

CHAPTER 4
CARDIOVASCULAR ENDURANCE

REVISED JULY 2024

TABLE OF CONTENTS

<u>INTRODUCTION</u>	4-3
<u>GUIDELINES</u>	4-4
Basic Cardiovascular Program Factors	4-4
Intensity	4-4
Duration.....	4-5
Frequency	4-5
Mode	4-6
Aerobic Activity/Pacing.....	4-6
Workout Components.....	4-6
Medical Considerations	4-6
<u>WALKING</u>	4-7
<u>JOGGING AND RUNNING</u>	4-8
<u>SWIMMING</u>	4-10
<u>BICYCLING AND STATIONARY CYCLING</u>	4-11
<u>ROPE SKIPPING</u>	4-14
<u>STAIR CLIMBING MACHINES</u>	4-15

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 4

CARDIOVASCULAR ENDURANCE

1. INTRODUCTION.

a. Cardiovascular endurance is defined as the ability to perform moderate- to high-intensity exercise for prolonged periods of time, using large muscle groups (e.g., jogging, bicycling, swimming, and brisk walking). This type of exercise is aerobic in nature and depends upon the ability of the respiratory and cardiovascular systems, and the exercising muscles to transport and utilize oxygen.

Cardiovascular endurance is a major component of physical fitness. This is due to the fact that a low cardiovascular fitness level is associated with an increase in premature death from all causes, especially cardiovascular disease; on the other hand, higher cardiovascular fitness levels are associated with many health benefits.

b. Regular cardiovascular exercise causes the heart and respiratory system to become more efficient, thus requiring less effort for the heart to function during normal activities and at rest. Improvement in several of the body's systems with cardiovascular exercise are as follows:

- (1) Increase in heart size (specifically, the chamber size of the left ventricle in the heart).
- (2) Increase in stroke volume (amount of blood the heart ejects with each contraction).
- (3) Increase in fat utilization during exercise.
- (4) Increase in maximum aerobic capacity (the amount of oxygen one can consume during maximal effort).
- (5) Resting heart rate is lowered.
- (6) Decrease in blood pressure in some people.
- (7) Decrease in blood cholesterol.
- (8) Decrease in stress and anxiety symptoms.

2. GUIDELINES.

a. Basic Cardiovascular Program Factors.

- (1) Intensity—the level of exertion.
- (2) Duration—the length of exertion.
- (3) Frequency—the number of workouts per week.
- (4) Mode—the type of exercise.

b. Intensity.

(1) During exercise, the heart rate increases proportionately with oxygen energy requirement. For this reason, the exercise heart rate is used as a simple measure for determining exercise intensity levels. To get the training effect (increase in cardiovascular fitness) from cardiovascular exercise, the heart rate must reach 55 percent of its calculated maximum. The American College of Sports Medicine recommends that exercise intensity should range between 55 to 90 percent of maximal heart rate. A well-conditioned person may be able to exercise at 80 percent of their maximum heart rate for two hours, where a poor-conditioned person may fatigue in just a few minutes. To determine if they are exercising at an intensity that will improve their cardiovascular fitness, it is important for individuals to know their exercising heart rate range. Use the following formula to determine the training heart rate range:

Training Heart Rate Range

	Lower Limit	Upper Limit
Maximal heart rate	190	190
Resting heart rate	<u>-60</u>	<u>- 60</u>
Heart rate reserve	130	130
Conditioning intensity (55-90 percent heart rate range)	<u>x.55</u>	<u>x.90</u>
	72	117
Resting heart rate	<u>+60</u>	<u>+60</u>
Target heart rate	132	177

NOTE: 220 minus age = maximum heart rate (the above formula is for a person 30 years of age with a resting heart rate of 60 beats per minute).

(2) The resting heart rate is best determined in the morning while still lying in bed. Locate pulse at the carotid artery, located under the jaw bone on the neck, slightly to the right or left of the windpipe; or at the radial artery, located on the inside of the wrist near the base of the thumb. Use the fingertips to take

the pulse rather than the thumb, as the pulse might also be detected in the thumb and give a false reading. When the pulse is felt, count the beats for 30 seconds and multiply by 2 to determine the beats per minute. It's best to take the resting heart rate for three days and then take the average.

(3) To ensure the appropriate intensity level is attained, check pulse rate while exercising. This is easy during exercises such as bicycling and brisk walking; however, it is more difficult while running or jogging. Therefore, the pulse should be checked immediately after exercising. If the heart rate is within the target range, the proper intensity level has been achieved. If above or below the target range, decrease or increase the intensity of the workout accordingly.

(4) Another method to obtain the exercising heart rate is to purchase a heart rate monitor or smart device. This allows for monitoring of the heart rate during any type of activity.

c. Duration.

(1) The amount of exercise may vary in length of time. Excluding warm-up and cooldown, an exercise session should range between 15 and 60 minutes in duration. Anything less than 15 minutes does not elicit an improvement in cardiovascular endurance. The appropriate length of the exercise session is related to the intensity. For example, an individual may choose to run for 15 minutes at 90 percent of maximum heart rate or run for 30 minutes at 70 percent of maximum heart rate. Both programs will improve cardiovascular endurance; however, lower intensity programs may carry a lower risk of orthopedic injury and heart problems during exercise.

(2) Remember, an exercise session refers to the time actually spent within the training heart rate range. It does not include the time it takes for the body to warm up and the heart to reach its minimum training rate.

d. Frequency. The frequency of exercise is dependent upon the duration and intensity of the exercise session. The recommended frequency ranges from three to five days a week. A minimum of three exercise sessions per week are required to improve cardiovascular fitness. More than five days per week produces little additional cardiovascular benefit and injuries are more likely to occur due to overtraining.

e. Mode.

(1) Activities that are low in intensity and short in duration produce low levels of improvement. Before an exercise can be considered aerobic, four criteria must be met:

- (a) The large muscles of the body must be used (primarily the legs).
- (b) The activity must be rhythmic and repetitive.
- (c) The training session must elicit a training heart rate between 55 percent and 90 percent of the maximum heart rate.
- (d) The activity must be sustained for a duration of at least 15 minutes, excluding warm-up and cooldown.

(2) If prone to injuries, particularly to the legs and feet, it is advisable to alternate weight-bearing with nonweight-bearing activities. Nonweight-bearing exercises such as cycling, swimming, and rowing are less stressful to the lower body than weight-bearing activities such as walking, running, and rope skipping.

f. Aerobic Activity/Pacing. In all aerobic activities, it is important to exercise at a comfortable pace. While exercising, a person should be able to maintain a conversation without undue fatigue. If still fatigued 10 minutes after stopping the exercise, they are pushing too hard. They are also working too hard if they have difficulty breathing or experience faintness during or after exercising. The aerobic activity should be decreased and the pulse checked to see if the training heart rate has been maintained.

g. Workout Components. Most workouts for developing physical fitness consist of a warm-up, main conditioning period, and cooldown phase. Prior to beginning any exercise program, refer to Chapter 3, Warm-Up, Stretching, and Flexibility, of this manual for proper warm-up and cooldown exercises.

h. Medical Considerations. Aches and pains are not unusual when first beginning an exercise program. However, if the pain persists after the first week, discontinue the program until a proper diagnosis has been obtained. Refer to Chapter 2, Injury Prevention and Treatment, of this manual for information on injury prevention and treatment.

3. WALKING.

a. Walking is a natural and healthy form of exercise. In some respects, walking is even better than running because it does not place a heavy strain on the tendons of the foot and leg. Walkers incur far fewer injuries than runners. If just beginning to get in shape and a weight-bearing type activity is desired, walking is an excellent choice.

- b. Walking for fitness should be at a brisk pace, with a definite rhythm. The pace should challenge the cardiovascular system but not cause shortness of breath. Arm swing should be normal and relaxed. Strike the ground with the heel first and then roll onto the ball of the foot. To ensure walking at the training heart rate level, monitor the heart rate midway through the workout and immediately afterward.
- c. Clothing should be comfortable, preferably made of cotton or a blend of cotton and polyester which absorbs sweat and allows for evaporation. Avoid clothing that traps sweat or retains heat, as it may cause excessive dehydration, heat exhaustion, or heat stroke. Weather permitting, wear a minimum amount of clothing. In colder weather wear thin layers of clothing adequate to maintain warmth around the chest and ribcage area. Additional suggested items are cotton gloves and a cap to prevent body heat loss. Most running shoes are also suitable for walking. Refer to paragraph 4.d. for tips on proper shoe selection.
- d. This exercise can be performed on a well-maintained treadmill.
- e. The following outlines workout criteria:
 - (1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).
 - (2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.
 - (3) Frequency. A minimum of three days per week up to a maximum of five days per week.
 - (4) Warm-Up and Cooldown. Five to ten minutes of slow walking.
 - (5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown periods. Refer to Chapter 3 of this manual for information on stretching and flexibility.

4. JOGGING AND RUNNING.

- a. Running is an excellent aerobic activity that can be done almost anywhere and with a minimum of equipment (*a well-maintained treadmill is acceptable*). When first beginning a fitness program, many people will start with a walking program and progress to jogging and running as their fitness level improves
- b. Jogging or running should be at a comfortable pace. Check pulse frequently until it is learned how the body feels at the training heart rate level. Run with hands

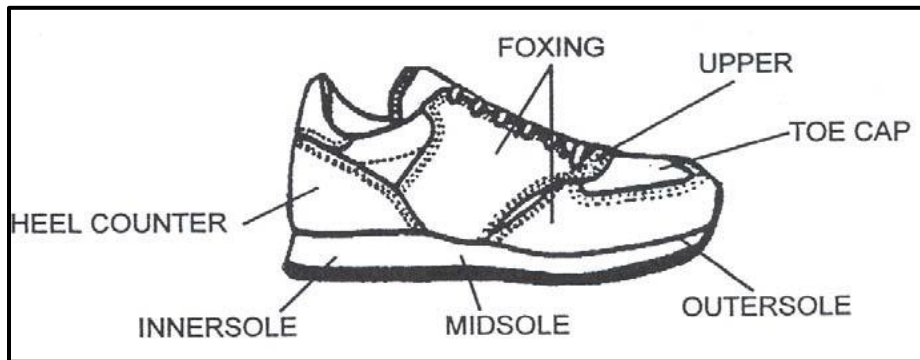
and arms relaxed and elbows slightly bent. The foot should strike the ground at the heel and roll forward onto the ball of the foot, finally pushing off with the toes. Do not run on the toes or the balls of the feet as this will lead to injuries. Most people will naturally find the stride that is best for their body. Do not attempt to adjust the stride unless uncomfortable.

c. Clothing should be comfortable and allow freedom of movement, preferably made of cotton or a blend of cotton and nylon or polyester. Clothing should absorb sweat and allow for evaporation. Avoid clothing that traps sweat or retains heat such as plastic or rubberized clothing. This is dangerous as it prevents evaporation or perspiration which causes body heat to rise to a dangerous level, promotes dehydration, and may lead to muscle cramps, fatigue, or even heat exhaustion. Weather permitting, wear a minimum amount of clothing. In colder weather, wear thin layers of clothing adequate to maintain warmth around the chest and ribcage area. All-weather suits (tops, pants, and hood) that are made from Gore-Tex or nylon may be desirable. Gore-Tex allows water vapor (sweat and heat) to pass through but resists water droplets (rain and snow). It insulates the body without letting it overheat or get wet or cold. Additional suggested items include cotton gloves and a cap to prevent body heat loss.

d. One should always wear shoes when running or jogging. Good running shoes will provide comfort and minimize the chance of injury. It is imperative that the wearer select shoes that fit well, meet their needs, and feel good.

(1) The best bet is to buy shoes from a reputable sporting goods store. Be cautious of the so-called "running shoes" that sell at bargain prices. Most of these are of poor quality and everything from blisters to shin splints may be part of the bargain. The key factors are not how the shoe looks or how much it costs, but rather that it provides good cushioning, a firm and supportive heel counter to provide stability, a good arch support, adequate flexibility, and durability. When trying on shoes for fit, wear the same type of socks that are worn when running. Tell the salesperson what sort of running surface is used as some shoes are designed for soft surfaces, others for hard. Be sure to try on and test various brands and models.

(2) Before buying shoes, check to see if they are built like the one in the following illustration:



(3) Always take measurements for size while standing and near the end of the day when feet are slightly larger. The following should be taken into consideration:

- (a) Cushioning. About 3/4 inch at the heel and good cushioning under the ball of the foot are needed.
- (b) Length. Shoes should be long enough to give toes plenty of room. Toes should not touch the front of the shoe.
- (c) Width. Shoes should feel snug and firm but should not be so tight that they bulge at the sides.
- (d) Counter. This should feel firm when squeezed. The counter should be set square and straight onto the heel—not tilted.
- (e) Heel. The heel should be wider at the base than at the top of the shoe (flared heel).
- (f) Flexibility. The forefoot area must be flexible, especially under the ball of the foot where the shoe will bend. To test for flexibility, hold the shoe in the hands and bend the toe box and forefoot area back toward the heel. It should bend easily but not all the way back to the shoe laces. Avoid shoes that are extremely stiff.
- (g) Replacement. Many shoes will continue to look good on top long after the sole and supportive structures are worn out. Do not wait for the shoe to look worn before replacing it.

e. Although ideal running surfaces are dirt or grass paths, they are not readily available for many people. Be sure shoes have good cushioning if running on pavement. Beginners, overweight individuals, and those who have a history of foot, ankle, or knee problems should avoid hard surfaces such as concrete or

asphalt. Beware of banked tracks and roads with an incline. When running on a banked surface, the upper foot is twisting inward with every step. As these conditions can lead to injuries, try to run on flat surfaces as much as possible. If the only roads available are banked, change the direction of travel every other day so that the same leg does not always bear the stress.

f. The following outlines workout criteria:

(1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).

(2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.

(3) Frequency. A minimum of three days per week up to a maximum of five days per week.

(4) Warm-Up and Cooldown. Five to ten minutes of slow jogging.

(5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown sessions. Refer to Chapter 3 of this manual for information on stretching and flexibility.

5. SWIMMING.

a. Swimming is an excellent systemic exercise that contributes to total body development, as well as developing cardiovascular fitness. Swimmers are less susceptible to muscle soreness and tightness and they generally do not sustain the shin splints, torn ligaments, or strains common to other aerobic activities.

b. Several unique factors associated with swimming should be noted. Swimming does not reduce body fat levels as effectively as other types of aerobic exercise. Approximately 80 to 90 percent of the work in swimming is done by the upper body, not the legs. Consequently, the criteria for aerobic training are not as easily met. Inexperienced swimmers are easily exhausted when highly specific demands are placed on their smaller upper body muscles. They quickly exceed their training heart rate which limits their exercise to a few minutes.

c. One way to assure a good aerobic workout is to swim on the back, using fins and only the legs. Kick from the hip with the body on a horizontal plane and the head back. The fins will increase the workload and swimming on the back will allow ease of breathing. There are other variations to this method. A kickboard can be used and other strokes may be mixed into the workout session.

- d. An inexperienced swimmer or nonswimmer may benefit from professional instruction through a community center or local college.
- e. Although equipment needs are minimal, swimming goggles are necessary to protect the eyes against irritation caused by chlorine. Swimming facilities should be well maintained with either a life guard or another swimmer available at all times. NEVER SWIM ALONE!
- f. The following outlines workout criteria:
 - (1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).
 - (2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.
 - (3) Frequency. A minimum of three days per week up to a maximum of five days per week.
 - (4) Warm-Up and Cooldown. Five to ten minutes of slow swimming or jogging in the water.
 - (5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown periods. Refer to Chapter 3 of this manual for information on stretching and flexibility.

6. BICYCLING AND STATIONARY CYCLING.

- a. Cycling programs are versatile as it is possible to alternate between a bicycle, stationary cycles, “Spin” classes, and devices such as Rollers that allow use of a regular bicycle as a stationary cycle. The ultimate aim of a cycling fitness program is to enable a person to steadily pump their legs at a rate sufficient to elevate and maintain their training heart rate for 30 to 60 minutes. If just beginning a cycling program, the first few weeks of training should consist of a moderate riding pace to allow leg muscles and body functions to adapt to the stresses of this type of exercise.
- b. To achieve a training effect, it is important to pedal vigorously enough to place adequate stress on the heart and lungs. A common mistake is to pedal in too high a gear. It is better to ride in a lower gear at high revolutions per minute (RPM). This is referred to as “spinning.” Pedal at the same rate of speed (about 70 to 80 RPMs) and adjust the gears to accommodate the terrain. Avoid rocking or

swaying the upper body. An easy way to monitor movements is to watch the shadow on the pavement if the sun is out.

c. The success of a cycling fitness program requires not only a good quality bicycle but one properly adjusted to the body. It is important to adjust the seat height correctly. If the seat is too low or too high, the leg muscles will not be able to function at peak efficiency and much energy will be wasted. With the toe on the pedal, there should be a small bend at the knee when the pedal is at its lowest point. Additional consideration should be given to the type of terrain, which may require alternations to the gears and tires. It is advisable to find a reputable bike shop (one that repairs as well as sells bikes) to assist and advise. Bikes need periodic checkups, including brakes, steering, and gear adjustments. Always make sure the bicycle is in good mechanical condition and that all safety devices are in good working order.

d. Improper clothing can hinder a cycling program. Avoid tight-fitting jeans or clothing which restricts movement. In general, bicycle wear should be lightweight, unrestrictive, protective, and durable. Cycling shorts should have a longer leg length to protect the legs from rubbing on the bicycle seat and a thick chamois sewn into the seat to provide a soft cushiony area between the rider and the saddle. The seams should be flat to avoid chafing.

e. Cycling shoes should be comfortable and have a more rigid sole than a running shoe so that pressure is distributed throughout the entire foot area. Street shoes do not have the necessary support for cycling and have a sole which makes it difficult to maintain traction on the pedal surface. Cycling shoes can be outfitted with cleats to accommodate both clip-on and toe-clip style pedals.

f. A protective helmet/scalp guard should be worn while riding a bicycle. The helmet should be lightweight and well ventilated with excellent shock absorbing qualities and a sturdy chin strap. Of the various plastic helmets on the market, those made by Bailen, Bell, MSR, Pro-Tec, and Skid-Lid have scored well in product tests.

g. During early training sessions, it is important to realize the need to become skilled at operating and controlling the bike in a safe manner. Until a practiced cyclist, it is recommended heavy traffic areas and steep or winding roads be avoided. Experience will improve the ability to maneuver and control the bike under all conditions. Anticipate trouble by being alert for potholes, roadway debris, and opening car doors. Slow speed if encountering heavy traffic. Always obey all traffic laws.

h. The exercise challenge on a stationary bicycle or bicycle ergometer is not provided by hills, speed, or gears, but rather by the resistance knob. Set the resistance knob at a workload that will allow the training heart rate to be reached while pedaling at approximately 70 to 80 RPMs. If the training heart rate is not reached, either increase the workload or pedal at a faster speed. Monitor the heart rate during and immediately after training sessions. As progress in the program is achieved, the pedal resistance will have to be increased to maintain the training heart rate.

i. In selecting a stationary bike, remember the quality of the equipment will directly affect the quality of the workout and the desire to continue with the program. Stationary bikes with a balanced weighted flywheel and calibrated resistance are recommended. There are also other types of stationary “cycles” such as recumbent bikes, Wind Trainers, and Rollers that offer a cardiovascular workout. Clothing considerations are less stringent for stationary cycling than a bicycle program. Attire should consist of comfortable sport type shoes and clothing which does not restrict movement.

j. The following outlines workout criteria:

(1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).

(2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.

(3) Frequency. A minimum of three days per week up to a maximum of five days per week.

(4) Warm-Up and Cooldown. Five to ten minutes of slow bicycling in a low gear or stationary cycling at a low resistance.

(5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown sessions. Refer to Chapter 3 of this manual for information on stretching and flexibility.

7. ROPE SKIPPING.

a. Rope skipping is an excellent aerobic training activity which will also improve agility and coordination. Rope skipping can be done both indoors and outdoors and only requires an inexpensive jump rope which can be easily transported.

b. As with all aerobic exercises, it is necessary to monitor the training heart rate and adjust exercise intensity accordingly. Try to maintain a count of 70 to 80 jumps per minute. The tendency when skipping rope is to exceed the training heart rate limits, which can lead to injuries in the early stages of an exercise program. Jumping rope places a sudden and rigorous demand on the ankle, knee, and hip joints, and it is this acute stress on the leg muscles that will sometimes limit an exercise session. Avoid jumping on hard surfaces such as concrete or asphalt. A carpeted surface may be used to help absorb the shock of landing.

c. There are several commercial types of jump ropes available, or can be handmade. Measure the proper length by standing with both feet on the middle of the rope. The ends should reach the armpits when the rope is held down with the feet. Clothing should be loose and allow for unrestricted movement. Shoes should be sport type shoes with plenty of cushioning.

d. The following outlines workout criteria:

(1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).

(2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.

(3) Frequency. A minimum of three days per week up to a maximum of five days per week.

(4) Warm-Up and Cooldown. Five to ten minutes of rope skipping at a low intensity.

(5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown sessions. Refer to Chapter 3 of this manual for information on stretching and flexibility.

8. STAIR CLIMBING MACHINES.

a. Stair climbing is an excellent aerobic activity that contributes to the development of major muscle groups, as well as cardiovascular fitness. Stair climbing, like all other modes of exercise, must be vigorous and prolonged to be effective. A moderate 20-minute workout can provide a cardiovascular workout equal to jogging without the impact to joints, while toning muscles in the buttocks, hips, and legs.

- b. How a machine feels is crucial. After all, 30 minutes of exercise three times a week is 78 hours of climbing a year. Of the machines on the market, some are compact enough for apartments, while others are “industrial-strength” giants suitable for gyms. Prices vary accordingly, from several hundred to several thousand dollars. Features to consider are step action, noise, digital displays, and availability of replacement parts.
- c. Rapid rises in heart rate and oxygen consumption may lead to overexertion for people who are not used to the activity. In addition, climbing stairs adds four to six times the body weight to the patellar surface, which may aggravate knee conditions such as chondromalacia. But for most people the activity is relatively risk free, if a few precautions are observed.
- d. Know when to stop. Stair climbing is exhausting, and weary exercisers may fall if they lose their footing or balance.
- e. People with chondromalacia should strengthen their muscles before starting a stair climbing program. Refer to Chapter 2, paragraph 3.g.(3), of this manual.
- f. While performing the stair climbing exercise, keep the back straight as slumping forward takes the weight off the legs, reducing the effectiveness of climbing. The handrails are meant for balance only, not support.
- g. For prevention of strain to the legs, keep the knees unlocked during this exercise. To warm up, easy climbing for several minutes prior to daily resistance training may be performed.
- h. Clothing should be comfortable and allow for freedom of movement. Shoes should be a comfortable sport-type that have supports and good cushioning.
- i. The following outlines workout criteria:
- (1) Intensity. A 55 to 90 percent of calculated maximal heart rate (training heart rate).
 - (2) Duration. A minimum of 15 minutes to a maximum of 60 minutes at training heart rate.
 - (3) Frequency. A minimum of three days per week up to a maximum of five days per week.
 - (4) Warm-Up and Cooldown. Five to ten minutes of stair stepping at a low intensity.

(5) Stretching Exercises. It is recommended that stretching exercises be included in warm-up and cooldown sessions. Refer to Chapter 3 of this manual for information on stretching and flexibility.