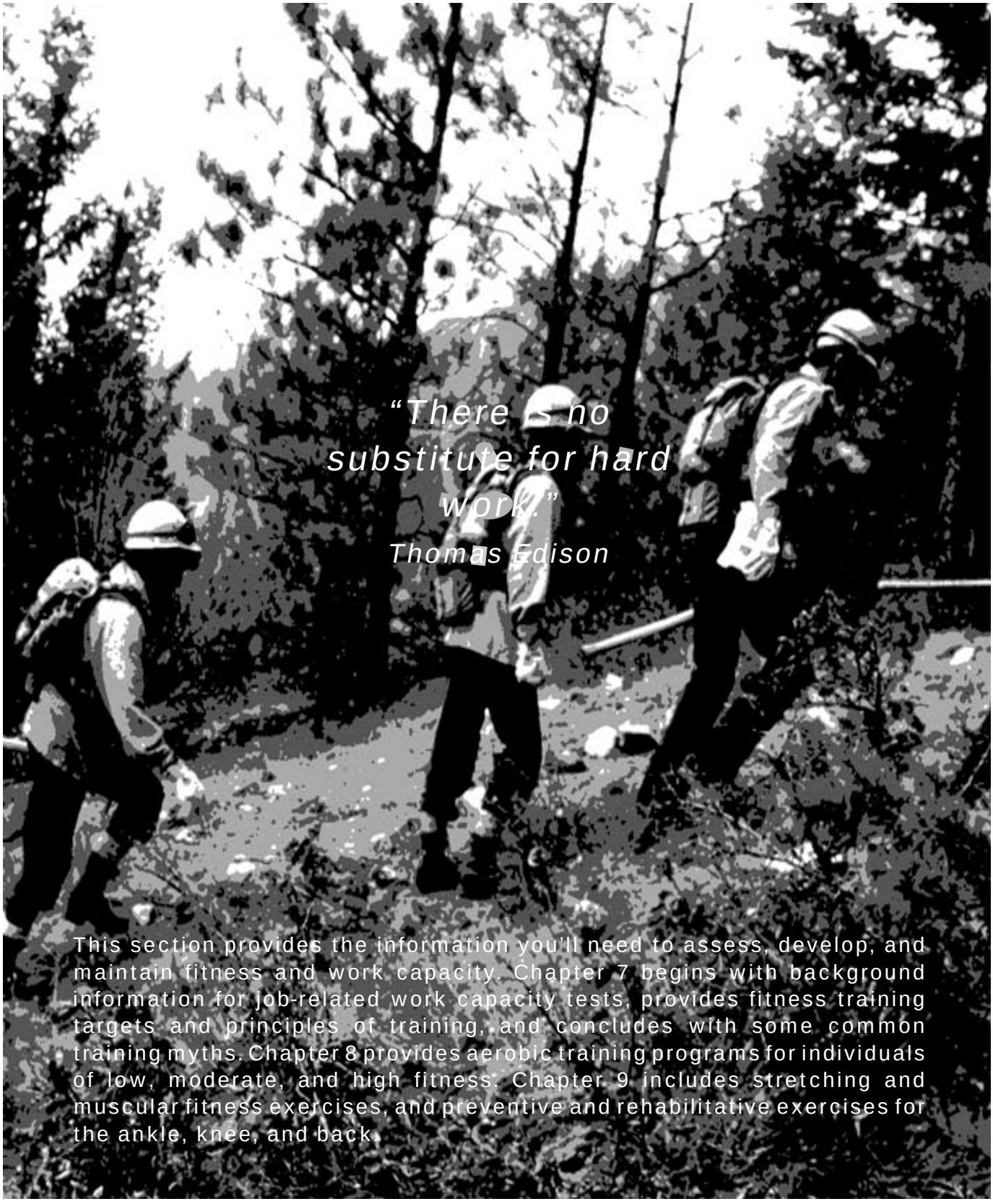
Part Three

Fit to Work



"There is no substitute for hard work."

Thomas Edison

This section provides the information you'll need to assess, develop, and maintain fitness and work capacity. Chapter 7 begins with background information for job-related work capacity tests, provides fitness training targets and principles of training, and concludes with some common training myths. Chapter 8 provides aerobic training programs for individuals of low, moderate, and high fitness. Chapter 9 includes stretching and muscular fitness exercises, and preventive and rehabilitative exercises for the ankle, knee, and back.

Chapter 7—*Work Capacity Tests and Training*

Studies of firefighting and other field tasks confirm the link between fitness and work performance. Fit workers accomplish more with less fatigue, and they perform better in a hot environment. Fit workers cope with and recover from adverse firefighting conditions like long shifts and reduced rest, and they miss fewer days of work because of illness or injury. In short, fitness is the most important factor in work capacity.

Wildland Firefighting Tasks

In 1995 the wildland firefighting job task analysis was revised with the participation of all National Wildfire Coordinating Group agencies. The analysis identified the tasks performed by firefighters and rated each task in terms of frequency, duration, difficulty, and importance (Table 7.1). New categories in the revised analysis

Table 7.1—**Energy costs of common wildland firefighting tasks.** The energy costs are estimates for someone weighing 150 pounds. Add or subtract 10% for each 15 pounds above or below 150 pounds.

Wildland Firefighting Tasks	Energy cal/min	Cost 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, fluid replacement, 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

included performing under adverse conditions and emergency responses. The table identifies the tasks and indicates the approximate energy cost of each task.

The analysis indicated that the most important firefighting tasks were digging or chopping with a handtool, performing under adverse conditions, hiking with light loads, and lifting and carrying light loads. Packing heavy loads, emergency responses, and chain sawing received somewhat lower ratings, primarily because they occurred less frequently.

Work Capacity Tests

Since 1975 Federal Agencies have utilized a 5-minute Step Test to screen candidates for wildland firefighting jobs. In 1994 the Missoula Technology and Development Center (MTDC) began a review of fitness testing and training materials. The goal was to revise and update all materials to ensure that they complied with new laws and information.

Based on a job task analysis and a review of studies on wildland firefighters, MTDC conducted laboratory and field studies to develop and validate a test of work capacity. The test needed to be: job-related, safe, inexpensive, brief, easy to administer, valid, reliable, and objective. Moreover, the test had to comply with applicable laws (Americans With Disabilities Act) and regulations (Equal Employment Opportunity Commission for adverse impact), and with the Federal Uniform Guidelines for Employee Selection Procedures. While several job-related tests were studied, only one —the Pack Test—met the criteria.

The Pack Test

The Pack Test consists of a 4.83-km (3-mile) hike with a 20.5-kg (45-pound) pack over level terrain. The pack is a 5-gallon backpack suppression water bag, a tool used by firefighters. Field studies show that performance on the Pack Test is significantly related to performance in other firefighting tasks, including fireline construction with hand tools and carrying loads over hilly terrain. Studies conducted at the University of Montana Human Performance Laboratory indicate that the test's energy cost is similar to that demanded on the job, and that performance is correlated to the Step Test, the 1.5-mile run, and the treadmill test of aerobic fitness. A score of 45 minutes on the Pack Test approximates an aerobic fitness score of 45 (mL/kg • min). Because of its length, the Pack Test is an excellent indicator of the capacity to perform prolonged arduous work under adverse conditions, with a reserve to carry out emergency responses. And performance on the Pack Test is significantly related to muscular fitness, including measures of upper and lower body strength.

The Pack Test is:

Job related—It is an actual work task and is correlated with performance on other work tasks.

Safe—The test poses less risk than the job itself.

Inexpensive—No additional equipment is required for test administration.

Brief—While the test takes over 40 minutes, a number of candidates can be tested at the same time.

Easy to administer—The instructions are simple.

Valid—The test clearly evaluates what it is intended to test. It meets the standard for content validity (work sample) and criterion-related validity (related to performance on other work tasks, to VO_2 max, and to muscular fitness).

Reliable—Test results are consistent; test-retest correlations are extremely high.

Objective—Scores are not subject to interpretation. There is little opportunity for scoring errors or cheating on the test.

Since it involves an actual work sample, the test does not discriminate against persons with disabilities. Scores are not adversely affected by gender, ethnicity, age, height, or weight. The procedure can be used for preseason training and for self-testing.

How to Train for the Pack Test

Begin training at least 4 to 6 weeks before you report for duty. Train by hiking or power walking, using the ankle-height footwear you will use in the test.

- *Hike a 3-mile flat course without a pack. When you can cover the course in less than 45 minutes*
- *Add a pack with about 25 pounds to your training hikes*
- *Increase the pack weight until you can hike 3 miles in 45 minutes with a 45-pound pack*
- *Also hike hills (with a pack) to build leg strength and endurance and jog the flat course (without a pack) to build aerobic fitness; do overdistance for stamina; cross train (mountain biking, weight lifting).*

Pack Test Instructions

The Pack Test is a valid, job-related test of work capacity. The test uses a firefighting tool (pack) and requires an energy cost similar to that demanded on the job. Test scores are correlated to laboratory measures of aerobic and muscular fitness and to performance of the firefighting tasks identified in the job task analysis. The duration of the test ensures the capacity to perform prolonged arduous work, under adverse conditions, with a reserve to carry out emergency responses.

While the Pack Test is relatively easy to administer, best results are obtained with a trained administrator, a measured course, accurate pack weight, and a well-informed candidate.

The Test Administrator

The administrator shall be a trained and certified first responder who is aware of symptoms of distress and appropriate first aid procedures. A written emergency plan should be posted at the test site. The administrator is responsible for checking the course for safety, verifying course length and pack weight, instructing the candidate, timing the test, and recording and interpreting the results. The administrator should be familiar with the purpose of the test, its development and validation procedures, and should be able to answer questions commonly asked by candidates.

The Course

The course requires a carefully measured 4.8-km (3-mile) loop or out-and-back course over level or essentially level terrain. A moderate grade (2 to 3%) is acceptable if the course starts and finishes at the same point. The surface should be relatively smooth and free of hazards such as roots and rocks. If a forest or rural road is used, the course should be marked with flags and cones to warn motorists and to provide a separate lane for the participants. Intersections should be avoided or manned with trained course marshals equipped with blaze orange vests and warning flags. Once selected, the course should be measured, verified, and marked with permanent markers. A measuring wheel or properly calibrated odometer on a mountain bike may be used to establish the course's length.

> **Course Options:** A 3-mile loop or out-and-back course is ideal if the route is flat. If a 3-mile loop is not available, consider a short loop or a school track. On short loops a counter may be needed to ensure that all candidates complete the full test distance.

The Pack

The pack is a 5-gallon backpack fire suppression water bag (FSN 8465-01-321-1678, available from the General Services Administration) filled to a gross weight of 20.5 kg (45 pounds ± $^1/_2$ pound). The weight should be checked before each test period using a calibrated scale.

> **Accommodations:** The pack has padded shoulder straps. However, candidates may use gloves or other material to make the pack more comfortable during the test. A walking stick (provided by the candidate) may be used during the test.

The Candidate

Candidates must be informed of the purpose of the test and told that there is a small likelihood of injury or adverse reaction. The candidate must read and complete the PAR Q health screening questionnaire. He or she should be encouraged to see a physician if answering yes to any of the questions. They must then sign and date a form indicating that they have been informed of the purpose and risks of the test, and have completed the PAR Q questionnaire.

> **Clothing:** Candidates may select the clothing worn during the test. Ankle-height boots (or sport shoes) are **required**.

Candidates must be instructed to hike the distance at a brisk pace but without breaking into a jog (their heel must touch the ground before their toe leaves the ground). They must be informed of the course's layout, check points, and hazards. They should be informed of the passing score and given the opportunity to ask questions. Finally they must be told that **they can terminate the test at any point for any reason**. Following instructions, the candidate should be allowed to stretch and warm up before donning the pack.

> **Note: Candidates should be informed of the test well in advance of testing so they will be able to train for it.**

The Test

Testing begins when the administrator says "Go" and finishes when the candidate crosses the finish (3-mile) line. The administrator should warn candidates to hike at their own pace and avoid visiting during the test. The administrator may use a bicycle to monitor candidates during the test. Remind candidates that jogging will result in disqualification. The test should be timed with two watches in case of malfunction or timing error. The time for completion (in minutes and seconds) is recorded as the candidate's score.

> **Environment:** Administer the test in moderate conditions (Chapter 5, page 29). Tests administered at elevations above 4000 feet should be adjusted (see Table 7.2).

The altitude adjustment assumes that the candidate has had an opportunity to acclimate to the altitude of the test site. A candidate who doesn't meet the required standard, even with the adjustment, should be encouraged to train at that altitude and retake the test (recommend 1 week of training for each 1000 feet above 5000 feet elevation).

The Results

Results provide evidence of a candidate's fitness for prolonged arduous work. Candidates should be encouraged to retake the test if they do not meet the required standard. Those close to the cutoff score may take the test at the next scheduled testing session. Candidates who score above 46 minutes should be encouraged to train for several weeks before attempting a retest. When possible, candidates should be allowed to use the 5-gallon backpack water bag while training for the test.

Other Job-related Tests

Since 1975 the Step Test and 1.5-mile run have been used to assess fitness and to help select wildland firefighters. Both tests are valid, reliable, and objective measures of aerobic fitness. The 3-mile Pack Test replaces the Step Test requirement for firefighters. Variations of the Pack Test have been developed to qualify candidates for jobs with lower fitness requirements. The tests include:

Fitness Requirement	*Test*	*Description*
Arduous (45 mL/kg • min) Lift over 50 lbs	Pack Test	3-mile hike with 45-pound pack in 45 min
Moderate (40 mL/kg • min) Lift 25-50 lbs	Field Test	2-mile hike with 25-pound pack in 30 min
Light (35 mL/kg • min) Light lifting	Walk Test	1-mile hike in 16 min

Use the Pack Test instructions to administer these tests. Be sure to complete the PAR-Q health screening questionnaire before using either test. Use the altitude correction table to adjust scores (Table 7.2).

Table 7.2—**Altitude correction**. Add the correction to the required test time.

Altitude (feet)	1-mile Walk Test (Seconds)	2-mile Field Test (Seconds)	3-mile Pack Test (Seconds)
4000	10	20	30
5000	15	30	45
6000	20	40	60
7000	25	50	75
8000	30	60	90

1.5-Mile Run

The 1.5-mile run provides an accurate estimate of aerobic fitness (VO_2 max). The prediction is based on the oxygen cost of running at certain speeds (Figure 7.1). Since the test requires a sense of pace and a near-maximal effort, it is essential that you have trained for the run and that you complete the PAR-Q health screening questionnaire. Inactive individuals older than 40 should consider a medical examination and 6 to 8 weeks of training before taking this strenuous test.

Rest after a light warmup. Then run 1.5 miles over a level, measured course. Pacing and high motivation are essential for best performances. Use time for the run to predict fitness (aerobic capacity) and work capacity. For a test taken between 5000 and 6000 feet altitude subtract 30 seconds to determine the adjusted time. An unadjusted time of 12 minutes and 30 seconds would adjust to 12 minutes, corresponding to a fitness score of 43.

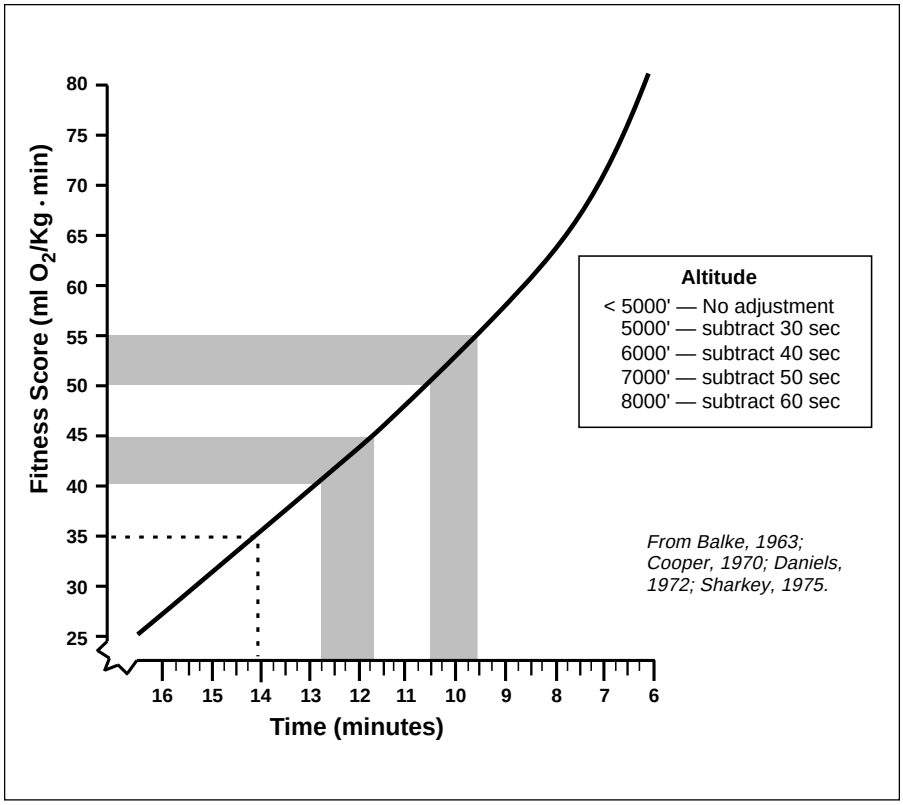


Figure 7.1—**The 1.5-mile fitness test**.

Fitness Targets

Here are some fitness targets to guide preseason preparation for field workers and firefighters. Table 7.3 includes required and recommended levels of aerobic and muscular fitness. The recommended levels are based on the capabilities of workers or on the known requirements of the job.

Remember, you can increase VO_2 max from 20 to 25% in 2 to 3 months, or by more than 30% with significant weight loss. Strength increases at a rate of 2 to 3% per week in the typical program, so it could take 2 months to increase strength by 20%. Muscular endurance increases rapidly, you can double the number of pushups or situps in 2 months. Start early and make sensible progress toward your goals.

Table 7.3—**Required (Req'd) and recommended (Rec) fitness levels**.

Job	Pack Test *(Minutes)*		Aerobic fitness *(mL/kg · min)*		Muscular fitness *(Recommendations)**				
	Req'd	Rec	Req'd	Rec	Leg press (lb) x body wt	Bench press (lb) x body wt	Pullups	Pushups	Situps
Field worker	—	45	—	45	1.5x	0.7x	3	15	25
Wildland firefighter	45	—	45	—	2.0x	0.8x	5	20	30
Hot shot crew member	45	42.5	45	50	2.5x	1.0x	6	25	40
Smoke-jumper**	—	42.5	48	50	2.5x	1.0x	7	25	45

**Recommended fitness levels provide the capacity to do the job safely and well, with a reserve to meet unforeseen emergencies.*

***Smokejumper requirements: 1.5-mile run in 11 minutes; 7 pullups, 25 pushups, 45 situps; packout - 3 miles with 110 pounds in less than 90 minutes.*

Fitness Coordinator

Ideally, each unit should include a qualified fitness coordinator to design and lead effective training programs. Qualifications should include academic preparation, fitness and field work experience, and certification by a recognized organization (such as the American College of Sports Medicine). If a person with this background isn't available, assistance may be provided by a local university, sports medicine clinic, health club, or YMCA. Another alternative is to help an interested employee acquire the necessary knowledge and experience. Identify an individual and help them turn their avocation into an asset for the organization.

Principles of Training

Apply these principles and you are certain to achieve your training goals.

Adaptation

Training is a gentle pastime that coaxes subtle, progressive changes as the body adapts to added demands. Training can't be rushed. Go too fast and you'll end up with fatigue, illness, or injury.

Individual Response

Individuals respond differently to training for a number of reasons, including heredity, maturity, nutrition, rest, level of fitness, environmental influences, and motivation.

Heredity—Physique, muscle fiber characteristics, heart and lung size, and other factors related to fitness and performance are inherited. The ability to respond to training may also be influenced by heredity. Training still has a major influence, so we need to do the best we can with the characteristics we've inherited.

Maturity—Immature workers need more rest and time for recovery.

Nutrition—Proper nutrition (energy, protein, nutrients) is essential since training depends on the ability to synthesize protein (enzymes for aerobic training, contractile protein for strength training).

Rest and Sleep—Lack of adequate rest and sleep reduces the effect of training.

Level of Fitness—The response to training is more dramatic when the initial level of fitness is low.

Environment—Individual differences in the response to heat, altitude, allergens, etc. influence the ability to train and perform.

Illness or Injury—Illness or injury influences one's ability to train.

Motivation—People train and work harder when they are motivated to be part of a team that has an important job to do.

Overload

Training must exceed the typical daily demands. As the body adapts to the increased load, more should be added. The overload stimulates changes designed to help the body cope with growing demands on the muscles and other systems.

Progression

When the load is increased too quickly, the body can't adapt; instead it breaks down. Make progress gradually, allowing time for rest and recovery. Make haste slowly! (See Figure 7.2)

Specificity

The effects of exercise and training are specific in terms of muscle fibers, metabolic pathways, energy sources, movement patterns, and more. Specific training brings specific results. Performance improves when training is specific to the activity. But every rule has its exceptions. Specificity does not mean that you should avoid training opposite or adjacent muscles. Other muscles should be trained to avoid imbalances that could predispose you to injury, and to provide back up when primary muscles become fatigued.

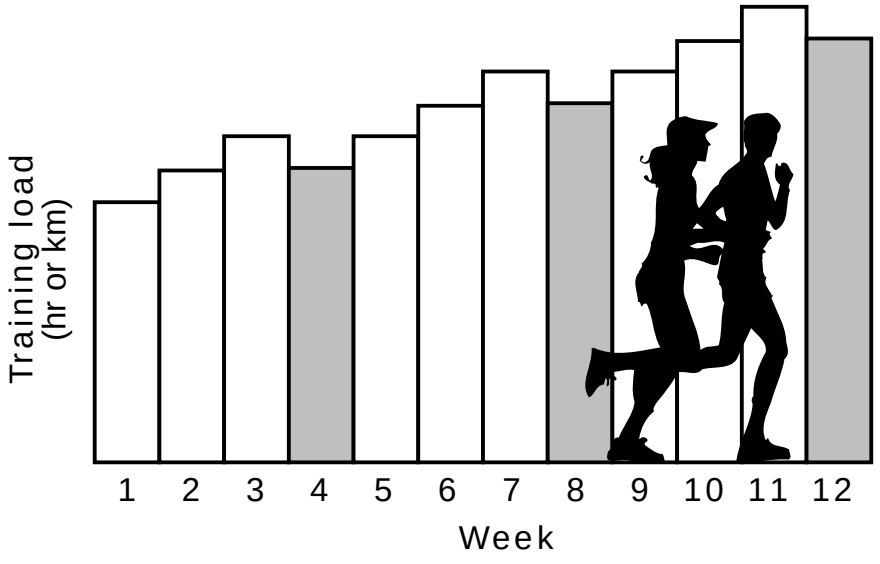


Figure 7.2—**Training progression with 4-week cycles**.

Variation

Vary the program to avoid boredom, to maintain interest, and to reduce the likelihood of overuse injuries. The primary variation is:

Work versus Rest—Muscles need time to adapt to the effects of training. Other variations to consider include:

Hard versus Easy—Follow a hard day with an easy one.

Long versus Short—Follow a long day with a short workout.

When workouts become dull, try something different, like cross training.

Warmup and Cooldown

Always plan for a warmup and cool-down. They are essential parts of every workout.

Long-term Training

It takes years of training to approach high levels of performance. Long-term training allows for gradual progress, adaptation, growth and development, and acquisition of skill and efficiency. Experience counts.

Reversibility

Most training adaptations are reversible; they are lost more rapidly than they are gained. Avoid losing hard-earned adaptations by maintaining a year-round program.

Moderation

Fitness is a lifetime endeavor to enhance health, performance, and the quality of life. Practice moderation in all things, including training. Pace yourself for the long haul.

Training Myths

A number of oft-quoted training myths have no basis in medical or scientific research, including:

- *No pain, no gain.*
- *Go for the burn.*
- *Break down muscle to improve it.*
- *Lactic acid causes muscle soreness.*
- *Muscle turns to fat (or fat turns to muscle).*
- *Run out of wind.*

Pain

Pain is not a natural consequence of exercise or training. It is a sign of a problem that shouldn't be ignored. During exercise the body produces natural opiates, called endorphins, that can mask discomfort. But an individual who experiences real pain during training should back off. If the pain persists, the problem should be evaluated.

Burn

Burning is a sensation experienced after many repetitions. It is probably due to the increased acidity associated with elevated levels of lactic acid in the muscle. While it isn't dangerous, it isn't a necessary part of strength training.

Break Down Muscle

Microtrauma sometimes occurs in muscle during vigorous training or competition. While this microtrauma may be part of the process, neither pain nor injury are normal consequences of training. Both should be avoided.

Lactic Acid

As I have noted, lactic acid is cleared from muscles and the blood within an hour of vigorous exercise, while soreness comes 24 hours later. The effort that led to the lactic acid may cause the soreness, but the lactic acid does not.

Muscle to Fat

Muscle and fat are highly specialized tissues. Muscle is composed of long thin fibers that contract; fat cells are spherical blobs. Aerobic training leads to storage of some fat within muscle fibers; the fat is used to fuel contractions. Overeating and inactivity leads to fat storage around organs and muscles. But muscle doesn't turn to fat, and fat cannot possibly turn into muscle.

Wind

The sensation of breathlessness during vigorous exercise does feel like you can't get enough air (wind). However, the real problem is an excess of carbon dioxide, the primary stimulus of respiration. The CO_2 produced during exercise must be eliminated with deep breathing that emphasizes the exhalation and the inhalation. The excess carbon dioxide could be a sign that you are working above your anaerobic threshold. The problem may concern the oxidative capacity of your muscles.

Fitness is a lifetime endeavor to enhance health, performance, and the quality of life.