 minutes of walking at an intensity you consider to be moderately light and can sustain for 30 to 45 minutes without undue fatigue. This exercise can be in three to four walks of 15 to 20 minutes each or all in one long walk.

Muscular: Core training. Bent-leg situps with a goal of 30 repeats during each set; pushups to failure or 15, whichever comes first; chair dips to failure or 15, whichever comes first; 10 chair squats adding weight in a pack so that by the 10th squat you are feeling tired. Repeat two to three times. Occasionally change exercises.

Tuesday
Aerobic: 30 minutes of continuous brisk walking.
Muscular: Same as Monday. Repeat once or twice.

Wednesday
Same as Monday.

Thursday
Aerobic: During the day, walk as briskly as possible for 5 to 8 minutes. Try to repeat four to six times during the day.

Muscular: Same as Monday. Repeat once or twice.

Friday
Aerobic: Try to walk at an easy pace in hilly terrain for a total of 30 to 60 minutes.

Saturday or Sunday
Aerobic: Find the time for 60 to 90 minutes of continuous moderate activity. This can be brisk walking (hiking), slower hiking in hills, or any other aerobic activity.

Harder Week

Monday
Aerobic: 60 minutes of brisk walking or walking at an intensity you would consider to be moderately light and you can sustain for 30 to 45 minutes without undue fatigue. This exercise can be in three to four walks of 15 to 20 minutes each or all in one long walk.

Muscular: Core training. Bent-leg situps with a goal of 30 repeats during each set; pushups to failure or 15, whichever comes first; chair dips to failure or 15, whichever comes first; 10 chair squats adding weight in a pack so that by the 10th squat you are feeling tired. Repeat two to three times. Occasionally change exercises. See the muscular fitness section in appendix F.

Tuesday
Aerobic: 5 minutes of moderately hard intensity followed by 3 to 5 minutes of light recovery repeated six times or at

six separate times during the day. The activity can be jogging, uphill hiking, or another activity that elevates your heart rate somewhat. Exercise at moderately hard intensity that would leave you winded after about 15 minutes.

Wednesday
Same as Monday.

Thursday
Aerobic: 30 minutes of continuous moderately hard aerobic activity. This can be jogging, brisk hiking with a pack, hiking in hills, or any other activity. By the end of the 30 minutes you should be tired, but not beat. After 5 to 10 minutes of rest, you should feel really good.

Friday
Same as Monday.

Saturday or Sunday
Aerobic: Find the time for 60 to 90 minutes of continuous moderate activity. This can be brisk walking (hiking), slower hiking in hills, or any other aerobic activity.

Appendix E–1—Off-Season Fitness Maintenance Program for Firefighters

This program will help firefighters maintain and gradually improve fitness during the off-season. Incident management team members who would like to improve their general aerobic fitness also will benefit from this program. After 12 weeks, firefighters should have the basic aerobic fitness they need to meet the job requirements of the average fireline workday.

You should begin this program about 5 months before the start of the next fire season, completing the program 8 weeks before the fire season. That will leave 5 weeks for more specific task-oriented training and 3 weeks for early season work hardening.

Each week of the maintenance program includes three phases: a basic workout, short interval runs (underdistance), and longer runs (overdistance). This program is based on the fundamental principles of training. If you are not a runner, you may adapt the workouts to any aerobic activity that you enjoy while maintaining the plan's training concept. If a particular week's program seems too hard, reduce the load (intensity or duration). If the program seems too easy, increase the load somewhat.

This program is not specifically for firefighting tasks. That training is covered in the next section, "Preseason and Early-Season Training."

For **Easier Weeks**, use the following schedule:

Monday—Basic endurance workout and muscular fitness and core training in appendix G

Tuesday—Underdistance workout and flexibility training in appendix H

Wednesday— Muscular fitness in appendix F

Thursday—Basic workout and flexibility

Friday—Underdistance and muscular fitness

Saturday or Sunday—Overdistance

For **Harder Weeks**, use the following schedule:

Monday—Basic endurance workout and muscular fitness

Tuesday—Underdistance workout and flexibility

Wednesday—Overdistance workout and muscular fitness

Thursday—Basic workout and flexibility

Friday—Underdistance workout and muscular fitness

Saturday or Sunday—Overdistance workout

When exercises are repeated, allow time for the body to recover while continuing to walk or jog (called active recovery).

Week 1—Easier Week

Basic workout:

1 mile in 12 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)
½ mile in 6 minutes (moderate pace)
Repeat twice with active recovery.
¼ mile in 3 minutes (moderate pace)
Repeat four times with active recovery.

Overdistance workout:

2-mile jog in 30 minutes (light pace). You should be able to talk easily in complete sentences while you're jogging at this pace.

Week 2—Harder Week

Basic workout:

1 mile in 10:30 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 5 minutes (hard pace)
Repeat twice with active recovery.
¼ mile in 2:30 minutes (moderate pace)
Repeat four times with active recovery.

Overdistance workout:
2½-mile jog in 40 minutes (light pace). You should be able to talk easily in complete sentences while jogging at this pace.

Week 3—Easier Week

Basic workout:
1 mile in 11 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:
¼ to ½ mile in 5 to 10 minutes (light pace)
½ mile in 5:20 minutes (moderate pace)
Repeat twice with active recovery.
¼ mile in 2:40 minutes (moderate pace)
Repeat four times with active recovery.

Overdistance workout:
2¼-mile jog in 34 minutes (light pace). You should be able to talk easily in complete sentences while jogging at this pace.

Week 4—Harder Week

Basic workout:
1 mile in 10 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:
¼ to ½ mile in 5 to 10 minutes (light pace)
½ mile in 4:50 minutes (hard pace)
Repeat twice with active recovery.
¼ mile in 2:25 minutes (hard pace)
Repeat four times with active recovery.

Overdistance workout:
3-mile jog in 42 minutes (light pace). You should be able to talk easily in full sentences while jogging at this pace.

Week 5—Easier Week

Basic workout:
1 mile in 10:30 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:
¼ to ½ mile in 5 to 10 minutes (light pace)
½ mile in 5:10 minutes (moderate pace)
Repeat twice with active recovery.
¼ mile in 2:30 minutes (moderate pace)
Repeat two times with active recovery.

Overdistance workout:
2½-mile jog in 35 minutes (light pace). You should be able to talk easily in full sentences while jogging at this pace.

Week 6—Harder Week

Basic workout:
1½ miles in 15 minutes (moderate pace)
Repeat twice with active recovery.

Underdistance workout:
¼ to ½ mile in 5 to 10 minutes (light pace)
½ mile in 4:40 minutes (hard pace)
Repeat twice with active recovery.
¼ mile in 2:20 minutes (hard pace)
Repeat four times with active recovery.
220 yards in 1:05 minutes (hard pace)
Repeat four times with active recovery.
100 yards in 30 seconds (hard pace)
Repeat twice with active recovery.

Overdistance workout:

3¼-mile jog in 45 minutes (light pace)

Increase your pace during the last quarter mile.

Week 7—Easier Week

Basic workout:

1 mile in 10 minutes (moderate pace)

Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4:55 minutes (moderate pace)

Repeat twice with active recovery.

¼ mile in 2:25 minutes (moderate pace)

Repeat three times with active recovery.

Overdistance workout:

3-mile jog in 40 minutes (light pace)

Increase the pace during the last quarter mile.

Week 8—Harder Week

Basic workout:

1 mile in 9 minutes (hard pace)

Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4:15 minutes (hard pace)

Repeat twice with active recovery.

¼ mile in 2 minutes (hard pace)

Repeat four times with active recovery.

220 yards in 55 seconds (hard pace)

Repeat four times with active recovery.

100 yards in 23 seconds (hard pace)

Repeat twice with active recovery.

Overdistance workout:

3¾-mile jog in 46 minutes (light pace)

Increase your pace during the last quarter mile.

Week 9—Easier Week

Basic workout:

1½ miles in 14:15 minutes (moderate pace)

Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4:35 minutes (moderate pace)

Repeat three times with active recovery.

¼ mile in 2:15 minutes (moderate pace)

Repeat three times with active recovery.

Overdistance workout:

3-mile jog in 37 minutes (light pace)

Increase your pace during the last quarter mile.

Week 10—Harder Week

Basic workout:

1½ miles in 12:45 minutes (hard pace)

Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4:05 minutes (hard pace)

Repeat twice with active recovery.

¼ mile in 1:55 minutes (hard pace)

Repeat four times with active recovery.

220 yards in 50 seconds (hard pace)

Repeat four times with active recovery.

100 yards in 21 seconds (hard pace)

Repeat twice with active recovery.

Overdistance workout:

4-mile jog in 46 minutes (light pace)

Increase your pace during the last quarter mile.

Week 11—Easier Week

Basic workout:

1 mile in 8:30 minutes (moderate pace)

Repeat twice with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4:10 minutes (moderate pace)

Repeat twice with active recovery.

¼ mile in 2 minutes (moderate pace)

Repeat three times with active recovery.

Overdistance Workout:

3-mile jog in 35 minutes (light pace)

Increase your pace during the last quarter mile.

Week 12—Harder Week

Basic workout:

1 mile in 8:15 minutes (hard pace)

Repeat three times with active recovery.

Underdistance workout:

¼ to ½ mile in 5 to 10 minutes (light pace)

½ mile in 4 minutes (hard pace)

Repeat twice with active recovery.

¼ mile in 1:50 minutes (hard pace)

Repeat four times with active recovery.

220 yards in 45 seconds (hard pace)

Repeat four times with active recovery.

Overdistance workout:

4-mile or longer jog in 46 minutes (light pace)

Increase your pace during the last quarter mile.

Week 13—The 1.5-Mile Run or Pack Test

1.5-Mile Run—After a 10- to 15-minute light warmup on a track, run your best for 1.5 miles (figure E.1). A time of 11:40 minutes or faster meets the fitness standard of 45 required for some firefighting positions. This time requires a pace of 1:56 minutes per lap maintained for six laps on a quarter-mile track. If you meet this standard, you are ready for the job-specific training in the next section. If you do not, continue the training program for a few more weeks, gradually increasing your training speeds in the underdistance workouts.

Work Capacity Test—As an alternative to the 1.5-mile Run, take the Pack Test. After a warmup and some stretching, take the test (3 miles with a 45-pound pack). Time the test to see if you are able to meet the 45-minute standard (45 minutes predicts a VO_2 max of 45 milliliters per kilogram-minute, the minimum for wildland firefighters. Refer to the Work Capacity Test Administrator's Guide (Whitlock and Sharkey 2003) for test instructions (*http://www.fs.fed.us/fire/safety/wct/pdf03512805dpi300.pdf*).

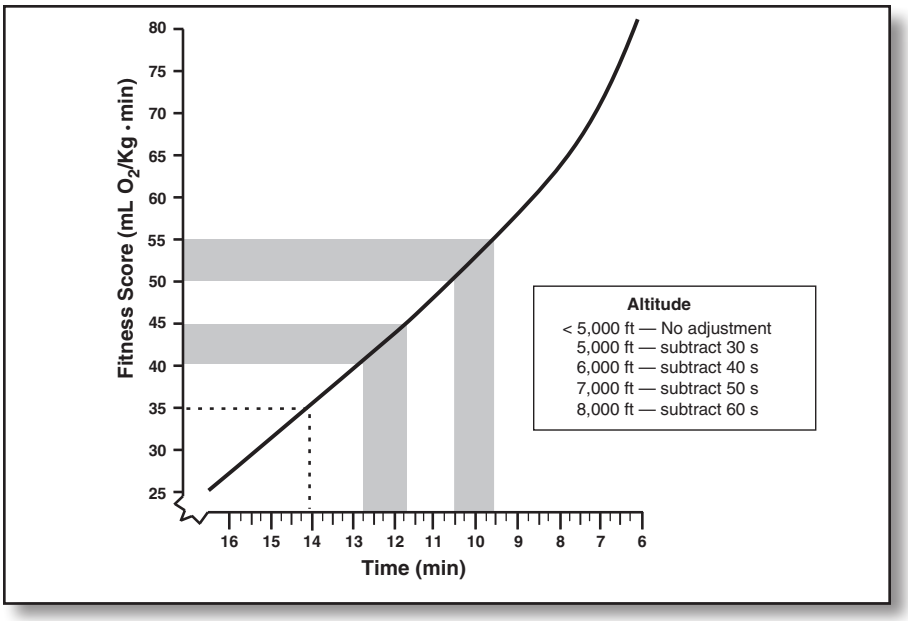


Figure E.1—The 1.5-mile Run.

Appendix E-2—Preseason and Early-Season Training

All of the programs are based on the "average" individual. You may have to adjust the times, your rate of progression, and the amount of exercise on any given day. It is okay to exercise more or less based on how you are feeling. We strongly recommend that you follow the general flow of each program and maintain patience. Progress modestly and you will maintain your health and improve your fitness.

The following programs are recommended for individuals who meet fitness standards provided by the Off-Season Fitness Maintenance Program. This 8-week training program is divided into two 4-week periods. The first period is designed to begin specific aerobic and muscular training before crews come together. The second period is designed for work hardening and assumes that crews can begin to practice or perform actual work duties. For core training exercises, see appendix G.

Preseason Training – Four weeks of exercises with increasing job specificity			
Week	**Day**	**Type II Firefighters**	**Type I Firefighters**
1 Moderate week	Monday	Warm up. Run 1 mile in 8 minutes. Walk 4 to 5 minutes. Repeat the 1-mile run.	Warm up. Run 1 mile in 7:44 minutes (1:56 minutes per lap on a track). Walk 4 to 5 minutes. Repeat the 1-mile run.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Two sets.	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Two sets.
	Wednesday	Hike in hills with a 15-pound pack for 1 hour. If hills are unavailable, climb stairs or stadium steps.	Hike in hills with a 20-pound pack for 1 hour. If hills are unavailable, climb stairs or stadium steps.
	Thursday	Bent-over rows, chair dips, pushups. Two sets.	Pullups, bent-over rows, chair dips, pushups, bicep curls, lat pulldowns. Two sets.
	Friday	Aerobic activity of your choice: bike, walk, row, run.	Aerobic activity of your choice: bike, walk, row, run.
	Saturday	2 hours or more of easy hiking.	2 hours or more of easy hiking with a light pack.
	Sunday	Off.	Off.

Week	Day	Type II Firefighters	Type I Firefighters
2 Easy week	Monday	Warm up. Run ½ mile in 4 minutes. Walk 3 to 4 minutes. Repeat three times. Run 1 mile.	Warm up. Run ½ mile in 3:50 minutes. Walk 3 to 4 minutes. Repeat four times.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Pullups, situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 20-pound pack for 30 minutes. If hills are unavailable, climb stairs or stadium steps.	Hike in the hills carrying a 20-pound pack for 30 minutes. If hills are unavailable, climb stairs or stadium steps.
	Thursday	Bent-over rows, chair dips, pushups. Three sets.	Pullups, bent-over rows, chair dips, pushups, bicep curls, lat pulldowns. Two sets.
	Friday	Aerobic activity of your choice: bike, walk, row, run.	Aerobic activity of your choice: bike, walk, row, run.
	Saturday	1½ hours or more of easy hiking on a hilly trail during a moderate hill climb.	1½ hours or more of easy hiking with a light (15 to 20 pound) pack on a hilly trail or during a moderate hill climb.
	Sunday	Off.	Off.

Week	Day	Type II Firefighters	Type I Firefighters
3 Hard week	Monday	Warm up. Run 1 mile in 7:40 minutes (1:55 minutes per lap on a track). Walk 4 to 5 minutes. Repeat three times, if possible.	Warm up. Run 1 mile in 7:32 minutes (1:53 minutes per lap on a track). Walk 4 to 5 minutes. Repeat four times, if possible.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Pullups, situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 25-pound pack for 45 minutes. If hills are unavailable, climb stairs or stadium steps.	Hike in the hills carrying a 25-pound pack for 45 minutes. If hills are unavailable, climb stairs or stadium steps.
	Thursday	Bent-over rows, chair dips wearing a pack for weight, pushups, half knee bends. Two sets.	Pullups, bent-over rows, chair dips, pushups, bicep curls, lat pulldowns. Three sets.
	Friday	Aerobic activity of your choice: bike, walk, row, run.	Aerobic activity of your choice: bike, walk, row, run.
	Saturday	3 or more hours of easy hiking carrying a 10-pound pack.	3 or more hours of easy hiking carrying a 25-pound pack.
	Sunday	Bent-over rows, chair dips with a pack for weight, pushups, half knee bends. Two sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, biceps curls, lat pulldowns. Two sets.

Week	Day	Type II Firefighters	Type I Firefighters
4 Moderate week	Monday	Warm up. Run 1 mile in 7:40 minutes. Walk 5 to 6 minutes. Repeat the 1-mile run.	Warm up. Run 1 mile in 7:28 minutes (1:52 minutes per lap on a track). Walk for 5 to 6 minutes. Repeat a second and third mile in 7:40 minutes.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Pullups, situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 30-pound pack for 30 minutes. If hills are unavailable, climb stairs or stadium steps.	Hike in the hills carrying a 30-pound pack for 30 minutes. If hills are unavailable, climb stairs or stadium steps.
	Thursday	Bent-over rows, chair dips wearing a pack for weight, pushups, half knee bends. Three sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, lat pulldowns. Three sets.
	Friday	Aerobic activity of your choice: bike, walk, row, run.	Aerobic activity of your choice: bike, walk, row, run.
	Saturday	1½ or more hours of easy hiking carrying a 20-pound pack on a hilly trail or during a moderate hill climb.	1½ or more hours of easy hiking carrying a 30-pound pack (45 pounds for smokejumpers) on a hilly trail or during a moderate hill climb.
	Sunday	Bent-over rows, chair dips wearing a pack for weight, pushups, half knee bends. Two sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, lat pulldowns. Two sets.

Early Season Training—Four weeks of job-specific work hardening			
Week	**Day**	**Type II Firefighters**	**Type I Firefighters**
5 Easy week	Monday	Warm up. Run ½ mile in 3:50 minutes. Walk 3 to 5 minutes. Repeat four times.	Warm up. Run ½ mile in 3:30 minutes. Walk 3 to 5 minutes. Repeat four times.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 20-pound pack and Pulaski for 20 minutes, dig line for 20 minutes, hike back for 20 minutes.	Hike in the hills carrying a 40-pound pack and Pulaski for 20 minutes, dig line for 20 minutes, hike back for 20 minutes.
	Thursday	Bent-over rows, chair dips wearing a pack for weight, pushups, half knee bends. Three sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, lat pulldowns. Three sets.
	Friday	45 minutes of upper body strength activities such as moving logs, sawing, brushing, moving pumps, and hoses.	45 minutes of upper body strength activities such as moving logs, sawing, brushing, moving pumps, and hoses.
	Saturday	1½ or more hours of easy hiking carrying a 20-pound pack on a hilly trail or during a moderate hill climb.	1½ or more hours of easy hiking carrying a 40-pound pack (55 pounds for smokejumpers) on a hilly trail or during a moderate hill climb.
	Sunday	Off.	Off.

Week	Day	Type II Firefighters	Type I Firefighters
6 Hard week	Monday	Warm up. Run 1½ miles in 11:40 minutes. Walk 4 to 7 minutes, then run 1 mile in 8 minutes.	Warm up. Run 1½ miles in 11:20 minutes. Walk 4 to 7 minutes, then run 1 mile in 7:40 minutes.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Pullups, situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 25-pound pack and a Pulaski or other tool for 30 minutes, dig line for 30 minutes, and hike back for 30 minutes.	Hike in the hills carrying a 25-pound pack and a Pulaski or other tool for 30 minutes, dig line for 30 minutes, and hike back for 30 minutes.
	Thursday	Bent-over rows, chair dips wearing a pack for weight, pushups, and half knee bends. Three sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, and lat pulldowns. Three sets.
	Friday	1½ hours of simulated mopup activities, (digging, moving pumps, laying hose, and pumping water), including carrying a water pack.	1½ hours of simulated mopup activities, (digging, moving pumps, laying hose, and pumping water), including carrying a water pack.
	Saturday	1½ or more hours of easy hiking carrying a 25-pound pack on a hilly trail or during a moderate hill climb. Finish with two sets of bent-over rows, chair dips wearing a pack for weight, pushups, and half knee bends.	Start with two sets of pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, and lat pulldowns. 1½ or more hours of easy hiking carrying a 40-pound pack on a hilly trail or during a moderate hill climb. Smokejumpers should carry a 90-pound pack on a flat trail for 60 minutes.
	Sunday	Off.	Off.

Week	Day	Type II Firefighters	Type I Firefighters
7 Easy week	Monday	Warm up. Run 1 mile in 7:50 minutes. Walk 4 to 7 minutes, then run 2 miles in 17 minutes.	Warm up. Run 1 mile in 7:50 minutes. Walk 4 to 7 minutes, then run 2 miles in 17 minutes.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Two sets.	Core training: Pullups, situps, planks, crunches, trunk lifts, and leg lifts. Two sets.
	Wednesday	Hike in the hills carrying a 25-pound pack and Pulaski or other tool for 15 minutes, dig line or other fire activity for 60 minutes, and hike back for 15 minutes.	Hike in the hills carrying a 25-pound pack and Pulaski or other tool for 15 minutes, dig line or other fire activity for 60 minutes, and hike back for 15 minutes.
	Thursday	Off.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, lat pulldowns. Two sets.
	Friday	Job-specific tasks. 2 hours.	Job-specific tasks. 2 hours.
	Saturday	Start with two sets of bent-over rows, chair dips wearing a pack for weight, pushups, and half knee bends. 2½ or more hours of easy hiking carrying a 35-pound pack on a hilly trail or during a moderate hill climb.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, and lat pulldowns. Two sets. 2½ or more hours of easy hiking carrying a 45-pound pack. Smokejumpers should carry an 80-pound pack for 1½ hours on a hilly trail or during a moderate hill climb.
	Sunday	Off.	Off.

Week	Day	Type II Firefighters	Type I Firefighters
8 Moderate week	Monday	Warm up. Run 2 miles in 16 minutes. Cool down.	Warm up. Run 2 miles in 15:30 minutes. Cool down.
	Tuesday	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.	Core training: Situps, planks, crunches, trunk lifts, and leg lifts. Three sets.
	Wednesday	Hike in the hills carrying a 35-pound pack and Pulaski or other tool for 40 minutes, dig line or other fire activity for 60 minutes, and hike back for 40 minutes.	Hike in the hills carrying a 45-pound pack and Pulaski or other tool for 40 minutes, dig line or other fire activity for 60 minutes, and hike back for 40 minutes.
	Thursday	Bent-over rows, chair dips wearing a pack for weight, pushups, and half knee bends. Three sets.	Pullups, bent-over rows, chair dips wearing a pack for weight, pushups, bicep curls, and lat pulldowns. Three sets.
	Friday	Fitness testing. See table 6.2.	Fitness testing. See table 6.2.
	Saturday	Off.	Off.
	Sunday	Off.	Off.

Appendix F—Job-Specific Muscular Fitness

Pullups

Modified Pullups—This is a biceps and back exercise for beginners. Stand with the bar about chest height. With an underhand grasp, hang from the bar with the body straight and feet on the ground. Pull up and return. Do as many as possible.

Normal Pullups—This is the intermediate version of the exercise. With the underhand grasp, pull up until your chin is over the bar. Return. Do as many as possible. Variations include using an overhand grip or climbing a rope. Keep working until you can do eight pullups. Then start wearing a small pack to increase resistance, adding 5 pounds at a time, as you become stronger.

Pike Pullups—This is an advanced exercise. Perform the chinup from the bar with legs in a pike position. Keep working until you can do eight pullups. Start wearing a small pack to increase resistance, adding 5 pounds at a time as you become stronger.

Pushups

Knee Pushups—This is a good chest and triceps exercise for beginners. With your hands outside your shoulders and your knees bent, push up, keeping your back straight. Do as many as possible.

Pushups With Added Resistance—This is an intermediate exercise. With your hands outside your shoulders, push up, keeping your back straight. Lower yourself until your chest almost touches the floor. Do as many as possible. Keep working until you can do 20 pushups. Start wearing a small pack to increase resistance, adding 5 pounds at a time as you become stronger.

Chair Dips

This is an advanced exercise. Make sure the chair you use is solid. Grasp the sides of the chair and slide your feet forward while supporting your weight on your arms. Lower your body and return. Do as many as possible, up to 25 or 30. Then start wearing a small pack to increase resistance, adding 5 pounds at a time as you become stronger. You can use parallel bars if they are available.

Half Knee Bends and Chair Squats

This exercise is good for leg strength and endurance. With feet apart and hands on hips, squat until your thighs are parallel to the ground. Stand. To keep from injuring yourself by squatting too low, stand in front of a chair and squat until your buttocks touch the chair. Do as many squats as possible up to 30, then start wearing a small pack to increase resistance, adding 10 pounds at a time as you become stronger. Try putting a 2-inch block under your heels to help you balance. Vary the weight to achieve the resistance desired.

Triceps Extension

Stand with your arms in front of you at shoulder height. Grasp the bar with your hands about 2 inches apart using an overhand grip. Pull the bar down until your arms are nearly straight.

Another way of performing triceps extensions is to sit astride a bench with your back straight. Grasp the bar with your hands about 2 inches apart, using an overhand grip. Bring the bar to full arm extension above your head. Lower the bar behind your head, keeping your elbows stationary.

Rowing

Rowing works the back muscles. While seated facing the weight machine, grasp the handles and pull them toward your side.

Another way of rowing is to bend over with your back flat and slightly higher than parallel with the floor. Spread your feet shoulder width apart, with knees comfortably bent. Grasp a barbell with an overhand grip. Your hands should be held slightly wider than your shoulders. Your buttocks should be lower than your shoulders. Pull the bar to your chest, then lower it to the starting position. Keep your upper body stationary.

You can reduce the risk of injuring your lower back by using a dumbbell and rowing with one arm at a time while resting your free hand on a bench.

Military Press

The military press works arm and shoulder muscles. Stand erect with your feet comfortably apart. Grasp a barbell with an overhand grip and raise it to your upper chest. Press the bar overhead, until your elbows are fully extended. Lower the bar to your chest. Repeat.

Bicep Curls

Stand with your feet comfortably apart and knees slightly flexed. Hold the bar in front of your thighs with an underhand grip, hands shoulder-width apart, arms straight. Flex your elbows, lifting the bar toward your chest. Keep your elbows close to your sides. Avoid raising your shoulders. Don't lean backward or bounce the bar with leg motion. Repeat.

Bench Press

Bench presses exercise the chest and arm muscles. Lie flat on your back with your feet on the floor astride the bench.

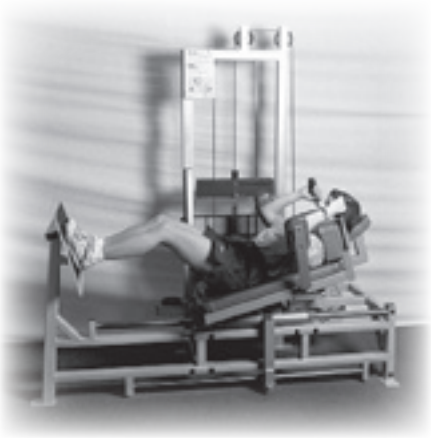
Grasp the bar with your hands farther apart than your shoulders, arms extended. Lower the bar to your chest, then press it up to the starting position. Inhale while lowering the weight. Exhale while pressing it. A partner should help with the weights before and after the exercise.

Lat Pulldowns

This exercise works the lats (the wing-like back muscles under each arm). Kneel on one or both knees, or sit on a bench if one is available. Grasp the handles. Pull the bar down and return it to the starting position.

Leg Presses

Leg presses work the quadriceps (the four major muscles on the front of the thigh). Place your feet on the pedals and grasp the handles by the seat. Press your feet forward to elevate the weight. Return. Inhale while lowering the weight. Exhale while lifting.



Leg Flexion

This exercise works the hamstrings (muscles on the back of the thigh). Lie face down on the exercise bench with your heels behind the padded bar. Flex your legs to raise the weight. Return to the starting position. You may experience leg cramps.

Leg Extension

This exercise works the quadriceps. Sit on the bench with your instep under the padded bar. Extend your legs to raise the weight. Return to the starting position.

Hills

Power walk up a steep hill, stadium steps, or office stairs. You may wish to use ski poles for balance, to lessen shock on downhills, or to exercise your arms. Wear a weighted pack for added resistance.

Bench Stepping

Step up and down on a bench as fast as possible for 30 seconds. Switch the lead leg and repeat. Bench stepping can also be done with a loaded pack.

Heel Raises

Stand erect, hands at your sides or on your hips, feet close together. Raise up on your toes 20 to 40 times. Heel raises can be done with toes on a 2-inch platform. You can wear a loaded pack for increased resistance.

Muscle Balance

Maintain muscle balance in your program. When one muscle group, such as the quadriceps muscles, becomes highly trained, it is important to maintain balance in the opposing muscle group, the hamstrings. Failure to maintain balance (a 3- to 2-strength ratio for quads and hamstrings) could predispose the leg to injuries.

Appendix G—Core Training Exercises

For core training always use 15 to 30 higher repetitions unless otherwise noted.

Bent Leg Sit-ups

This is a good exercise for abdominal strength and endurance. On your back with arms crossed on the chest and knees bent, curl up to a semisitting position, and return. Repeat 10 to 15 times. Variations: Do repetitions very fast. Exercise on an inclined board. Hold a weight on your chest.

Basket Hang

This is a more advanced exercise. Hang from the bar with an underhand grasp. Raise your legs into a "basket" and return. Do as many as possible.

Planks

In prone position, resting on your toes and elbow, with your torso and legs maintaining a straight line (plank), hold your position for increasing lengths of time, starting with whatever is comfortable and repeating two or three times. The goal is to hold your position for 1½ minutes. Repeat twice with a short rest separating the two planks. These can also be done on your right and left sides.

Crunches

Lie on your back with your hands crossed to opposite shoulders. Balance on your buttocks with straight legs extended and head and back off the floor. Begin a series of 'crunches' by touching your elbows to your knees and then extending, while remaining balanced. Repeat as many times as possible up to two sets of 25 to 30 repetitions.

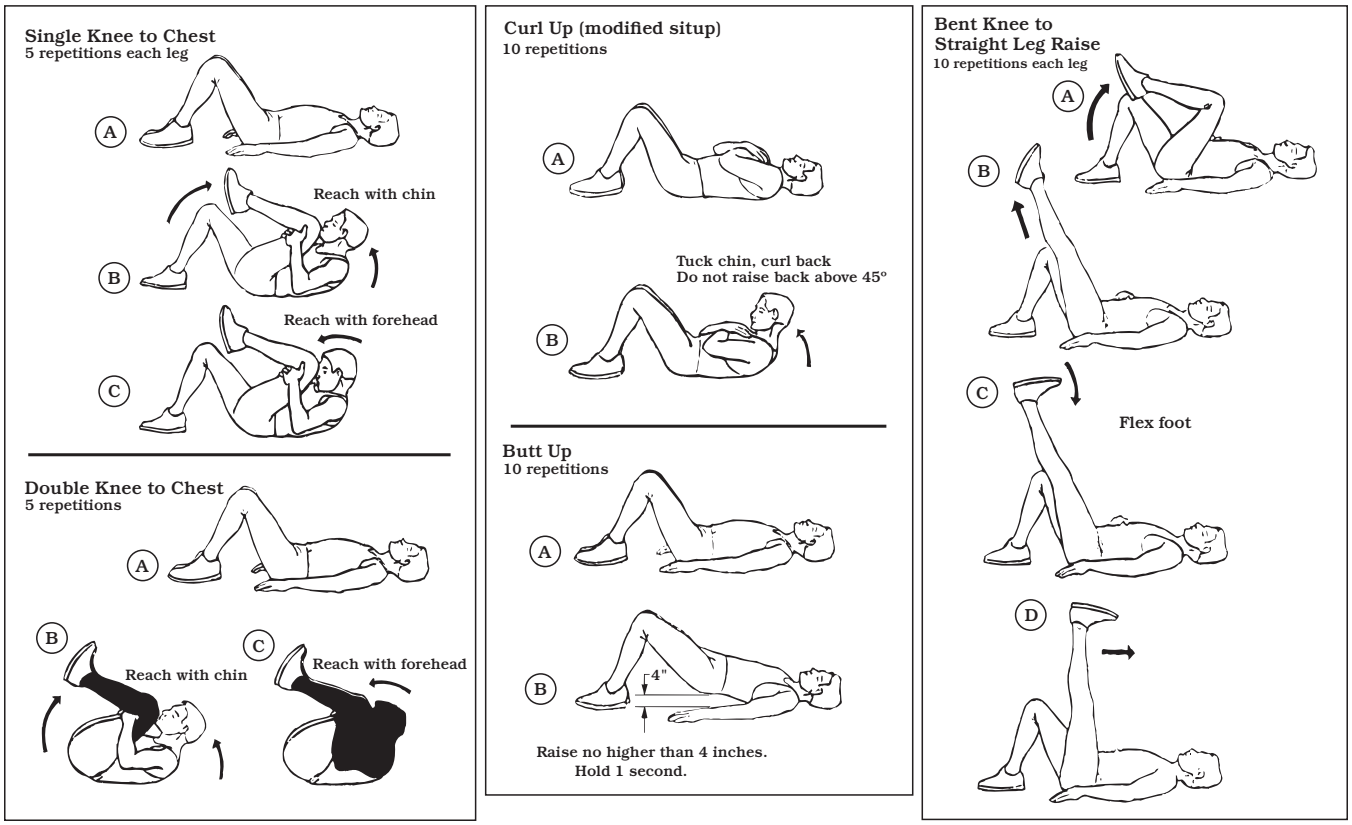
Leg Lifts

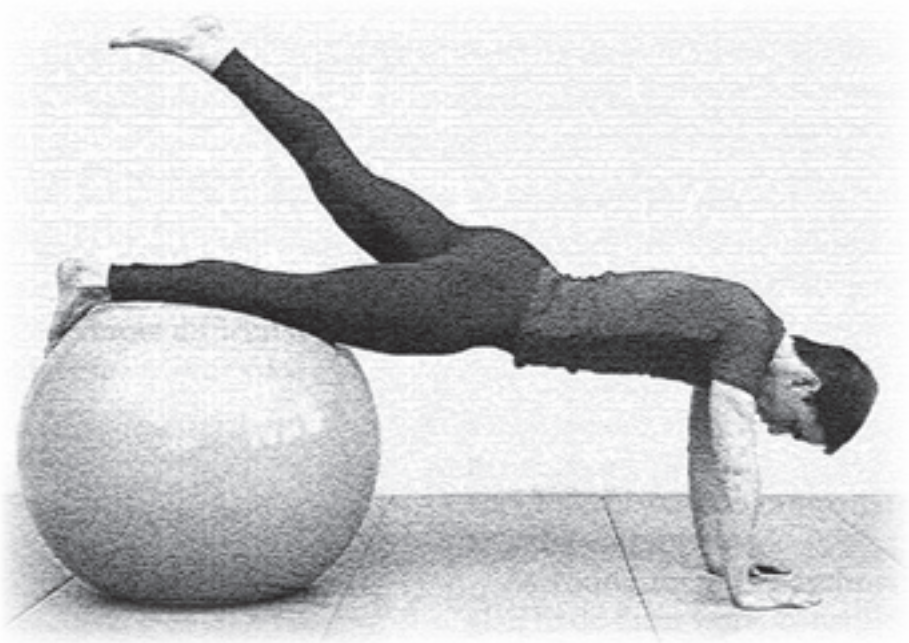
This is a good exercise for back strength and endurance. Lying facedown on the floor, with a partner holding your trunk down, raise your legs 5 to 10 times. Avoid hyperextension.

Trunk Lifts

Lying face down on the floor with fingers laced behind your head and ankles anchored to the ground, raise your trunk 5 to 10 times. Don't overextend.

Lower Back Exercises





More information on core training is available at FireFit, *http://www.nifc.gov/FireFit/fitness.htm*.

Appendix H—Flexibility

Flexibility training should be done two to three times a week, preferably after you have warmed up. The most effective time to stretch is after physical training.
We recommend static stretching, using slow movements to reach a point of stretch, holding the position for 5 to 10 seconds, and relaxing. The stretch may be repeated. Dynamic job-specific movements should be employed before work.

Shoulder and Arm Stretch

Intertwine your fingers above your head with your palms facing up. Push your arms up and slightly to the rear. Feel the stretch in your arms, shoulders, and upper back.

Hand Stretches

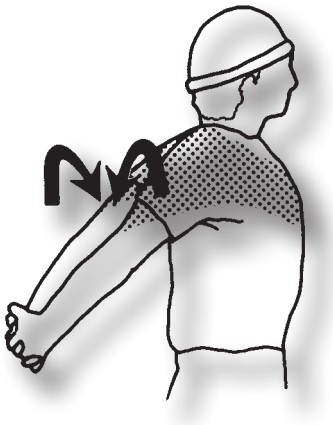
With the wrist and fingers of one hand extended, use your other hand to gently increase the extension of the fingers. Repeat with opposite hands. Other options for stretching the hands include extending the wrist and flexing your fingers at the same time or extending your wrists and spreading your fingers out as far as possible.

Neck Stretch

Lean your head sideways toward your right shoulder while reaching down with your left arm. To increase the stretch, use your right hand to pull your left arm behind your back. Repeat on the opposite side.

Shoulder Stretch

Intertwine your fingers behind your back with your palms facing in. Start the stretch by turning your elbow while maintaining straight arms. For a second stretch, maintain an erect posture and raise your arms behind you until you feel a mild stretch.



Upper Chest Stretch

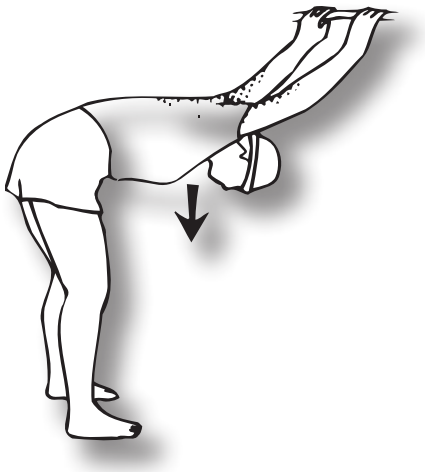
Stand in front of a door jamb or a similar structure. Place your hands about shoulder height on the door jamb and gently lean forward, feeling a stretch across the front of your shoulders and chest. For a little more stretch, step back from the door jamb and relax your shoulders to let gravity increase the stretch.

Trunk Stretch

Standing upright, look over your right shoulder and turn your upper torso to the right as far as possible. Try to keep your hips facing forward. Repeat to the left. As an alternative, stand about 18 inches from a wall while facing away from it. Keeping your hips facing forward, rotate both hands and shoulders and touch the wall. Go only as far as is comfortable.

Back Stretch

Place both hands shoulder width apart on a bar or other solid support that is about chest high. With your knees slightly bent, let your torso droop forward. Keep your hips directly above your feet. Try bending your knees a little more to increase the stretch. Try holding onto objects at different heights.



Side Bend Stretch

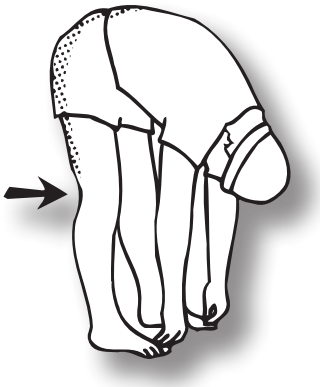
Stretch your right arm up and behind your head. Grasp your right elbow with your left hand as you bend to the left. Pull your right arm at the same time. Feel the stretch from the elbow down though the upper arm and upper torso. Repeat on the left side.

Lower Back and Shoulder Stretch

While standing or sitting, place your hands on your lower back. Bring your shoulders back and your elbows toward one another while pushing your back forward.

Lower Back and Hamstring Stretch

Stand with your feet about shoulder width apart. Slowly bend forward from the hips while keeping your knees slightly bent to reduce lower back stress. Feel your neck, arms, and back relax. Once you reach a point of mild discomfort, straighten up and relax for 20 to 30 seconds. To reduce back stress, increase the bend in your knees before straightening up.



Standing Groin Stretch

With your feet spread, bend your left knee while keeping your right leg straight. Push your hip down and toward your left foot until you feel a modest stretch along the inner thigh of the right leg. Repeat on the other side.

Groin and Hamstring Stretch

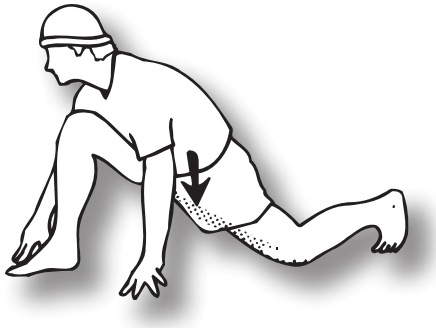
Stand with your left side to a table or bench. While facing forward, place your left foot out to the side with your toe on the bench. Gently lean toward the bench and hold the stretch. You should feel a stretch in the hamstrings and groin. Repeat on the other side.

Groin, Hamstring, and Front of Hip Stretch

Place the ball of your foot on a secure support, such as a table. Keep the support leg pointed forward. Push your hips toward the front foot while bending the front knee. Feel the stretch in the groin and hamstring of the elevated leg and in the front of the hip on the side of the support leg. Repeat on the opposite side.

Groin, Hamstring, and Hip Stretch

Place your right knee directly above your ankle and extend your rear leg behind you. Your weight should be on the toes and ball of the rear foot. Repeat on the other side. Hold an easy stretch by letting your torso relax forward past the front knee. Use your hands for balance.



Calf Stretches

Leaning against a wall or solid support, place most of your weight on your rear foot. Push your hips down and forward while keeping your rear leg straight and your heel on the ground to stretch your upper calf. An additional stretch in this position is to relax the hips and focus on pushing the rear knee forward and down while keeping the heel on the ground to stretch the lower calf. Repeat with the other leg.

Knee and Quad Stretch

While balancing against a wall, hold the top of your right foot with your left hand and gently pull your foot up toward your buttocks. Repeat with your left foot and right hand.

Squat Stretch

You will feel this stretch in the lower legs, knees, back, ankles, Achilles tendons, and groin. Squat down with your feet flat, knees above your toes, and toes pointing out slightly. Changing the width of your feet and knees will change the areas stretched.

Single Leg Hamstring Stretch

Sitting on the floor with your torso upright, tuck the sole of one foot by your inner upper thigh and relax the knee to the floor. Slowly bend forward from the hips toward the foot of the extended leg until you feel a modest stretch. Keep your back straight. Repeat on the other side.

Upper Hamstring and Hip Stretch

Sitting on the floor (if necessary, sit with your back to a wall), hold onto the outside of your ankle (and/or knee) and foot as shown. Gently pull the entire leg toward your torso until you feel a slight stretch in the back of your upper leg. Repeat on the other side. An additional stretch that you can do in this position is to use your hand to gently rotate the foot through its full range of motion, stretching tight ligaments.

Sitting Groin Stretch

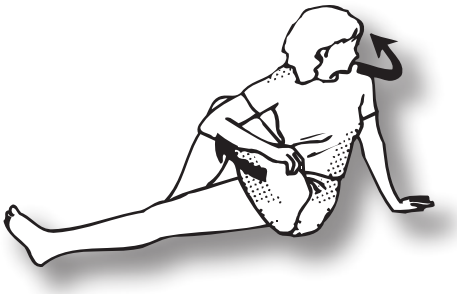
Sitting on the floor, place the soles of your feet together as shown and gently hold onto your toes. Gently bring your torso forward by bending at the hips. You may also use your elbows to gently push the knees toward the floor to increase the stretch. Be gentle.

Outer Hip Stretch

Sitting on the floor as shown with one leg extended and the other bent and placed over the extended leg, gently pull the knee across your torso into the opposite shoulder. Repeat on the other side.

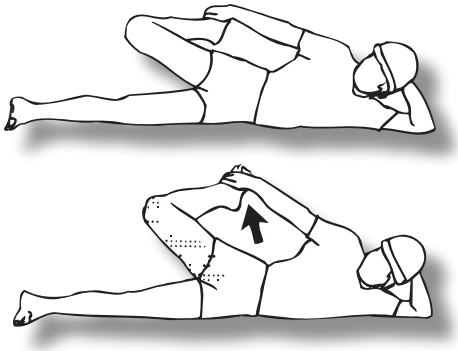
Spine Stretch

This stretch may be felt across the entire back, outside of the hips, and in the ribs. Sit upright on the floor with your right leg out in front. Bend the left leg and place the foot on the floor across the extended right leg. Bend your right elbow and place it on the outside of the left thigh near the knee. Use your left arm for balance as shown and twist, looking over your left shoulder while maintaining pressure with the right arm on the left knee. Repeat on the other side.



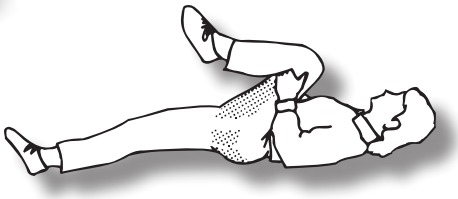
Ankle and Quad Stretch

Lie on one side with your lower arm supporting your head. Hold the top of the upper foot with your free hand as shown. Gently pull your heel toward your buttocks to stretch your ankle and quadriceps. Push the top of your foot into your hand and upward by contracting the gluteus (buttocks) muscles. This movement should further stretch the quadriceps. Repeat on the other side.



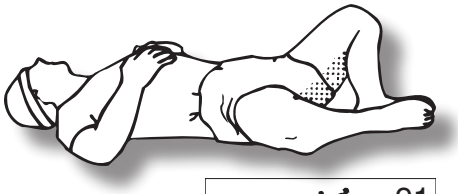
Quad and Gluteus Stretch

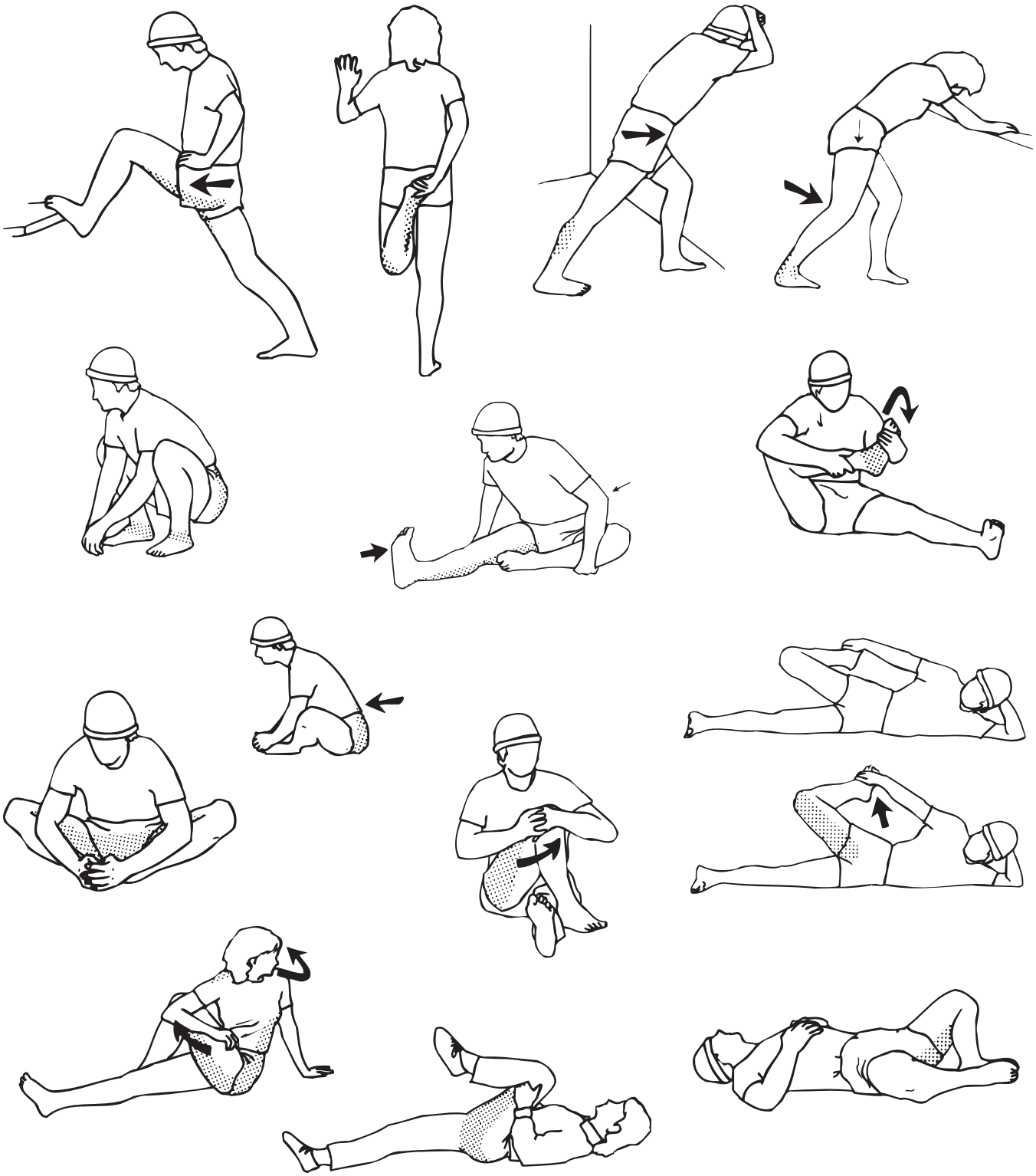
Lie on your back with your head and shoulders on the floor. One leg should be extended and the other knee and hip flexed. Use both hands to hold the lower thigh behind your knee and gently pull your knee toward your chest. Repeat on the other side.



Groin Stretch

Lie on your back with your head and shoulders contacting the floor. Place the soles of your feet together and pull them in toward your buttocks. Gently let your knees droop toward the floor, letting gravity do the work. Relax and breathe.





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Appendix I—The Fatigue Index

This simple test has proven effective in detecting the early stages of overtraining in wildland firefighters. It is an inexpensive but accurate way to judge when a firefighter is accumulating fatigue. The results correlate closely with immune function: when the fatigue index goes up, immune function declines. All you need to conduct the test is a sturdy 8-inch bench (or bottom stair step) and a stop watch. A heart rate monitor helps, but is not required. You can teach wildland firefighters to take the test in the morning. The resting, exercise, and recovery heart rates are summed to provide a fatigue index. After a baseline is established, subsequent tests can gauge the extent of fatigue. Large increases in the fatigue index suggest the need for additional rest or a break from hard training (table I.1).

The Fatigue Test Procedure—After rising in the morning but before breakfast or stimulants (tea or coffee):

- Sit quietly for 3 to 5 minutes until your heart rate is stable. You can read the paper during this time.
- Take your resting heart rate at the wrist for 10 seconds, then multiply the number of beats by 6 to get the rate per minute.
- Start the stop watch and begin stepping (up with one foot then the other, then down with the first foot and then the other—the entire sequence of stepping up and down should take 2 seconds and be repeated 30 times in 1 minute).
- After 1 minute of stepping, stop and take the postexercise heart rate while standing. Sit down immediately afterward.
- Relax. At 30 seconds after exercise, take your heart rate (10 seconds x 6 = beats per minute).
- At 60 seconds after exercise, take the final heart rate.

To calculate the fatigue index, sum all heart rates (resting, postexercise, 30-second recovery, and 60-second recovery). The total is the fatigue index. The index is unique for each individual and should be compared to the individual's average index for several days during a rested period. Use table I.1 to evaluate the index.

During a 3-week extended duty cycle, a firefighter chose to ignore the signs of fatigue appearing at day 8. By day 12, he had developed a serious cold and sore throat and was unable to work for the next 2 weeks.

Avoiding overtraining is as much an art as a science, requiring careful observation of fatigue symptoms, good communication, and the willingness to rest—the only effective treatment for overtraining or overwork. Mild cases may improve with reduced workload and more rest. More serious cases demand time off or even bed rest. Because the immune system is depressed, an overworked wildland firefighter is more likely to contract an upper respiratory tract infection. Remember, training should be approached as a gentle pastime. Make haste slowly and you will eventually reach your goals.

Table I.1—Criteria for Evaluating the Fatigue Test—The higher the index is above baseline values, the greater the likelihood that the wildland firefighter has not recovered from prior training or work. When the fatigue index is more than 20 beats above normal, the firefighter is at increased risk for depressed immune function and upper respiratory infections.

Increase in Fitness Index	Risk of overtraining
0 to 20 above normal	Not generally a concern unless sustained
20 to 30 above normal	Slightly increased (Avoid hard training)
30 to 45 above normal	Increased risk (Suggest easy training only)
More than 45 above normal	High risk (Suggest no training)

Reprinted, with permission, from B.J. Sharkey and S.E. Gaskill, 2006, Sports physiology for coaches. (Champaign, IL: Human Kinetics), 238.

Appendix J—Medical Considerations

Reproductive Risks

Wildland firefighters and field workers face many hazards in the conduct of their duties. Among these hazards are potential reproductive risks, such as exposure to toxic chemicals, heat, and other factors that can threaten someone's ability to conceive or bear a healthy child. These potential risks affect both men and women.

Smoke

While exposure to cigarette smoke has been linked to low birth weight, spontaneous abortion, still birth, preterm birth, and cleft palate, there is little information concerning the risks of exposure to toxic chemicals at levels measured in the breathing zone of wildland firefighters. Carbon monoxide has the potential to affect the developing fetus, but cigarette smokers are regularly exposed to levels of carbon monoxide several times higher than those occasionally experienced by firefighters. Prolonged exposure to fine particulate ($PM_{2.5}$, smaller than 2.5 microns) can deaden ciliary action in airways and suppress immune function, opening the door to respiratory infections, bronchitis, pneumonia, and even heart disease.

Heat

Exposure to extreme heat has been linked to male infertility and possibly to birth defects in the offspring of exposed mothers. Although maternal illness with prolonged high fever has been associated with birth defects, sauna studies and case studies of pregnant runners have not revealed birth problems. In fact, the opposite has been true for women who remain active during pregnancy. And while wildland firefighting has the potential for heat stress, studies have not indicated severe heat problems, especially when firefighters are fit, acclimatized, and hydrated. Low humidity and wind enhance evaporative and convective cooling, lowering the risk of heat stress.

Pregnant women who are physically capable of performing the duties of their position may continue working at their discretion (U.S. Supreme Court: Automobile Workers v. Johnson Controls, Inc., 499 U.S. 187, 1991). While it is not the obligation of the employer to protect the fetus, the employer may be able to assign the worker to less hazardous duties when requested to do so. Workers who are pregnant, breast feeding, or attempting to conceive should consult their physician if they are concerned about the reproductive risks of firefighting or other duties. Pregnant firefighters who, on the advice of a physician, cannot continue working in any capacity, should request leave based on the existing pregnancy or on other leave policies of the agency they work for.

Stress Test

The American College of Sports Medicine recommends a medical examination for persons older than 40, for those with heart disease risk factors, and for those who have been sedentary before a major increase in activity. For many others, a simple health screening questionnaire provides assurance of the readiness to engage in training, work, or a job-related work capacity test. Use of the questionnaire substantially reduces the risk of taking work capacity tests or training for apparently healthy adults. Candidates for fitness training, firefighting, or field work should have a medical examination or complete the health screening questionnaire before taking a work capacity test or beginning strenuous training.

If you are 45 or older, have one or more heart disease risk factors (smoking, high blood pressure, elevated cholesterol), and have been inactive, your physician may recommend an electrocardiograph (ECG)-monitored exercise test. A progressive treadmill test (stress test) determines cardiovascular health.

Warning Signs

Here are some points to consider if symptoms or warning signs appear during work capacity testing, training, or work.

Group 1

These warning signs may be remedied without medical consultation. Report them if they occur frequently.

Side stitches are muscle spasms (intercostal muscles between the ribs or the diaphragm) that may be relieved by sitting, leaning forward, and pushing the abdominal organs against the diaphragm. Side stitches usually disappear as training progresses and fitness improves.

Breathlessness that lasts more than a few minutes after exercise stops may be relieved by training at a lower intensity or using the talk test (you should be able to carry on a conversation during aerobic exercise).

Nausea or vomiting during or after exercise may be relieved by waiting several hours after eating before exercising. Exercise moderately and extend the cool-down period.

Prolonged fatigue the day after exercise or insomnia can be relieved by reducing the intensity of training, then increasing training gradually.

Group 2

Try the suggested remedies for these warning signs. If they don't help, consult your physician.

Arthritic flareups during or soon after exercise can be relieved by rest, cooling the affected area with an ice pack, and taking aspirin or ibuprofen. Resume exercise gradually. Use cross training to reduce repetitive trauma.

Rapid heart rate during or shortly after vigorous exercise can be relieved by training at a lower intensity and increasing exercise intensity slowly. Avoid exercising in the heat.

Wheezing and phlegm during or soon after exercise may be relieved by warming up gradually, reducing exercise intensity, avoiding cold, dry air, or by using a mask to warm cold air.

Group 3

If any of these occur, STOP EXERCISE. Consult your physician before resuming exercise.

Pain or pressure in the middle of the chest or in the arm or throat, precipitated by exercise or occurring soon after exercise.

Abnormal heart action during or soon after exercise. Abnormalities include irregular or fluttering pulse, palpitations in the chest, a sudden burst of rapid heart beats, or a sudden drop in heart rate.

Dizziness, light-headedness, sudden loss of coordination, confusion, cold sweat, glassy stares, pallor, blueness, or fainting. Stop exercising. Sit with your head between your legs or lie down with your feet elevated.

Things To Avoid

Sudden vigorous exercise without warming up can cause cardiac abnormalities. Warming up and cooling down reduce the likelihood of cardiac complications.

Downhill running has been called a "crime against the body" by experienced crew leaders. Running down steep grades increases the impact and the risk of chronic knee problems. While uphill hiking or running is good for training, minimize the amount of downhill running. Hike or jog slowly on the downhills or use hiking poles to reduce impact.

Straight leg situps don't help stomach muscles and they can aggravate back problems. Do bent-knee crunches or curlups with the arms folded across the chest.
Full squats with weights can aggravate knee problems. Use leg press machines or squat with a spotter. Don't go beyond a 90-degree knee bend.

Neck circles and the backover (lying on your back, raising your legs over your head to touch the floor) may be stressful for those at risk of neck injuries.
Standing toe touches can aggravate the lower back when the legs are straight. Use a seated toe touch with the knees slightly bent.

Exercise Problems

Minor exercise problems should be viewed as symptoms. Here are some common problems and some possible solutions.

Blisters can be prevented with properly fitted shoes, good socks (two pairs or a double-layer pair), and lubrication (Bag Balm). Blisters can be treated with moleskin or duct tape.

Muscle soreness can be minimized by warming up and stretching, gradually progressing with exercise intensity, and avoiding fast or eccentric movements (where a lengthening muscle is contracted). Delayed onset muscle soreness occurs a day or more after vigorous effort (especially after downhill running). Stretching and anti-inflammatory agents such as ibuprofen relieve the discomfort or soreness.

Muscle cramps are powerful involuntary contractions that may be caused by dehydration, electrolyte (sodium, potassium, calcium) imbalance, or both. Avoid cramps by warming up and by replacing fluids and electrolytes. Relieve cramps by stretching and massaging the cramped muscle.

Bone bruises on the feet can be avoided by careful foot placement, running on soft surfaces, and good footwear. Treatment includes ice, padding, and cross training to allow recovery.

Shin splints (pain on the front of the shins) have many possible causes. Preventing shin splints includes gradually changing training intensity or distance, running on softer surfaces, wearing good footwear, stretching, and performing strengthening exercises. Other effective treatments may include rest, ice, massage, taping your shins, and putting heel pads in your shoes to cushion impact. A persistent point of pain could indicate a stress fracture. Persistent diffuse pain could signal increased pressure on the muscle on the front of the shin. See an athletic trainer or sports medicine specialist.

Knee pain could be due to a number of factors. Use rest, ice, and anti-inflammatory agents (such as ibuprofen) to reduce discomfort. Resume activity with new footwear. If problems persist, see a podiatrist. If the problem is an old injury with associated arthritis, try rest, ice, and anti-inflammatory agents to reduce the pain. Resume activity with exercises to strengthen the thigh muscles (weightlifting, bicycling). If the problem persists, see a sports medicine specialist.

Lower back pain can be due to poor posture, inactivity, lack of flexibility, or weak abdominal and back muscles. Preventing lower back pain requires paying attention to each possible cause and to proper lifting technique. Treatment involves rest, but only until pain subsides, followed by a gradual return to activity.

Exertional Rhabdomyolysis

Exertional rhabdomyolysis is a potentially dangerous syndrome associated with intense exercise, particularly in hot, humid conditions. Inside damaged muscles, cell membranes leak, allowing the contents of the muscle cells to enter the bloodstream. The kidneys may fail while they try to cleanse the blood.

Although rhabdomyolysis is uncommon, its consequences can be life threatening. Symptoms include dark urine (myoglobin leaked from muscle cells), muscle soreness, weakness, and swelling. Laboratory tests may be needed to confirm the diagnosis. If you suspect that you or a coworker may be experiencing exertional rhabdomyolysis, seek medical help immediately.

Exertional rhabdomyolysis is more likely to occur in untrained individuals involved in intense exertion in the heat, during military or firefighter training, for instance. Other risk factors include impaired muscle blood flow (crush injuries or compartment syndrome in which blood supply is cut off to muscles that swell, but don't have room to expand), viral illnesses, drug use (prescription and recreational), certain metabolic disorders, sickle cell trait, and malignant hyperthermia (a special type of heat illness).

To avoid exertional rhabdomyolysis:

- Increase training gradually
- Acclimate to the heat
- Maintain hydration
- Avoid excessive exertion, especially eccentric activity where a lengthening muscle is contracted (running downhill, repetitive lowering of heavy weights)

About the Authors

Brian Sharkey, an exercise physiologist at MTDC, has done research and development work on fitness tests and programs, heat stress, hydration, nutrition, protective clothing, tools, fatigue, work/rest cycles, and employee health (wellness). His work has been honored with USDA Superior Service and Distinguished Service Awards, and a Forest Service Technology Transfer Award. In 2009, Sharkey received the Wildland Fire Safety Award from the International Association of Wildland Fire. He is past president of the American College of Sports Medicine and author of several books including "Hard Work" (2008) with Dr. Paul Davis, published by Human Kinetics.

Steve Gaskill of the University of Montana's Human Performance Laboratory was a coach for the U.S. Cross Country Ski Team before earning a doctorate in exercise physiology. His research includes laboratory and field studies of wildland firefighters. Gaskill and Sharkey coauthored "Sport Physiology" (2006) and "Fitness and Health," 6th ed. (2007, http://www.HumanKinetics.com).

Library Card

Sharkey, Brian; Gaskill, Steven E. 2009. Fitness and work capacity: 2009 edition. NWCG PMS 304-2. Boise, ID: National Wildfire Coordinating Group, Safety and Health Working Team, National Interagency Fire Center. 98 p.

This report updates "Fitness and Work Capacity: Second Edition," published in 1997. The 2009 edition includes new information on core training and nutrition. This report is intended to help forestry field workers and firefighters achieve health and fitness while improving their work capacity. The first edition of "Fitness and Work Capacity" was published in 1977.

Keywords: aerobic fitness, core training, health education, muscular fitness, nutrition, wellness, work capacity tests, workout programs

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