

# Marathon Challenge

## PROGRAM OVERVIEW

NOVA assembles a team of 13 sedentary non-athletes aged 21 to 60 to face the ultimate test: Run the 26.2-mile Boston marathon.

The program:

- reviews why the novices joined Team NOVA.
- profiles the team that will be coaching the runners from start to finish.
- shows the tests team members undergo at Tufts University to establish baseline fitness levels—a sophisticated body composition analysis and a maximum oxygen consumption measurement, known as  $VO_2$  max.
- notes that runners who are at an ideal body weight may still be over-fat and under-muscled.
- reveals through animations how  $VO_2$  max provides information on heart, blood vessel, and capillary fitness.
- reviews the runners' 40-week training regimen.
- notes the circulatory system improvements that occur after nine weeks of training—hearts are more efficient, arteries are more elastic, new capillaries have developed, and mitochondria have increased to aid aerobic metabolism.
- chronicles the physical injuries and mental challenges the runners face as they carry out their training.
- identifies the two types of muscle fibers in the human body.
- presents the idea that humans evolved anatomically to run long distances, an advantage that would have allowed them to engage in long-distance hunts.
- notes that most heart attacks are caused by blocked coronary arteries—often due to a poor diet and lack of exercise—rather than by a tired and stressed heart muscle.
- retests body composition and maximum oxygen consumption in the trained runners and finds that while most have dramatically improved their  $VO_2$  scores, few weight or body composition changes occurred.
- explains why running on its own is not particularly effective for active weight loss efforts.
- points out that the body uses both fat and carbohydrates for fuel to run, and that while even lean people have a large reserve of fat, carbohydrates stored as glycogen in the liver can be depleted during a marathon.
- follows Team NOVA members as they run the 2007 Boston Marathon.



## BEFORE WATCHING

- 1 To give students an appreciation for a marathon distance, have them plot on a map the route for a marathon race in your area. If there is no local marathon, have them find a route from the school to a location that is 26.2 miles away, or determine how many laps around the school would equal that distance.
- 2 Organize students into four groups and assign each group one of the following topics to take notes on as they watch: tests done to measure body fitness, the training regimen, changes in the runners' bodies over the training period, and the physical and mental challenges the runners faced. While viewing, pause the program after the initial introductions, the five-mile run, the ten-mile run, and the twenty-mile run and ask students to predict who they think will succeed and why.

## AFTER WATCHING

- 1 Have each group report what it learned while watching. As a class, discuss what it takes physically and mentally to run a marathon. What do students think the most difficult challenge was? What happened to the runners' bodies as they became more physically fit? Did students' expectations of who would succeed match the final results? What surprised students the most regarding how the runners fared?
- 2 Ask students to list what inspired the runners to train for and complete the marathon and what obstacles they faced. Could students identify with any of the participants? What inspires students to exercise or prevents them from exercising? Brainstorm with students ways they might overcome some of their obstacles.

**Taping rights:** Can be used up to one year after program is recorded off the air.

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## CLASSROOM ACTIVITY

### Activity Summary

Students take each other's pulses at rest and after exercise to determine recovery times.

### Materials for Class

- same-sized slips of paper, one for each student

### Materials for Each Student

- copy of the “Matters of the Heart” student handout
- copy of the “Data Sheet” student handout
- copy of the “Plotting Your Results” student handout
- clock or timer with seconds

### Background

Physical fitness can be determined by tests, including those designed to measure heart rate during exercise, the volume of oxygen consumed while exercising at maximum capacity (known as  $VO_2$  max), body fat percentage, muscle fitness, flexibility, and heart recovery rate.

Heart recovery rate is the time it takes for the heart to return to its normal resting beat. A healthy heart will return quickly to its normal beat after exercising. Heart recovery rates can be improved by making lifestyle changes, such as eating a healthy diet, not smoking, and exercising regularly.

Normal resting heart rate values for different ages are:

- newborn infants: 100 to 160 beats per minute
- children 1 to 10 years: 70 to 120 beats per minute
- children over 10 and adults (including seniors): 60 to 100 beats per minute

Athletes can have much lower resting heart rates, as low as 40 to 60 beats per minute.

In this activity, students take each other's pulses at rest and after exercise to determine recovery times.

## LEARNING OBJECTIVES

Students will be able to:

- measure pulse rate and investigate the affect of exercise on pulse rate.
- construct and interpret a graph displaying recovery time.

## STANDARDS CONNECTION

The “Matters of the Heart” activity meets the following National Science Education Standards (see [books.nap.edu/html/nses](http://books.nap.edu/html/nses)).

GRADES 5–8

### Science in Personal and Social Perspectives

- Personal health

GRADES 9–12

### Science in Personal and Social Perspectives

- Understanding personal and community health

*Video is not required  
for this activity.*

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## CLASSROOM ACTIVITY (CONT.)

### Procedure

- 1 Begin by asking students the question: “What does heart rate have to do with fitness?” (*Students may suggest that a slower heart rate would indicate that the heart is more efficient and has to work less to pump blood.*)
- 2 Organize students into pairs and distribute the student handouts to each student. Review the activity with students.
- 3 Have students take their resting pulse rates. It is *very* important that students master the technique of taking their pulse and obtain consistent values before doing the exercises. A slight variation is expected in pulse rate but readings should be within three to five beats per minute during the resting rate calculation. (If taking the pulse for 15 seconds is not generating consistent results, have students take 30-second readings and multiply their values by two.) If students still have problems, you may want to show them how to measure the pulse at the carotid artery in the neck. Whatever method students choose, they should use that method for the entire experiment.
- 4 Have students average the three resting rate trials and multiply the average by four to determine resting heart rate per minute. Pass out small slips of paper. Have students write their average resting heart rate per minute on their slip and hand it back in. Write the heart rates on the board (without identifying the students) and ask students what might cause any variability in resting heart rates. (*Resting heart rates vary with age, sex, physical shape, and cardiovascular condition. Resting rates can also vary due to emotional changes, caffeine intake, and medication side effects. Athletes generally have lower resting pulse rates than non-athletes.*) As a class, analyze the data set for high, low, average, and median values. (You may want to have students collect data from a similar number of adults for comparison.)
- 5 Before each team does its jumping jacks, emphasize to students that when they collect heart-rate data it is important that they collect their data at exactly one-minute intervals after the initial pulse measurement (o) is taken at the moment the jumping jacks are done. Explain to students that each minute includes the time that they are counting the heartbeats.
- 6 Instruct each team to conduct the exercise and pulse-measuring portion of the activity. If students are having difficulty measuring a pulse rate, suggest that they find the pulse a few seconds before they have to start counting.

### SAFETY NOTE

Students with heart or respiratory conditions should not do the exercises.

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## CLASSROOM ACTIVITY (CONT.)

- 7 As a class, determine the range for the y-axis of the “Recovery Time” graph. The range should include the highest heart rate per minute among students as well as the lowest heart rate per minute (including resting heart rates, which will also be plotted). All students should use the same range when plotting their results.
- 8 Have students do the exercise and plot their results. Collect the graphing sheets and choose a few of the slopes from the “Recovery Time” graph (including the highest and lowest) to plot on the board to show the range of results among class members. Discuss with students what the different slopes mean and how recovery rate is connected to fitness. To conclude, discuss what ways recovery rates could be improved.
- 9 To illustrate other ways to evaluate fitness, show students the portion of the program (3:55) that presents how doctors measure body composition and maximum oxygen consumption ( $VO_2$  max) and animates how the body consumes oxygen.  
[www.pbs.org/nova/teachers/activities/3414\\_marathon.html#video](http://www.pbs.org/nova/teachers/activities/3414_marathon.html#video)  
(QuickTime or Windows Media plug-in required.)  
After students have viewed the video, ask them to explain how someone with an ideal body weight can still be considered unfit. (*Weight is only one measure of fitness. A person with an ideal body weight may still have a poor lean-to-fat ratio. While fat is necessary for body metabolism, more than 25 percent fat in men and more than 30 percent in women is considered unhealthful.*)
- 10 As an extension, have students test for muscle fatigue. Have students open and close a clothespin for 20 seconds. Then have them rest for a few seconds and do another 20-second-long set. How long does it take before muscle fatigue sets in? Have students research and write a one-page report on what causes muscle fatigue.

### Classroom Activity Author

Fred Sculco taught science for 35 years, including courses in biology, environmental science, genetic engineering, and alternative energy resources. In addition to his middle- and high-school teaching experience, Sculco has worked as a consultant for the National Institutes of Health, the U.S. Department of Energy, and the Massachusetts Audubon Society.

## ACTIVITY ANSWER

During the recovery period, the heart is pumping blood to the muscles. Oxygen and carbon dioxide are being exchanged in the lungs and the muscles. Immediately after exercise, a high demand is placed on the cardiovascular system to provide oxygen and remove carbon dioxide from the muscles being exercised. The pulse rate should be highest right after exercise. As time progresses, more and more blood will be pumped to the muscles exchanging oxygen and carbon dioxide. Over time, the levels of oxygen in the muscle will return to normal and the CO<sub>2</sub> formed during exercise will be removed. At this point, a normal resting pulse rate will return.

A rough estimation of the physical fitness of an individual can be made based on the amount of time required to return to a resting pulse rate. An athlete with an efficient cardiovascular system will return to resting rate in a shorter period of time that someone whose heart muscle and pumping volume are inefficient.

### Student Handout Questions

- 1 What are some of the factors that influence resting pulse rate? Why might an athlete have a lower pulse rate than a person who does not exercise regularly? *A variety of factors can influence pulse rate, including physical condition, age, weight, heart disease, medications, smoking, and emotional state such as stress. In general, pulse rates will be lower in those who exercise and are in good physical condition. (Exercise increases the strength of the heart muscle. A stronger heart muscle pumps more efficiently, i.e., more blood pumped per pulse beat. As a result, the number of beats [pulses] required to move the same amount of blood through the body is decreased. In addition, exercise increases the number of capillaries in muscle. This provides more channels to transport oxygen and carbon dioxide during exercise. The result is that gas exchange in both the lungs and the muscles is faster. This, in turn, reduces demand on the heart to pump faster.) Weight also influences pulse rate. The heart must pump harder to move the blood through more body tissue, in this case mostly fatty tissue. This extra tissue places a demand on the circulatory system for oxygen and nutrients. To compensate, the heart must pump faster, increasing the pulse rate. Additionally, the amount of blood in the arteries increases, often leading to higher blood pressure.*
- 2 In the “Recovery Time” graph, describe the changes that occurred to your heartbeat in minutes 1–7. Use specific numbers from the data table in your response. *Answers will vary.*
- 3 If you compared the graph of an extremely fit athlete with the graph of a sedentary 50-year-old individual, would you expect them to be alike or different? Explain your reasoning. *You would expect the extremely fit athlete to return to resting heart rate more quickly, as indicated by a steep slope on the graph. This would likely be due to the athlete having a stronger cardiovascular system.*

## LINKS AND BOOKS

### Links

#### NOVA—Marathon Challenge

[www.pbs.org/nova/marathon](http://www.pbs.org/nova/marathon)

*Features profiles of Team NOVA members, four of the runners' diaries, a training calendar, information about how exercise affects the body, tips for rookie runners, and more.*

#### Amazing Heart Facts

[www.pbs.org/nova/heart/heartfacts.html](http://www.pbs.org/nova/heart/heartfacts.html)

*Gives facts on heart rate and the structure of the heart.*

#### Map of the Human Heart

[www.pbs.org/nova/heart/heartmap.html](http://www.pbs.org/nova/heart/heartmap.html)

*Shows blood flow through the heart and diagrams heart structures.*

#### Researchers Find Heart Rate Worth a Thousand Words

[www.webmd.com/news/20000919/researchers-find-heart-rate-worth-thousand-words](http://www.webmd.com/news/20000919/researchers-find-heart-rate-worth-thousand-words)

*Explains heart rate recovery and how it can be improved.*

### Books

#### Essentials of Human Anatomy and Physiology

by Elaine Nicpon Marieb.

Redwood City, Calif.: Benjamin Cummings Publishing Inc., 1994.

*Provides basic chemistry of the human body and an overview of all its systems.*

#### The Human Body: An Illustrated Guide to Its Structure, Function, and Disorders

by Charles B. Clayman, MD.

London, New York: DK Publishing, 1995.

*Uses medical drawings and images from diagnostic technologies to help explain the body's anatomy, function, and common disorders.*

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## ACTIVITY ANSWER

- 4 What effect could a longer pulse recovery period have on a person's ability to perform certain activities? What effect could a shorter pulse recovery period have? *A longer pulse recovery time would limit the type of endurance activity a person could undertake. Endurance events, such as a marathon, provide a continual demand on the cardiovascular system. If oxygen levels are not replaced and carbon dioxide is not removed in muscles, the muscle cells will move into anaerobic respiration, an inefficient state that eventually leads to cramping and muscle fatigue. A shorter pulse recovery time indicates an efficient cardiovascular system. Gas exchange between lungs and muscles is efficient and therefore muscles can function for an extended period of time without moving into anaerobic respiration. This person likely will not become cramped or fatigued as quickly and will be able endure more prolonged exercise.*
- 5 What might a person do to improve his or her recovery period? *A person could exercise, which would strengthen the heart muscle, increase its efficiency, increase elasticity in blood vessels, and increase capillary supply to muscles.*

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David H. Koch

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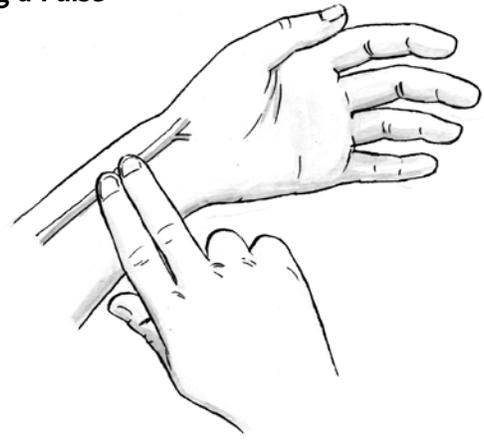
# Matters of the Heart

Fitness is determined by a number of factors, including the type of diet you choose and the amount of exercise you get. Part of being fit is having a healthy heart. In this activity, you will take a look at your heart health by investigating how quickly your heart recovers after exercise.

## Procedure

- 1 Work with your partner to practice finding each other's pulse. (See *Finding a Pulse* for directions.) Make sure you are sitting and resting. Count the number of beats (pulses) that occur in 15 seconds. Practice until you get two consistent measurements in which the values you obtain are within one to three beats of each other per minute.
- 2 Each partner should take the pulse of the other three times (each time for 15 seconds). Record these on your "Data Sheet" handout. If necessary, repeat the procedure until the three values are within one to three beats of each other per minute.
- 3 Multiply the average of your three trials by four to determine your resting heart rate per minute.
- 4 Now for some exercise: Decide with your partner who will go first. The person who goes first will perform 50 jumping jacks. The other partner will take the exerciser's pulse for 15 seconds *immediately* after the exercise stops. This value should be recorded under Pulse Rate next to "0" under Time after Exercise. Then, 45 seconds later, take the pulse for another 15 seconds. (Each 15 seconds of recorded pulse will take up the first quarter of each minute interval.) Record this value under the Minute 1 entry. Continue to take and record pulse measurements for up to 7 minutes after finishing the exercise.

## Finding a Pulse



Use the tips of the first two fingers as shown in the diagram. You will find the pulse on the thumb-side of the wrist and will need only gentle pressure to feel the pulsation. Having your partner bend his wrist slightly inward may help find the pulse. Don't use your thumb to take the pulse because it has a tiny pulse of its own that could confuse your count.

- 5 Multiply your data by four to determine beats per minute.
- 6 When the data is collected, repeat the procedure for the remaining partner.
- 7 When both team members have collected their data, each team member should graph his or her data on the "Plotting Your Results" handout and answer the questions listed on the handout.

# Data Sheet

## Resting Pulse Rate

Fill in your three resting state values. Calculate the average of the three trials. Multiply the final average by four to determine your resting pulse rate per minute.

### DATA COLLECTION

	Resting Pulse Rate (Beats per 15 Seconds)
Trial 1	
Trial 2	
Trial 3	
Average	

### CALCULATION

Resting Pulse Rate per Minute (Average Resting Pulse x 4)

## Recovery Time

Complete 50 jumping jacks. Have your partner take your pulse immediately after the exercise, and then again each minute after (each 15 seconds your partner is taking the pulse counts as part of one minute). When your partner has taken your pulse measurements for seven minutes, multiply them by four and record the data below.

### DATA COLLECTION

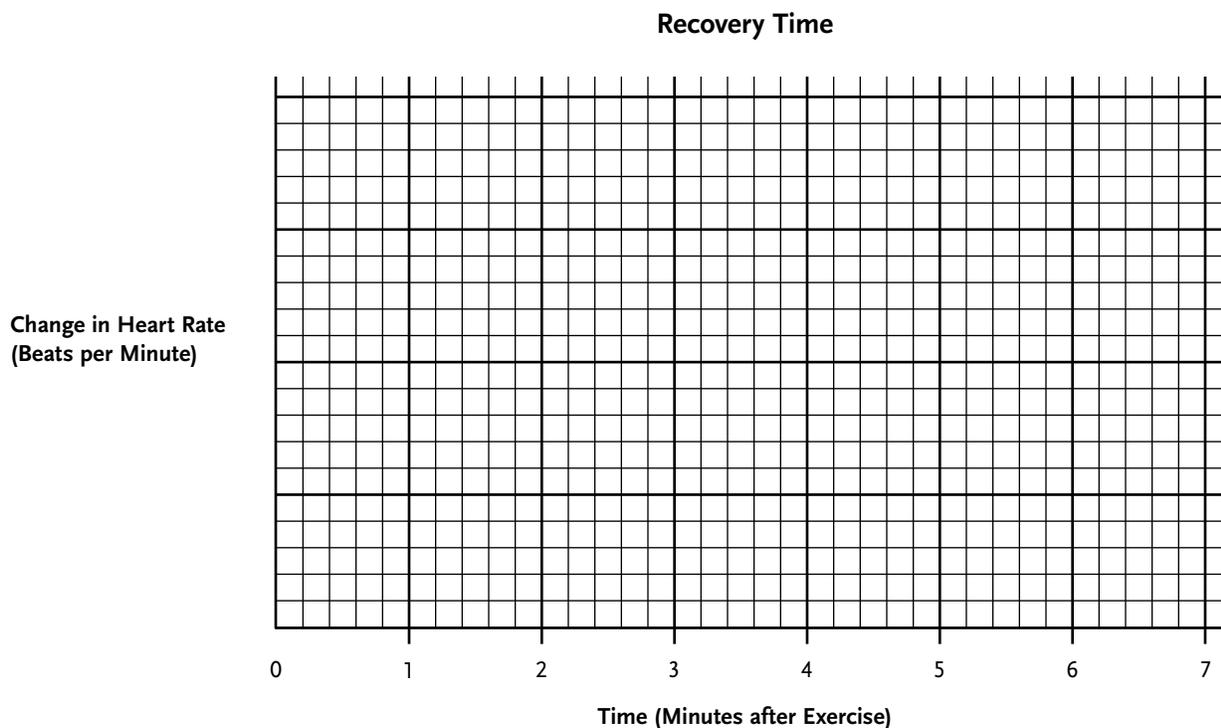
Time (Minutes After Exercise)	Pulse Rate (Beats per 15 Seconds)
0	
1	
2	
3	
4	
5	
6	
7	

### CALCULATION

Time (Minutes After Exercise)	Pulse Rate per Minute (Beats Per 15 Seconds x 4)
0	
1	
2	
3	
4	
5	
6	
7	

# Plotting Your Results

As a class, you will determine the range of heartbeats per minute to fill in on the y-axis of your data table. When that axis has been filled in, plot your resting pulse rate on the graph below with a dotted line. After you have exercised and calculated your pulse rate per minute for the seven-minute period, plot your results on the graph below. Then draw a line through the data points.



## Questions

Write your answers on a separate sheet of paper.

- 1 What are some of the factors that influence resting pulse rate? Why might an athlete have a lower pulse rate than a person who does not exercise regularly?
- 2 In the “Recovery Time” graph, describe the changes that occurred to your heartbeat in minutes 1–7. Use specific numbers from the data table in your response.
- 3 If you compared the graph of an extremely fit athlete with the graph of a sedentary 50-year-old individual, would you expect them to be alike or different? Explain your reasoning.
- 4 What effect could a longer pulse recovery period have on a person’s ability to perform certain activities? What effect could a shorter pulse recovery period have?
- 5 What might a person do to improve his or her recovery period?