

GRADE 8 PHYSICAL EDUCATION & HEALTH

First edition

5 units

10 lessons • one quarter

A video for every lesson

FIRST EDITION

COURSE GUIDE

This short course follows five strands of health and fitness through one quarter of the school year: keeping active, water, food, strength and the heart and lungs. Each lesson is built around a real study or person: the Framingham Heart Study, which began following 5,209 adults in 1948; Jim Thorpe's all-round gifts at the 1912 Olympics; Charles Blagden sitting in a room hotter than boiling water in 1774; Jim Peters collapsing in the heat at Vancouver in 1954; Elmer McCollum naming vitamin D in 1922; the Swedish scientists who measured fuel inside working muscles; Thomas DeLorme rebuilding soldiers' legs in 1944-45; a government study of how workers lift safely; Werner Forssmann and the first measurements inside the living heart; and Bill Bowerman bringing jogging to ordinary Americans.

Every lesson follows the same path. First comes **the story**. Then **how they figured it out**: the question they faced, what they tried and what they measured. Then **how your body works**, explained for an eighth grader with real vocabulary and a little arithmetic: beats per minute, ounces of sweat, milligrams on a label, sets and reps, liters of blood per minute. Last, **try it**: the student runs a real test, workout, kitchen task or training run, records the numbers in a fitness journal, and tries to improve on the second try.

God made the body good, and He gave it to us to care for. This course is about stewardship, strength, joy in movement and good habits. It is never about size or looks: students are measured only against their own effort and improvement. The old Latin saying *Fabricando fit faber*, "by making, one becomes a maker," fits here too: fitness is built by practice, a little more each week. The quarter ends with a family fitness day, when the whole household moves, plays and eats together.

Most videos come from hospitals, universities and teaching channels:
Arkansas Children's, Phoenix Children's, the University of Vermont
Children's Hospital, the Framingham Heart Study itself, TED-Ed,

FuseSchool, Khan Academy, the Mayo Clinic and the British Heart Foundation, with a few smaller physical-therapy and teaching channels chosen lesson by lesson. Every video was previewed for accuracy and for modest dress. A few were made for adults or for medical students; the lesson notes say so. Some end with an invitation to subscribe or a short advertisement for the hospital's clinic; you can stop the video when the teaching ends. Watch together and talk about what you saw.

Start with Lesson 1.1 →

WHO IT IS FOR

Written for students in grade 8 (about ages 13–14) who read independently, can work with fractions, decimals and percentages, and can make a table and a line or bar graph. A parent or teacher supervises every activity, helps in the kitchen and serves as timer and spotter. Nothing needs to be bought: every activity uses household things such as a sturdy chair, a bottom stair, a backpack with books, gallon water jugs, a broom handle, measuring cups, a tape measure and a timer.

HOW TO USE THIS COURSE

1. **The weekly rhythm.** The quarter has 10 lessons, one a week, each with three sessions of 40–45 minutes. Session 1 is the warm-up, the video, the teaching and the picture study, with a little movement. Session 2 is the activity (the test, the workout or the kitchen task) and the fitness journal. Session 3 repeats the activity and tries to improve on it. In the second week of each unit, use part of Session 3 for the unit review and the unit challenge. On the other days, aim for at least 60 minutes of movement in sport, chores, play and walking.
2. **Check with your doctor first.** A parent should know about and supervise every activity. If your student has asthma, a heart condition, diabetes, a recent injury or any other health concern, check with your doctor before starting, and follow the doctor's advice about what to change.
3. **Story, then science, then doing.** The core ideas are written for the student to read, with a parent reading along. The paragraphs marked *The story* and *How they figured it out* tell what happened; *How your body works* explains the science; *Try it* explains the activity. After reading, ask the student to explain the main idea in his or her own words, and to show the arithmetic on any number.

4. **Picture study.** Each lesson has one public-domain painting or historic photograph chosen for what it shows about work, play, food, water or rest. Look at it quietly for two minutes, put it away and tell everything you remember, then bring it back and work through the “look for” items and questions.
5. **The fitness journal.** Use one notebook for the whole quarter. Every activity is done, recorded and done again: reps, seconds, beats per minute, ounces, milligrams, minutes and miles. Date every page. Write how it felt and what you will try next time. Honest records matter more than big numbers.
6. **Health, not looks.** In this course we talk about what bodies can do and how to care for them, never about size or shape. We do not weigh students (the one exception is the sweat check in Lesson 2.2, where a parent weighs the student before and after practice and records only the difference, which is water lost in sweat). Calories appear only as a unit of food energy, never as something to count or cut. Foods are “nutrient-dense foods” and “treats,” and feasts and treats are good gifts in their place. Grades come from effort, consistency and personal improvement, never from comparing one student with another.
7. **Optional books and gear.** Some units list a free web page from a children’s hospital or a government agency, or simple gear such as a light resistance band or a water bottle with ounce marks. They are never required.
8. **Unit review and unit challenge.** Each unit ends with a review worth 50 points, with at least one worked calculation and one short written answer, and a unit challenge: an activity log, a hydration plan tested at practice, a planned and cooked day of meals, a two-week strength plan with a before-and-after test, or a 5K plan with a pacing chart. Keep the challenge pages in a folder.
9. **Safety.** Read the safety note before each activity. Warm up first and cool down after. Clear a space with a flat, non-slip floor and wear good shoes. Stop and tell an adult right away at chest pain, dizziness, fainting, trouble breathing or sharp pain; tired muscles are normal, but joint pain is not. Strength work in this course uses body weight, light household loads (a backpack with books, water jugs) and light resistance bands, always with good form and never as a test of the heaviest possible lift. Outdoors, run with a buddy or an adult, away from traffic, in daylight, with water and shade in hot weather. A parent supervises knives and the stove and checks for food allergies before any tasting. Exercise and food are never used as a reward or a punishment.

10. **The family fitness day.** In the last week, the student plans and leads a family fitness day: a warm-up, stations from every unit, a water table with a hydration plan, a snack the student cooks, and a family walk-run over a measured course. Everyone moves at his or her own pace.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1–2

Keeping Active

What the Framingham Heart Study taught about activity and the heart, the activity guidelines for teens and a heart-health baseline with a week-long log; and the six parts of skill-related fitness, through Jim Thorpe at the 1912 Olympics, with six home tests and a retest.

- 1.1 The Framingham Heart Study
- 1.2 Skill-Related Fitness: Jim Thorpe’s All-Round Gifts

UNIT 3 • WEEKS 5–6

Nutrition

Iron, calcium and vitamin D, through rickets, cod-liver oil and Elmer McCollum’s discovery, with a label lab and a bone-building lunch; and eating for sport, through the Swedish muscle-fuel studies of the 1960s, with a cooked game-day meal and a recovery snack.

- 3.1 Iron, Calcium and Vitamin D
- 3.2 Eating for Sport: Fuel Before, Repair After

UNIT 2 • WEEKS 3–4

Hydration

How sweat cools the body, through Charles Blagden’s heated-room experiments of 1774 and an evaporation lab; and a hydration plan for game day, through Jim Peters’s collapse in Vancouver in 1954, with a parent-run sweat check and a sweat-rate calculation.

- 2.1 How Sweat Cools You: Charles Blagden’s Hot Room
- 2.2 A Hydration Plan for Game Day

UNIT 4 • WEEKS 7–8

Strength

Thomas DeLorme and progressive resistance, with a two-week home strength plan using light household loads; and the hinge and the squat, through a government study of safe lifting, with broom-handle drills and a carry-and-lift circuit.

- 4.1 Thomas DeLorme and Progressive Resistance
- 4.2 The Hinge and the Squat

UNIT 5 • WEEKS 9–10

Aerobic Training

Cardiac output (stroke volume $\times$ heart rate),
through Adolf Fick and Werner Forssmann,
with resting and exercise heart-rate tables; and
training for a 5K, through Bill Bowerman’s
jogging class, with a four-week run-walk plan,
a pacing chart and the family fitness day.

5.1 Your Heart’s Output

5.2 Training for a 5K: Bill Bowerman and the Joggers

WEEKLY PACING CALENDAR

WEEK	PLAN
1	• Session 1: Lesson 1.1 The Framingham Heart Study: warm-up, video, teaching and picture study • Session 2: Lesson 1.1 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it <i>Three short sessions a week is the usual rhythm: one to learn, two to move. Keep moving every day, even on days with no lesson.</i>
2	• Session 1: Lesson 1.2 Skill-Related Fitness: Jim Thorpe’s All-Round Gifts: warm-up, video, teaching and picture study • Session 2: Lesson 1.2 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it • Session 3 (end of unit): Unit 1 review and unit challenge
3	• Session 1: Lesson 2.1 How Sweat Cools You: Charles Blagden’s Hot Room: warm-up, video, teaching and picture study • Session 2: Lesson 2.1 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it

WEEK	PLAN
4	• Session 1: Lesson 2.2 A Hydration Plan for Game Day: warm-up, video, teaching and picture study • Session 2: Lesson 2.2 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it • Session 3 (end of unit): Unit 2 review and unit challenge
5	• Session 1: Lesson 3.1 Iron, Calcium and Vitamin D: warm-up, video, teaching and picture study • Session 2: Lesson 3.1 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it
6	• Session 1: Lesson 3.2 Eating for Sport: Fuel Before, Repair After: warm-up, video, teaching and picture study • Session 2: Lesson 3.2 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it • Session 3 (end of unit): Unit 3 review and unit challenge
7	• Session 1: Lesson 4.1 Thomas DeLorme and Progressive Resistance: warm-up, video, teaching and picture study • Session 2: Lesson 4.1 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it
8	• Session 1: Lesson 4.2 The Hinge and the Squat: warm-up, video, teaching and picture study • Session 2: Lesson 4.2 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it • Session 3 (end of unit): Unit 4 review and unit challenge
9	• Session 1: Lesson 5.1 Your Heart's Output: warm-up, video, teaching and picture study • Session 2: Lesson 5.1 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it
10	• Session 1: Lesson 5.2 Training for a 5K: Bill Bowerman and the Joggers: warm-up, video, teaching and picture study • Session 2: Lesson 5.2 activity and fitness journal • Session 3: Repeat the activity, try to improve, and log it • Session 3 (end of unit): Unit 5 review and unit challenge

MATERIALS

Fitness journal (any notebook)

One for the quarter: logs, tables, graphs, form checklists, meal plans and reflections.

A timer or stopwatch (a phone timer works)

For pulse counts, the step test, timed holds, work-and-rest sets and timed runs.

Good athletic shoes and comfortable, modest clothes for exercise

Every activity lesson.

A sturdy chair, a wall, a bottom stair or sturdy step about 8–12 inches high, and a towel or mat

For the step test, push-ups, split squats and stretches.

A backpack and some books, two gallon water jugs (or milk jugs filled with water) and a broom handle

For the light-load strength work and the hinge drills in Unit 4.

A 12-inch (30 cm) ruler, a tape measure, a tennis ball and four cones (cups or shoes work)

For the skill-related fitness tests in Lesson 1.2 and marking courses.

Two kitchen or outdoor thermometers, a few small cloths, a clear plastic bag and a fan

For the evaporation lab in Lesson 2.1. One thermometer works if you test one condition at a time.

A water bottle and a measuring cup

For the hydration logs and the sweat check in Unit 2.

Food labels, ordinary groceries for two cooked meals, measuring cups and spoons

For the label lab, the bone-building lunch and the game-day meal in Unit 3.

Graph paper and colored pencils

For heart-rate graphs, before-and-after charts and pacing charts.

GRADING

Grades come mostly from the activities and the fitness journal, because fitness is learned by doing, recording and doing again. A student who works hard, records honestly and improves on his or her own numbers earns full credit, whatever those numbers are.

PART	%
Activities (effort, participation and good form)	40
Fitness journal (dated logs, tables, graphs and reflections)	25
Unit reviews	15
Unit challenges	20

Scale: A 90–100, B 80–89, C 70–79, D 60–69. Below 60: repeat the activity or review with help.

- Fitness marks reward effort, consistency and improvement against the student's own earlier numbers. They never depend on body size, body measurements or comparison with other students.
- A journal page earns full marks when it has a date, the numbers with units (reps, seconds, beats per minute, ounces, milligrams), any arithmetic shown, a sentence about how it felt and a sentence about what to try next time.
- On the unit reviews, calculations earn credit for the steps shown as well as the answer.
- A student who finds sport hard, or who has a health condition that limits some activities, is graded on faithful effort within what the doctor allows. Every body can grow stronger; the goal is faithfulness, not being the best.

A NOTE TO PARENTS

You do not need to be a coach to teach this course. Read the story along with your student, watch the video together, and then be the timer, the spotter, the counter and the encourager. Do the workouts alongside your student when you can. Teenagers

notice what adults actually do, and a parent who walks, lifts and cooks well teaches more than any lecture.

Keep the talk about bodies on what they can do and how to care for them. Thirteen- and fourteen-year-olds grow at very different rates, and comparisons with siblings or friends do no good. Praise effort, good form and honest records, and steer back to the journal: “Did you beat your own number from last month?” Exercise is good for the body, and Scripture says plainly that godliness is better still (1 Timothy 4:8). We move, eat, drink and rest to the glory of God.

A few stories touch on serious things and are told plainly: heart attacks among the adults of Framingham, a marathon runner who collapsed from the heat, rickets in children a century ago, and soldiers injured in war. The focus each time is on what careful people learned and how that knowledge protects us now. Lesson 2.2 includes a sweat check in which you weigh your student before and after practice; please record only the difference, as water lost, and keep the starting number to yourself.

UNIT 1

KEEPING ACTIVE

In 1948, doctors began following 5,209 ordinary men and women in the town of Framingham, Massachusetts, examining them every two years to learn why so many Americans were dying of heart disease. Over the next twenty years the Framingham Heart Study found the things that make heart disease more likely, gave them the name “risk factors,” and in 1967 reported that physically active people had less heart disease. In this unit you will learn what the study did, what today’s activity guidelines ask of teenagers, and how to tell moderate from vigorous activity. Then you will run your own heart-health baseline with a step test and keep an honest log of a week of activity.

Fitness is more than a strong heart. In the second lesson you will meet Jim Thorpe, who won both the pentathlon and the decathlon at the 1912 Olympics, and learn the six parts of skill-related fitness: agility, balance, coordination, power, reaction time and speed. You will test all six at home, use a little physics to turn a falling ruler into a reaction time, practice, and retest.

PREREQUISITES

- Can find a pulse at the wrist or neck and count it for 30 seconds
- Can multiply and divide whole numbers and decimals, and find an average
- Knows how to warm up and cool down (from earlier grades), or will learn it in Lesson 1.1

MASTERY CHECKLIST

- ☐ I can tell how the Framingham Heart Study worked and what it found about physical activity and the heart.
- ☐ I can state the activity guidelines for teens: at least 60 minutes a day, mostly aerobic, with vigorous, muscle-strengthening and bone-strengthening activity on at least 3 days a week.
- ☐ I can use the talk test to tell moderate from vigorous activity, and I can take my resting and recovery heart rate.
- ☐ I can name and give an example of the six parts of skill-related fitness.
- ☐ I can run six skill tests safely, record my results, practice, and compare a retest with my own first numbers.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **Framingham Heart Study (official site)**: Free. The study's own pages, including its history and its list of research milestones year by year. Use with Lesson 1.1.
- **A stopwatch and a 25-foot tape measure**: Handy for the step test, the shuttle run, the dash and the standing long jump. A phone timer and a yardstick work too.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1 The Framingham Heart Study

3 sessions of 40–45 minutes

1.2 Skill-Related Fitness: Jim Thorpe's All-Round Gifts

3 sessions of 40–45 minutes

UNIT 1 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

Describe how the Framingham Heart Study worked. Who was studied, starting when, and how often were they examined?

2. 5 pts

What is a risk factor? Name three risk factors the Framingham study identified, and say what it reported about physical activity in 1967.

3. 5 pts

State the physical activity guidelines for young people ages 6–17.

4. 5 pts

Calculation: In one week Sam logged these activity minutes: 45, 70, 30, 85, 60, 20, 75. What is his weekly total and his daily average? On how many days did he meet the guideline?

5. 5 pts

Explain the talk test. Give one example each of moderate and vigorous activity.

6. 5 pts

Your recovery heart rate after the step test was 128 bpm at the start of the week and 121 bpm at the end. What does a lower recovery heart rate suggest? Name two other things that could cause a difference in one week.

7. 5 pts

Name the six parts of skill-related fitness and match each to one of these: catching a pop fly, a basketball rebound jump, a goalkeeper diving at a penalty, a soccer player dodging a defender, a 100-meter sprint, walking on a balance beam.

8. 5 pts

Calculation: In the ruler-drop test you caught the ruler at 20 cm. Use $t = \sqrt{(2d \div 980)}$ to find your reaction time.

9. 5 pts

Why did Jim Thorpe lose his 1912 Olympic medals, and what happened later?

10. 5 pts

Short written answer: In three or four sentences, explain why skill-related fitness improves so quickly with practice, and why this course grades you on your own improvement instead of comparing you with others.

ANSWER KEY

1. Beginning in 1948, the study followed 5,209 men and women aged 30 to 62 from Framingham, Massachusetts, who had not had a heart attack or stroke. They were examined every two years (blood pressure, blood tests, heartbeat recordings, questions about habits), and researchers watched to see who later developed heart disease. Their children (1971) and grandchildren (2002) were added later.
2. A risk factor is a habit or condition that makes a disease more likely. Examples: high blood pressure, high cholesterol, smoking (also not being active). In 1967 the study reported that physical activity was linked to a lower risk of heart disease.
3. At least 60 minutes of activity every day, mostly aerobic; vigorous activity on at least 3 days a week; muscle-strengthening activity on at least 3 days; and bone-strengthening activity on at least 3 days.
4. Total = $45 + 70 + 30 + 85 + 60 + 20 + 75 = 385$ minutes. Average = $385 \div 7 = 55$ minutes a day. He met 60 minutes on 4 days (70, 85, 60, 75). His average falls a little short, and the goal is 60 minutes every day, so he should add movement on the three short days.
5. During moderate activity you can talk but not sing (brisk walking, easy cycling, raking leaves). During vigorous activity you can say only a few words before needing a breath (running, fast swimming, a hard game of soccer or basketball).
6. A lower recovery heart rate suggests the heart is recovering faster, a sign of improving fitness. In one week the difference could also come from sleep, nerves, food or drink, temperature, time of day or a slightly different stepping pace. That is why tests should be done the same way and repeated.
7. Coordination: catching a pop fly. Power: rebound jump. Reaction time: goalkeeper diving. Agility: dodging a defender. Speed: 100-meter sprint. Balance: balance beam. (Several parts work together in most skills.)
8. $t = \sqrt{(2 \times 20 \div 980)} = \sqrt{(40 \div 980)} = \sqrt{0.0408} \approx 0.20$ seconds.
9. In 1913 it came out that he had been paid to play minor-league baseball in 1909–1910, and the rules then allowed only amateurs, so his medals were taken away. In 1982 the International Olympic Committee restored his status as champion, and in 2022 it listed him again as the sole winner of the pentathlon and decathlon.

10. Answers will vary. Skill-related fitness depends heavily on the nervous system; with practice the brain learns the movement pattern and sends faster, better-timed signals to the muscles. Students grow and develop at different rates and start at different places, so comparing with others is unfair and discouraging. Faithful practice and improvement on one's own numbers show stewardship of the body God gave.

UNIT CHALLENGE: TWO-WEEK ACTIVITY LOG AND PLAN

Keep your seven-day activity log from Lesson 1.1 going for a second week, using the change you chose. For each day record moderate and vigorous minutes (judged by the talk test), whether you did muscle- and bone-strengthening activity, and your hours of sitting outside of school. At the end, make a bar graph of all fourteen days with a line at 60 minutes, calculate your weekly totals and daily averages for both weeks, and retest your step-test recovery heart rate. Write a paragraph comparing the two weeks and a plan for keeping the habits that worked, including one skill-related drill from Lesson 1.2 that you will keep practicing.

LOOK FOR	WHAT IT MEANS
Faithful, honest log	Fourteen dated days with minutes and categories filled in, judged honestly with the talk test.
Calculations	Weekly totals and daily averages for both weeks, shown with the arithmetic.
Graph and retest	A neat bar graph of fourteen days with a 60-minute line, and a recovery heart-rate retest done the same way as the baseline.
Reflection and plan	A paragraph naming what changed, what was hard and a specific plan for the weeks ahead. Effort and improvement count, not the size of the numbers.

1.1 THE FRAMINGHAM HEART STUDY

OBJECTIVES

- Tell how the Framingham Heart Study began, how it gathered its evidence, and what it found about physical activity and heart disease.
- State the physical activity guidelines for teens and explain the difference between moderate and vigorous activity.
- Measure resting heart rate and recovery heart rate with a three-minute step test, and keep a seven-day activity log.
- Calculate weekly and average daily minutes of activity and compare them with the guidelines.

Warm-up. Five-minute warm-up: 1 minute marching in place with high knees, 10 arm circles forward and back, 10 slow bodyweight squats, 10 walking lunges, and 1 minute of easy jogging in place. Then sit for 2 minutes and find your pulse at the wrist. Think about it: how could doctors find out what keeps hearts healthy without waiting for people to get sick?

WATCH

What happens inside your body when you exercise?

[British Heart Foundation](#) · 2:33

<https://www.youtube.com/watch?v=wWGulLAa000>

WHEN TO WATCH

After “How your body works,” for a quick animated look at what the heart, lungs, muscles and blood do during exercise, the very changes the Framingham doctors measured.

KEY TERMS

cohort study

A study that follows a large group of people (a cohort) over many years, measuring them again and again to see who develops a disease and what was different about them.

risk factor

A habit or condition that makes a disease more likely, such as smoking, high blood pressure or not being physically active. The Framingham study introduced the term in 1961.

moderate activity

Activity that raises your breathing and heart rate so that you can talk but not sing, such as brisk walking or easy cycling.

vigorous activity

Hard activity that makes you breathe so fast you can say only a few words without stopping for breath, such as running, fast swimming or a hard game of basketball.

resting heart rate

How many times your heart beats in one minute when you are sitting or lying quietly, measured in beats per minute (bpm).

recovery heart rate

Your heart rate a short time after exercise stops. A heart that is becoming fitter slows down faster after work.

CORE IDEAS

The story. In the 1940s, heart disease had become the leading cause of death in the United States, and doctors understood very little about why. Many believed that hardening of the arteries and high blood pressure were simply part of growing old. In 1948 the United States Public Health Service, with money voted by Congress, set out to study heart disease in one ordinary town. They chose Framingham, Massachusetts, about twenty miles west of Boston, partly because its townspeople were eager to help. Doctors, nurses and other volunteers signed up first to set an example. In the end 5,209 men and women between the ages of 30 and 62, none of whom had yet had a heart attack or a stroke, agreed to be examined every two years for the rest of their lives. Dr. Thomas Dawber led the study from 1949 to 1966. Many of those volunteers came faithfully for decades, and in 1971 their children joined a second group, and in 2002 their grandchildren a third.

How they figured it out. At every visit the volunteers were weighed and measured, had their blood pressure taken and their blood tested, had a recording made of their heartbeat (an electrocardiogram), and answered questions about their habits, including smoking and how active they were. Then the researchers waited and watched to see who developed heart disease. Because they had measured everyone *before* anyone got sick, they could compare: did the people who later had heart attacks differ from those who did not? Over the years the answers came: high blood pressure and high cholesterol (1957), smoking (1960), and in 1961 the study gave the world a new term, **risk factor**. In 1967 it reported that physical activity was linked to

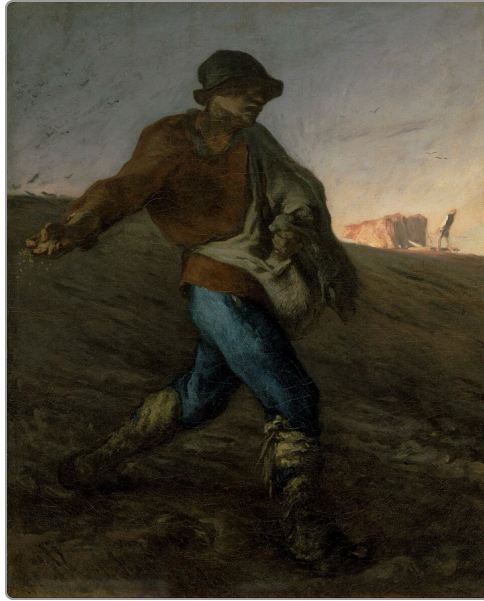
a lower risk of heart disease. Today doctors around the world still use Framingham's findings and the risk scores built from them, and more than 3,000 scientific papers have come from the study.

How your body works. Your heart is a muscle, and like other muscles it responds to regular work. When you are active, your heart pumps more blood with each beat, your blood vessels stay flexible, your blood pressure and blood sugar stay in a healthy range, and your muscles get better at using oxygen. The U.S. *Physical Activity Guidelines for Americans* (2nd edition, 2018) say that young people ages 6 to 17 need **at least 60 minutes of activity every day**, most of it aerobic (moving the big muscles steadily, like walking, running, cycling or swimming). On at least 3 of those days, some of it should be **vigorous**; on at least 3 days it should include **muscle-strengthening** activity (push-ups, climbing, carrying, lifting); and on at least 3 days **bone-strengthening** activity (running, jumping, jump rope, basketball). Use the **talk test** to judge intensity: during moderate activity you can talk but not sing; during vigorous activity you can say only a few words before you need a breath. Long hours of sitting work against all of this, so break up screen time and desk time with movement.

Think it through. Framingham showed a link: active people had less heart disease. Careful scientists are slow to say one thing *causes* another from one study alone, so they looked for the same pattern in other studies, such as Jerry Morris's London bus study of 1953, and in experiments where people began exercising and their blood pressure and heart fitness improved. When many kinds of evidence agree, we can trust the conclusion. God made your body "fearfully and wonderfully," and caring for it is part of thankfulness.

Try it. This week you will run your own small "Framingham exam": resting heart rate, a three-minute step test with a recovery heart rate, and a few simple fitness checks. Then you will keep an honest seven-day activity log, add up your minutes, and retest at the end of the week. Your numbers are your baseline: the starting point you will try to improve during the quarter.

PICTURE STUDY



The Sower, Jean-François Millet, 1850 · Oil on canvas · Museum of Fine Arts, Boston

Image: [Wikimedia Commons](#), public domain

Jean-François Millet grew up on a farm in Normandy, France, and spent his life painting the people who worked the land. In *The Sower* a farmer strides down a hill, scattering grain by hand from a bag at his side. A hundred years later, most workers in the towns studied by heart researchers sat at desks or drove vehicles instead.

Look closely

- Look at the sower's legs and arms. What is each one doing? Is this moderate or vigorous work?
- Find the bag of seed. How heavy might it be when it is full, and how far might he walk in a day?
- Look at the slope of the field and the light in the sky. What time of day is it, and how long has he been working?
- Find the man with the oxen on the ridge and the birds in the sky. What are they doing?

Talk about it

1. Farmers like this man did not need an activity plan; their work kept them moving. Why must most people today choose to be active?

2. If you could “sow” 60 minutes of activity into your day, where would you scatter it?
3. Jesus told a parable about a sower (Matthew 13). How is building a good habit like sowing seed and waiting for a harvest?

Safety first. Check with your doctor before starting this course if you have asthma, a heart condition, diabetes, a recent injury or any health concern. Do the step test on a sturdy bottom stair or step with a handrail or wall nearby, in shoes with good grip. Stop and tell an adult right away if you feel chest pain, dizziness, faintness, trouble breathing or sharp pain.

ACTIVITY

My Heart-Health Baseline and a Week of Activity

The Framingham volunteers came back again and again so that changes could be measured. You will do the same on a small scale: record a baseline, keep a week-long log, and retest. The goal is not a big number but an honest one that you can improve.

You will need

- A sturdy bottom stair or step 8–12 inches high, near a wall or rail
- A timer, and a metronome app or a helper who can count a steady beat
- A towel or mat and a wall
- Fitness journal with a baseline table and a seven-day log (day, moderate minutes, vigorous minutes, muscle-strengthening yes/no, bone-strengthening yes/no, hours sitting outside of school)

Steps

1. **Resting heart rate (Session 2).** Sit quietly for 5 minutes. Count your pulse at the wrist for 30 seconds and multiply by 2. Wait 1 minute and count again. Record the average in beats per minute (bpm).
2. **Warm up** with the 5-minute warm-up above.
3. **Three-minute step test.** Step up with one foot, up with the other, down with the first, down with the second (“up, up, down, down”) to a steady beat of 96 counts a minute, which is 24 full steps a minute. A helper can say “up-up-down-down” to a metronome set to 96. Keep going for exactly 3 minutes, switching the leading foot once in the middle.
4. **Recovery heart rate.** As soon as the 3 minutes end, sit down. Within 5 seconds, start counting your pulse for a full 60 seconds. Record it. A lower number means your heart is recovering faster.
5. **Three quick checks** (rest 2 minutes between): (a) push-ups at a level you can do with a straight body (wall, chair against a wall, knees or toes), as many good reps as you can in 60 seconds; (b) a wall sit, back flat against the wall and thighs about level with the floor, timed until your form slips; (c) a forearm plank, timed until your hips sag. Record all three.

6. **Cool down** with 3 minutes of easy walking and 20-second stretches for your calves, thighs, hips and chest.
7. **Seven-day log.** Starting today, write down every day's activity in your log and judge it with the talk test. Count only real movement: walking to the store counts, riding in the car does not. Be honest; this log is for you.
8. **Retest (Session 3, at the end of the week).** Repeat the resting heart rate, the step test and the three checks in exactly the same way, at about the same time of day. Record the new numbers beside the old ones.
9. **Add it up.** Total your moderate and vigorous minutes for the week and divide by 7 to get your daily average. Count your vigorous days, muscle days and bone days. Compare each with the guidelines and write one specific change you will make next week.

Tips

- Count a pulse with your first two fingers, not your thumb (your thumb has its own pulse). Start counting at zero on the first beat.
- One week is too short for big changes in the step test. Small differences can come from sleep, food or nerves. That is why scientists repeat measurements.
- Walking briskly to do an errand, carrying groceries, shoveling, mowing and helping a neighbor all count toward your minutes.

Check your work

- ☐ I can explain what the Framingham Heart Study measured and what it found about activity.
- ☐ I recorded my resting heart rate, step-test recovery heart rate and three checks, and retested them the same way.
- ☐ I can total my weekly minutes, find my daily average and compare them with the guidelines.

FITNESS JOURNAL

1. Make a baseline table: resting heart rate, recovery heart rate, push-ups in 60 seconds, wall sit and plank, with columns for test 1 and test 2.
2. Draw a bar graph of your daily activity minutes for the seven days, with a red line at 60 minutes. Shade the vigorous part of each bar.

3. Show your arithmetic: weekly total $\div 7$ = daily average. Which days met 60 minutes? What got in the way on the others?
4. Write a short paragraph: If you had been a Framingham volunteer in 1948, what would you have wanted to know about your own heart?

From history. Framingham was chosen over Paintsville, Kentucky, partly because so many of its residents were interested in helping. The study was meant to last twenty years. In 1968 a committee recommended ending it, but Congress voted to keep it going, and it continues today with its third generation of volunteers.

COMMON MISTAKES

- Counting pulses with the thumb, or counting for only 10 seconds and multiplying by 6. Counting for 30 or 60 seconds is more accurate.
- Changing the step height, the beat or the time of day between tests. A fair retest changes nothing but you.
- Counting time spent in sports practice standing in line or sitting on the bench as vigorous activity.
- Thinking a long workout on Saturday makes up for a week of sitting. The guidelines call for activity every day.

Make it a game • Study Detective. Explain the Framingham Heart Study to your parent as if you were a researcher presenting results. Define cohort and risk factor, then answer her three questions. She will sneak in one false claim about activity; catch it. Next, measure resting and recovery heart rates around two minutes of vigorous exercise. Record the difference.

Scripture. “I will praise thee; for I am fearfully and wonderfully made: marvellous are thy works” (Psalm 139:14, KJV)

The Framingham doctors spent decades learning how the heart works and what keeps it well. The more we learn, the more marvelous God’s design appears, and the more reason we have to care for it.

1.2 SKILL-RELATED FITNESS: JIM THORPE’S ALL-ROUND GIFTS

OBJECTIVES

- Tell the story of Jim Thorpe at the 1912 Olympics and why his medals were taken away and later restored.
- Name and define the six parts of skill-related fitness and give a sport example of each.
- Run six home tests safely and accurately, including a ruler-drop reaction test converted to seconds with a formula.
- Practice with simple drills and compare a retest with your own first results.

Warm-up. Dynamic warm-up, about 6 minutes: 2 minutes of easy jogging (or jogging in place), 10 walking knee hugs, 10 leg swings forward and back on each leg (hold a wall), 10 side shuffles each way, 10 skips with big arm swings, and 3 easy 10-yard build-up runs. Think about it: what does a basketball point guard need besides strong legs and good lungs?

WATCH

Brain Bites - Skill Related Fitness

Lynn Hefe · 2:27

<https://www.youtube.com/watch?v=28tO4NPo65Y>

WHEN TO WATCH

After “How your body works.” Pause after each of the six parts and name a sport moment that needs it.

Note: A short animated lesson from a physical education teacher’s channel. It ends with a discussion question you can answer together.

KEY TERMS

agility

The ability to change direction quickly while keeping control of your body.

balance

The ability to keep your body steady, whether still (static balance) or moving (dynamic balance).

coordination

The ability to use your senses and different body parts together smoothly, such as eyes and hands when catching.

power

The ability to use strength quickly, as in jumping or throwing. Power combines strength and speed.

reaction time

The time between noticing a signal (a sound, a sight, a touch) and starting to move.

speed

The ability to move your body, or part of it, from one place to another in as short a time as possible.

CORE IDEAS

The story. Jim Thorpe was born in 1887 in what is now Oklahoma, a member of the Sac and Fox Nation. At the Carlisle Indian Industrial School in Pennsylvania, his coach Glenn “Pop” Warner found that Thorpe could do almost anything: run, jump, throw, tackle and kick. At the 1912 Olympic Games in Stockholm, Sweden, Thorpe won gold medals in both the pentathlon (five events) and the decathlon (ten events: sprints, hurdles, jumps, throws and the 1,500 meters), finishing far ahead of everyone else. Sweden’s King Gustaf V is reported to have told him that he was the greatest athlete in the world. Thorpe went on to play major-league baseball and professional football.

How they figured it out. In 1913 newspapers reported that Thorpe had been paid a small amount to play minor-league baseball in 1909 and 1910. The rules of the time allowed only unpaid amateurs in the Olympics, so his medals were taken away. Thorpe had played as many college players did, not knowing the rule would be applied to him. For decades his family and supporters gathered the facts and asked for a fair hearing. In 1982 the International Olympic Committee restored his status as champion, and in 2022 it listed him again as the sole winner of both events. Truth and fairness took a long time, but they came.

How your body works. Physical educators divide fitness into two families. **Health-related fitness** is what keeps you well for life: heart and lung endurance, muscular strength, muscular endurance and flexibility. **Skill-related fitness** is what helps you perform skills in sport and work. It has six parts: **agility, balance, coordination, power, reaction time and speed.** All six depend heavily on your nervous system: your brain, spinal cord and nerves deciding what to do and signaling the right muscles at the right moment. Your senses (eyes, inner ear and the sensors in your

muscles and joints) tell your brain where your body is. That is why skill-related fitness improves so much with practice: your brain learns the pattern and sends faster, better-timed signals. Your teenage years are an excellent time to build these skills.

Think it through. Reaction time can be measured with a falling ruler and a little physics. A ruler dropped from rest falls a distance $d = \frac{1}{2}gt^2$, where g , the pull of gravity, is about 980 centimeters per second per second. Solving for time gives $t = \sqrt{(2d \div 980)}$. If you catch the ruler after it falls 15 cm, your reaction time is $\sqrt{(30 \div 980)} = \sqrt{0.0306} \approx 0.17$ seconds. Quick table: 5 cm ≈ 0.10 s, 10 cm ≈ 0.14 s, 15 cm ≈ 0.17 s, 20 cm ≈ 0.20 s, 25 cm ≈ 0.23 s, 30 cm ≈ 0.25 s.

Try it. In Session 2 you will run six tests, one for each part of skill-related fitness, and record your best results. Then you will practice a drill for each. In Session 3 you will warm up, practice again and retest. Like Thorpe, you are not trying to beat anyone else, only to find out what your body can do and help it do a little more.

PICTURE STUDY



Jim Thorpe at the 1912 Olympic Games, Unknown photographer, 1912 · Photograph · Stockholm, Sweden

Image: [Wikimedia Commons](#), public domain

This photograph shows Jim Thorpe at the Stockholm Olympics in 1912, the summer he won the pentathlon and the decathlon. In those days athletes traveled to the Games by ship, and the American team trained on the deck during the voyage.

Look closely

- Look at how Thorpe is standing. What does his face and posture tell you about him?
- Look at his clothes and shoes. How are they different from what athletes wear today?
- Look at the background. What can you tell about the stadium and the crowd?

Talk about it

1. The decathlon needs speed, power, agility and coordination, plus endurance for the 1,500 meters. Which of its ten events do you think would be hardest for you, and why?
2. Thorpe's medals were taken away and restored seventy years later. Why does it matter to tell the truth about history, even long after?

3. Which part of skill-related fitness would help you most in a sport or job you enjoy?

Safety first. Warm up well before sprints and jumps. Test on grass or a flat, dry, non-slip surface with plenty of room to slow down after the dash and the shuttle, and nothing to trip over. Land jumps softly with bent knees, and stop if you feel sharp pain in a muscle or joint.

ACTIVITY

Six-Part Skill Test and Retest

You will test each part of skill-related fitness in a simple, repeatable way, practice for a session, and retest. Write down exactly how you set up each test so that the retest is fair.

You will need

- Four cones (cups or shoes work) and a tape measure
- A 12-inch (30 cm) ruler with centimeter marks, and a helper
- A tennis ball and a smooth outside wall with no windows
- A stopwatch
- Fitness journal with a table: test, trial 1, trial 2, best, retest best, change

Steps

1. **Set up** on grass or a flat yard: mark a starting line, a line 20 yards away for the dash, and three cones 5 yards apart in a line for the shuttle. Warm up for 6 minutes.
2. **Speed: 20-yard dash.** From a standing start, run through the far line as the helper times from your first movement. Two trials, 2 minutes' rest between. Record the faster time.
3. **Agility: 5-10-5 shuttle.** Start at the middle cone. Run 5 yards to one end cone and touch the ground, turn and run 10 yards to the other end and touch, then turn and sprint 5 yards back through the middle. Two trials, 2 minutes' rest. Record the faster time.
4. **Power: standing long jump.** Stand behind a line, feet apart. Swing your arms and jump forward as far as you can, landing on both feet. Measure from the line to the back of the nearer heel. Best of three.
5. **Balance: stork stand.** Hands on hips, place the sole of one foot against the inside of the other knee. Rise onto the ball of the standing foot and hold. The helper times until your heel touches down, your hands leave your hips or your foot slips, up to 60 seconds. Best of two on each leg.

6. **Coordination: alternate-hand wall toss.** Stand 6 feet (about 2 meters) from a wall. Throw the ball underhand with your right hand and catch it with your left, then throw with your left and catch with your right. Count catches in 30 seconds. Best of two.
7. **Reaction time: ruler drop.** The helper holds the ruler at the top end, with the 0 cm mark just above your open thumb and finger. Without warning, the helper lets go; you catch it as fast as you can. Read the centimeter mark at the top of your thumb. Do 5 trials, drop the highest and lowest, and average the other three. Convert to seconds with the formula or the table.
8. **Practice (end of Session 2 and start of Session 3), 15 minutes:** chalk-ladder footwork or cone weaves (agility); stork stands with eyes on a fixed point, then with head turns (balance); juggling two balls or wall tosses (coordination); 3 sets of 5 soft broad jumps with a full arm swing (power); 3 sets of 10 ruler catches (reaction); 3 smooth build-up runs (speed). Rest 1 minute between drills.
9. **Retest (Session 3).** Warm up the same way and run all six tests exactly as before. Record the change for each test, and cool down with walking and stretches.

Tips

- On the dash and shuttle, stay low for the first few steps and pump your arms. On the shuttle, plant your outside foot and push off it.
- On the long jump, swing your arms back, then drive them forward and up as you jump. Land with knees bent, like a spring.
- Practice helps most on the tests that depend on timing (coordination and reaction). Do not be surprised if those improve fastest.

Check your work

- ☐ I can name and define the six parts of skill-related fitness and tell Jim Thorpe's story.
- ☐ I ran all six tests the same way twice and recorded every trial.
- ☐ I converted my ruler-drop distance to a reaction time in seconds and showed my work.

FITNESS JOURNAL

1. Make a table of all six tests with your first best, your retest best and the change. Circle the test that improved most.
2. Show the reaction-time calculation for your own average catch distance, step by step.
3. Draw a “skill profile” bar graph with six bars (one per part), using your retest results. Write which part you most want to build next and one drill you will use.
4. Choose a sport or job (catcher, goalkeeper, firefighter, carpenter) and write which three skill-related parts it needs most, with an example of each.

From history. Thorpe was named the first president of the American Professional Football Association in 1920, the league that soon became the National Football League. The town of Jim Thorpe, Pennsylvania, is named in his honor.

COMMON MISTAKES

- Sprinting or jumping without warming up. Cold muscles strain more easily.
- Measuring the long jump to the toes instead of the back of the nearest heel.
- Letting the helper count “3, 2, 1” before the ruler drop. Reaction time is about responding to a surprise.
- Comparing your numbers with a sibling’s or a friend’s instead of your own first try.

Make it a game • Six Skills Test. Test the six parts of skill-related fitness: agility run, balance hold, coordination toss and catch, power jump, reaction drop catch and speed dash. Record each result and retest next week. Name a sport for each. Tell Jim Thorpe's story and why his medals were taken and later restored. Beat your own record.

UNIT 1

KEEPING ACTIVE

In 1948, doctors began following 5,209 ordinary men and women in the town of Framingham, Massachusetts, examining them every two years to learn why so many Americans were dying of heart disease. Over the next twenty years the Framingham Heart Study found the things that make heart disease more likely, gave them the name “risk factors,” and in 1967 reported that physically active people had less heart disease. In this unit you will learn what the study did, what today’s activity guidelines ask of teenagers, and how to tell moderate from vigorous activity. Then you will run your own heart-health baseline with a step test and keep an honest log of a week of activity.

Fitness is more than a strong heart. In the second lesson you will meet Jim Thorpe, who won both the pentathlon and the decathlon at the 1912 Olympics, and learn the six parts of skill-related fitness: agility, balance, coordination, power, reaction time and speed. You will test all six at home, use a little physics to turn a falling ruler into a reaction time, practice, and retest.

PREREQUISITES

- Can find a pulse at the wrist or neck and count it for 30 seconds
- Can multiply and divide whole numbers and decimals, and find an average
- Knows how to warm up and cool down (from earlier grades), or will learn it in Lesson 1.1

MASTERY CHECKLIST

- ☐ I can tell how the Framingham Heart Study worked and what it found about physical activity and the heart.
- ☐ I can state the activity guidelines for teens: at least 60 minutes a day, mostly aerobic, with vigorous, muscle-strengthening and bone-strengthening activity on at least 3 days a week.
- ☐ I can use the talk test to tell moderate from vigorous activity, and I can take my resting and recovery heart rate.
- ☐ I can name and give an example of the six parts of skill-related fitness.
- ☐ I can run six skill tests safely, record my results, practice, and compare a retest with my own first numbers.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **Framingham Heart Study (official site)**: Free. The study's own pages, including its history and its list of research milestones year by year. Use with Lesson 1.1.
- **A stopwatch and a 25-foot tape measure**: Handy for the step test, the shuttle run, the dash and the standing long jump. A phone timer and a yardstick work too.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1 The Framingham Heart Study

3 sessions of 40–45 minutes

1.2 Skill-Related Fitness: Jim Thorpe's All-Round Gifts

3 sessions of 40–45 minutes

UNIT 1 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

Describe how the Framingham Heart Study worked. Who was studied, starting when, and how often were they examined?

2. 5 pts

What is a risk factor? Name three risk factors the Framingham study identified, and say what it reported about physical activity in 1967.

3. 5 pts

State the physical activity guidelines for young people ages 6–17.

4. 5 pts

Calculation: In one week Sam logged these activity minutes: 45, 70, 30, 85, 60, 20, 75. What is his weekly total and his daily average? On how many days did he meet the guideline?

5. 5 pts

Explain the talk test. Give one example each of moderate and vigorous activity.

6. 5 pts

Your recovery heart rate after the step test was 128 bpm at the start of the week and 121 bpm at the end. What does a lower recovery heart rate suggest? Name two other things that could cause a difference in one week.

7. 5 pts

Name the six parts of skill-related fitness and match each to one of these: catching a pop fly, a basketball rebound jump, a goalkeeper diving at a penalty, a soccer player dodging a defender, a 100-meter sprint, walking on a balance beam.

8. 5 pts

Calculation: In the ruler-drop test you caught the ruler at 20 cm. Use $t = \sqrt{(2d \div 980)}$ to find your reaction time.

9. 5 pts

Why did Jim Thorpe lose his 1912 Olympic medals, and what happened later?

10. 5 pts

Short written answer: In three or four sentences, explain why skill-related fitness improves so quickly with practice, and why this course grades you on your own improvement instead of comparing you with others.

ANSWER KEY

1. Beginning in 1948, the study followed 5,209 men and women aged 30 to 62 from Framingham, Massachusetts, who had not had a heart attack or stroke. They were examined every two years (blood pressure, blood tests, heartbeat recordings, questions about habits), and researchers watched to see who later developed heart disease. Their children (1971) and grandchildren (2002) were added later.
2. A risk factor is a habit or condition that makes a disease more likely. Examples: high blood pressure, high cholesterol, smoking (also not being active). In 1967 the study reported that physical activity was linked to a lower risk of heart disease.
3. At least 60 minutes of activity every day, mostly aerobic; vigorous activity on at least 3 days a week; muscle-strengthening activity on at least 3 days; and bone-strengthening activity on at least 3 days.
4. Total = $45 + 70 + 30 + 85 + 60 + 20 + 75 = 385$ minutes. Average = $385 \div 7 = 55$ minutes a day. He met 60 minutes on 4 days (70, 85, 60, 75). His average falls a little short, and the goal is 60 minutes every day, so he should add movement on the three short days.
5. During moderate activity you can talk but not sing (brisk walking, easy cycling, raking leaves). During vigorous activity you can say only a few words before needing a breath (running, fast swimming, a hard game of soccer or basketball).
6. A lower recovery heart rate suggests the heart is recovering faster, a sign of improving fitness. In one week the difference could also come from sleep, nerves, food or drink, temperature, time of day or a slightly different stepping pace. That is why tests should be done the same way and repeated.
7. Coordination: catching a pop fly. Power: rebound jump. Reaction time: goalkeeper diving. Agility: dodging a defender. Speed: 100-meter sprint. Balance: balance beam. (Several parts work together in most skills.)
8. $t = \sqrt{(2 \times 20 \div 980)} = \sqrt{(40 \div 980)} = \sqrt{0.0408} \approx 0.20$ seconds.
9. In 1913 it came out that he had been paid to play minor-league baseball in 1909–1910, and the rules then allowed only amateurs, so his medals were taken away. In 1982 the International Olympic Committee restored his status as champion, and in 2022 it listed him again as the sole winner of the pentathlon and decathlon.

10. Answers will vary. Skill-related fitness depends heavily on the nervous system; with practice the brain learns the movement pattern and sends faster, better-timed signals to the muscles. Students grow and develop at different rates and start at different places, so comparing with others is unfair and discouraging. Faithful practice and improvement on one's own numbers show stewardship of the body God gave.

UNIT CHALLENGE: TWO-WEEK ACTIVITY LOG AND PLAN

Keep your seven-day activity log from Lesson 1.1 going for a second week, using the change you chose. For each day record moderate and vigorous minutes (judged by the talk test), whether you did muscle- and bone-strengthening activity, and your hours of sitting outside of school. At the end, make a bar graph of all fourteen days with a line at 60 minutes, calculate your weekly totals and daily averages for both weeks, and retest your step-test recovery heart rate. Write a paragraph comparing the two weeks and a plan for keeping the habits that worked, including one skill-related drill from Lesson 1.2 that you will keep practicing.

LOOK FOR	WHAT IT MEANS
Faithful, honest log	Fourteen dated days with minutes and categories filled in, judged honestly with the talk test.
Calculations	Weekly totals and daily averages for both weeks, shown with the arithmetic.
Graph and retest	A neat bar graph of fourteen days with a 60-minute line, and a recovery heart-rate retest done the same way as the baseline.
Reflection and plan	A paragraph naming what changed, what was hard and a specific plan for the weeks ahead. Effort and improvement count, not the size of the numbers.

HYDRATION

Working muscles turn most of the energy they use into heat, so a hard workout could raise your body temperature to dangerous levels within minutes if your body had no way to get rid of it. In 1774 the English physician Charles Blagden and his friends stepped into rooms heated hotter than boiling water and came out unharmed, and Blagden explained why: the body cools itself, largely by sweating. In this unit you will learn how sweat and blood flow carry heat out of the body, why humid air makes cooling harder, and you will run an evaporation lab and a sweat session of your own.

Then you will learn from a famous collapse. In 1954 the English marathon runner Jim Peters entered the stadium at Vancouver far ahead of everyone, but in the heat he fell again and again and never finished. You will learn the warning signs of heat illness, what to drink before, during and after exercise, and how to measure how much you sweat. With a parent's help you will do a sweat check at practice, calculate your sweat rate, and write and test a hydration plan for game day.

PREREQUISITES

- Knows that water makes up much of the body and that thirst, dark urine, headache and tiredness are signs of dehydration (earlier grades)
- Can take a pulse in beats per minute (Unit 1)
- Can convert cups to ounces (1 cup = 8 fluid ounces $\approx$ 240 mL) and divide to find a rate

MASTERY CHECKLIST

- ☐ I can tell the story of Charles Blagden's heated room and explain how sweating cools the body by evaporation.
- ☐ I can explain thermoregulation: the brain's thermostat, sweat glands and blood vessels in the skin, and why humidity matters.
- ☐ I can name the signs of heat exhaustion and heat stroke and say what to do for each.
- ☐ I can calculate a sweat rate from a sweat check and use it to plan how much to drink during practice.
- ☐ I can write and follow a game-day hydration plan for before, during and after exercise.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Dehydration” (Nemours KidsHealth):** Free. A clear article on the signs of dehydration and how to prevent it during sports. Read it with Lesson 2.2.
- **A reusable water bottle with ounce markings:** Makes the water logs and the game-day plan easy to measure. A measuring cup and any bottle work just as well.
- **Two inexpensive kitchen or outdoor thermometers:** For the evaporation lab in Lesson 2.1. One thermometer works if you test one condition at a time.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 How Sweat Cools You: Charles Blagden’s Hot Room	3 sessions of 40–45 minutes
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2.2 A Hydration Plan for Game Day	3 sessions of 40–45 minutes
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UNIT 2 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. **5 pts**

Describe Charles Blagden’s heated-room experiment. Why did the eggs cook while the men stayed near normal temperature?

2. **5 pts**

Explain thermoregulation during exercise. Name the part of the brain involved and two things it does when you get hot.

3. **5 pts**

In the evaporation lab, which condition cooled the thermometer most: wet in still air, wet in front of a fan, or wet inside a plastic bag? Explain why each result happened.

4. **5 pts**

Why is a hot, humid day more dangerous for exercise than a hot, dry day?

5. (5 pts)

What happened to Jim Peters at the 1954 Vancouver marathon, and what lessons did sports doctors draw from collapses like his?

6. (5 pts)

List three signs of heat exhaustion and three signs of heat stroke. What should you do for each?

7. (5 pts)

Calculation: At a 90-minute practice, Maria's sweat check showed she lost 1.5 pounds and drank 20 ounces. What is her fluid lost in ounces and her sweat rate in ounces per hour?

8. (5 pts)

Calculation: Using Maria's sweat rate of about 29 ounces per hour, about how much should she drink every 15 minutes at her next practice? Is it wise to drink more than this?

9. (5 pts)

Write a short game-day hydration plan for a two-hour soccer tournament game day, with before, during and after.

10. (5 pts)

Short written answer: In three or four sentences, explain why wearing heavy or plastic clothing to "sweat more" is a bad idea.

ANSWER KEY

1. In 1774 Blagden and his friends stepped into rooms heated as hot as about 260 °F (127 °C). Eggs left in the room cooked hard, but the men's body temperature stayed near normal. The living body can get rid of heat, especially by sweating: sweat evaporating from the skin carried heat away. An egg cannot sweat.
2. Working muscles make heat. The hypothalamus senses the warming blood and (1) widens blood vessels near the skin (vasodilation) so warm blood can lose heat to the air, and (2) signals the sweat glands to release sweat, which cools the skin as it evaporates.
3. Wet in front of the fan cooled most, because moving air carries away water vapor and speeds evaporation. Wet in still air cooled some. Wet in the bag cooled least, because the humid air inside slowed evaporation. Dry, the thermometer stayed at room temperature.
4. In humid air sweat evaporates slowly, so it carries away less heat. The body keeps heating up even though the athlete is dripping with sweat, and loses fluid without cooling. The heat index shows this combined effect.
5. On a hot day he entered the stadium about 17 minutes ahead but collapsed seven times, took about 11 minutes to cover 200 meters, and never finished or raced again. Lessons: running hard in heat without enough fluid is dangerous; athletes should drink before, during and after exercise, pace themselves, avoid the hottest hours and get used to the heat gradually.
6. Heat exhaustion: heavy sweating, cool clammy skin, weakness, dizziness, headache, nausea, fast pulse. Stop, move to shade, cool off, drink water, tell an adult. Heat stroke: very high body temperature, confusion or strange behavior, collapse, often hot skin. Call 911 and cool the person immediately with cold water or ice while waiting.
7. Fluid lost = $1.5 \times 16 = 24$ oz. Total sweat = $24 + 20 = 44$ oz. Time = 1.5 hours. Sweat rate = $44 \div 1.5 \approx 29$ oz per hour.
8. $29 \div 4 \approx 7$ oz every 15 minutes (a little under a cup). No; she should aim to replace what she sweats, not drink far more, because drinking much more than you sweat can also be harmful.
9. Before: water with meals; about 16 oz 2–3 hours before; about 8 oz 10–20 minutes before. During: 4–8 oz every 15–20 minutes and at every break. After: drink to replace losses and eat a meal or snack with carbohydrate and some salt; check that urine is pale yellow. Plus shade, rest and knowing the warning signs.

10. Heavy or plastic clothing traps heat and moist air against the skin, so sweat cannot evaporate and cool the body. The athlete loses large amounts of fluid without any cooling benefit, raising the risk of dehydration and heat illness. Sweating more is not a sign of a better workout. Light, loose, breathable clothing is safer.

UNIT CHALLENGE: TESTED GAME-DAY HYDRATION PLAN

Turn your Lesson 2.2 plan into a finished, tested plan. Over the unit, record at least two sweat checks (with a parent) and at least three days of a water log (cups and ounces drunk at each time of day, and urine color morning and afternoon). Use your sweat rate to write a final plan card for before, during and after exercise, with a heat-safety section. Include a chart of your two sweat checks and your water log, and a paragraph explaining what you changed after the first test and why.

LOOK FOR	WHAT IT MEANS
Careful measurement	Two sweat checks done the same way with a parent, recorded as fluid lost (not body weight), plus three days of water logs.
Correct calculations	Fluid lost and sweat rate worked out with every step shown, and turned into 15-minute drinking amounts.
Complete plan	A clear plan card covering before, during and after, sensible amounts, and the signs of heat illness with what to do.
Reflection	A paragraph explaining what changed between the tests and why. Effort and good habits count, not the size of the numbers.

2.1 HOW SWEAT COOLS YOU:

CHARLES BLAGDEN'S HOT ROOM

OBJECTIVES

- Tell the story of Charles Blagden's heated-room experiments and what he concluded.
- Explain thermoregulation: how the brain, blood vessels in the skin and sweat glands keep your core temperature steady.
- Show by experiment that evaporation cools, that moving air speeds it, and that humid air slows it.
- Record heart rate, effort and signs of sweating in a workout, and compare a warmer and a cooler session.

Warm-up. Five-minute warm-up: 1 minute brisk walking or marching, 20 jumping jacks, 10 squats, 10 push-ups at your level, 1 minute of jogging in place. Then hold your wrist against your cheek. Does your skin feel warmer than before? Think about it: where did that heat come from, and where will it go?

WATCH

Why do we sweat? - John Murnan

TED-Ed · 4:48

https://www.youtube.com/watch?v=fctH_1NuqCQ

WHEN TO WATCH

After “How your body works.” Watch for where body heat comes from, the two kinds of sweat glands, and why sweat must evaporate to cool you.

BACKUP VIDEO

LeBron Asks: Why does sweating cool you down? | NCLEX-RN | Khan Academy

Khan Academy · 5:40

<https://www.youtube.com/watch?v=jgnNhL2jSXY>

For a deeper explanation, drawn on a blackboard, of why evaporating water molecules carry heat away.

KEY TERMS

thermoregulation

The body's control of its own temperature, keeping the core near 98.6 °F (37 °C) whether the air is hot or cold.

evaporation

Liquid changing into vapor (gas). The fastest-moving molecules escape first and carry heat with them, so the surface left behind cools.

vasodilation

The widening of blood vessels. When you are hot, vessels near the skin widen so warm blood can give off heat to the air.

hypothalamus

A small part of the brain that acts as the body's thermostat, sensing blood temperature and switching on sweating, shivering and changes in blood flow.

eccrine sweat glands

The millions of small sweat glands over most of your skin that release watery sweat for cooling.

humidity

The amount of water vapor in the air. In humid air, sweat evaporates slowly, so it cools you less.

CORE IDEAS

The story. In January 1774, Charles Blagden, a young English physician and member of the Royal Society, joined his friend the doctor George Fordyce and several other gentlemen of science in a bold experiment in London. They heated a set of rooms with stoves and flues until the air was hotter than boiling water and then stepped inside for minutes at a time. On the hottest trials the air reached about 260 °F (127 °C). To show just how hot it was, they left eggs in the room, and the eggs cooked hard. A thermometer held under the tongue showed that their own bodies stayed very close to normal temperature, although their pulses raced. Blagden reported the experiments to the Royal Society in 1775.

How they figured it out. Why did the eggs cook but the men did not? Blagden reasoned that a living body has a power to get rid of heat that an egg lacks. He noticed that their skin was covered in sweat that dried almost as fast as it formed in the dry heat, and he concluded that sweating played a key part in keeping the body cool. He was among the first scientists to recognize the role of perspiration in

controlling body temperature. Later scientists measured how much heat evaporation carries away and found that it is the body's most powerful way to cool itself during exercise and in hot weather.

How your body works. Your muscles are not very efficient engines: when you exercise, only about a quarter of the energy they use becomes movement, and the rest becomes heat. Your body must move that heat outward or your core temperature would climb quickly. The **hypothalamus** in your brain senses the warming blood and does two things. First, it widens the blood vessels near your skin (**vasodilation**), sending warm blood to the surface; that is why your face turns red. Second, it signals your two to four million **eccrine sweat glands** to release sweat, which is mostly water with some salt. When sweat **evaporates**, the fastest-moving water molecules escape into the air and carry heat with them, cooling your skin and the blood beneath it. Sweat that drips off does almost nothing. That is why **humid** air is dangerous: when the air is already full of water vapor, sweat cannot evaporate well, and you heat up even while dripping wet. The heat index combines temperature and humidity to show how hot it really feels to your body.

Think it through. Every ounce of sweat you make is water taken from your blood. If you do not drink to replace it, your blood volume falls, your heart must beat faster to deliver the same blood, and eventually you sweat less and heat up faster. Cooling and hydration go together.

Try it. In Session 2 you will run an evaporation lab with thermometers to see the cooling power of evaporation, the help of moving air and the problem of humid air. Then you will do a 20-minute workout and record where and when you sweat, your heart rate and your effort. In Session 3 you will repeat the workout in cooler conditions and compare.

PICTURE STUDY



The Veteran in a New Field, Winslow Homer, 1865 · Oil on canvas · The Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Winslow Homer painted this picture in 1865, just after the American Civil War ended. A man who has come home from the army has gone back to farming, cutting ripe wheat with a scythe under a hot summer sun, in his shirtsleeves.

Look closely

- Look at the sky and the color of the wheat. What season is it, and how hot might the day be?
- Look at the man's clothes: shirtsleeves, suspenders and a hat. How do they help him in the heat?
- Look at how much wheat is still standing. How many hours of work are left, and what would he need to drink in that time?
- Look at the swing of the scythe. Which muscles is he using, and how much heat might they be making?

Talk about it

1. Harvest work was done in the hottest weeks of the year. How would sweat, shade and water have kept this man safe?
2. Why might the white shirt help him stay cooler than a dark one?

3. This soldier went from war back to peaceful work. What does the painting say about the dignity of hard, honest work?

Safety first. Do the workout in a shaded or indoor space, not in the hottest part of the day, and drink water before, during and after. Stop, rest in the shade and tell an adult if you feel dizzy, sick to your stomach, very tired or confused, or if you get a headache. Handle thermometers with care (use digital or alcohol-filled ones, never mercury).

ACTIVITY

The Evaporation Lab and the Sweat Session

Blagden used thermometers and careful notes to understand cooling. You will do the same: first with thermometers and wet cloths, then with your own body during a workout.

You will need

- One or two thermometers (digital or alcohol-filled)
- Small cloths or paper towels, a rubber band, room-temperature water, a fan and a clear plastic bag
- A timer, a water bottle and a measuring cup
- Fitness journal with a lab table (condition, temperature at 0, 2, 4, 6, 8 and 10 minutes) and a workout table (heart rate, effort 1–10, where you sweat, water drunk)

Steps

1. **Set up the lab (Session 2).** Let the thermometer sit in the room for 5 minutes and record the air temperature. This is condition A: *dry*.
2. **Condition B: wet, still air.** Wrap the bulb or tip in a small cloth soaked in room-temperature water and fastened with a rubber band. Record the temperature every 2 minutes for 10 minutes.
3. **Condition C: wet, moving air.** Re-wet the cloth and place the thermometer in front of a fan on low. Record every 2 minutes for 10 minutes. (With two thermometers you can run B and C at the same time.)
4. **Condition D: wet, humid air.** Re-wet the cloth and put the thermometer and a damp paper towel inside a clear plastic bag, loosely closed. Record every 2 minutes for 10 minutes. Write a sentence explaining each result.
5. **The sweat session.** Before you start, record your resting heart rate and the room temperature, and drink a cup (8 oz) of water. Then do 20 minutes of steady work: 4 rounds of 2 minutes jogging in place or up and down the stairs, 1 minute of jumping jacks, 1 minute of squats and 1 minute of easy walking. Take a 15-second pulse after each round (multiply by 4).

6. **Record** after each round your effort on a scale of 1 (very easy) to 10 (as hard as possible), where you first noticed sweat (forehead, back, arms), and how much water you sipped (measure it).
7. **Cool down** for 3 minutes of walking and stretches, and drink to thirst. Note how long it takes your face to stop feeling hot.
8. **Session 3: repeat the sweat session** exactly the same, but in a cooler setting: earlier in the day, in a cooler room, or with a fan blowing on you. Compare heart rates, effort and sweating with Session 2, and explain the difference using what you learned in the lab.

Tips

- Use water at room temperature for the lab; cold water would cool the thermometer by itself and spoil the test.
- Wiping sweat off constantly can slow cooling. Let it evaporate, and dab only what gets in your eyes.
- Light-colored, loose clothing lets air reach your skin and reflects sunlight.

Check your work

- ☐ I can explain why the eggs cooked in Blagden's room but the men did not.
- ☐ I recorded all four lab conditions and can explain how moving air and humid air changed the cooling.
- ☐ I compared two workouts and explained the difference in heart rate and effort.

FITNESS JOURNAL

1. Draw a line graph of temperature against time for lab conditions B, C and D on the same axes, in three colors. Label which cooled most and least.
2. Draw a person exercising and label the path of heat: muscles → blood → skin → sweat → evaporation into the air. Add the hypothalamus.
3. Make a table comparing your Session 2 and Session 3 workouts: room temperature, average heart rate, highest effort, water drunk.
4. Write a paragraph: Why is a hot, humid summer afternoon more dangerous for exercise than a hot, dry one?

From history. Blagden later became Secretary of the Royal Society and was knighted in 1792. He is also remembered for Blagden's law, his discovery that dissolving salt in water lowers its freezing point in proportion to how much salt is added, which is why salt melts ice on winter roads.

COMMON MISTAKES

- Thinking that more sweat dripping off means more cooling. Only sweat that evaporates cools you.
- Wearing heavy or rubberized clothing to “sweat more.” It traps heat and can be dangerous.
- Waiting until you are very thirsty to drink during a long, hot workout.
- Believing that if you stop sweating in the heat you have cooled down. Hot, dry skin with confusion can be a sign of heat stroke, an emergency.

Make it a game • Sweat Cooling Lab. Use a damp cloth and a fan or a wave of your hand to test evaporation on your skin. Explain thermoregulation using hypothalamus, vasodilation and sweat glands in order. Tell Blagden's hot room story. Your parent plays a doubter and challenges each step. Defend it. Humidity round: why does sweat cool less on damp days?

2.2 A HYDRATION PLAN FOR GAME DAY

OBJECTIVES

- Tell the story of Jim Peters at the 1954 Vancouver marathon and what it teaches about heat and fluids.
- Name the signs of heat exhaustion and heat stroke and explain what to do for each.
- Measure fluid lost in a parent-run sweat check and calculate a sweat rate in ounces per hour.
- Write a game-day hydration plan for before, during and after exercise, test it, and improve it.

Warm-up. Six-minute warm-up: 2 minutes easy jogging, 10 walking lunges, 10 side shuffles each way, 10 high-knee skips, 10 push-ups at your level and 3 short build-up runs. Then take one sip of water and notice how much is in one sip (most people sip about 1 ounce). Think about it: how many sips would you need to replace a cup of sweat?

WATCH

Meet the Experts: Heat and Hydration Tips for Your Young Athlete

Arkansas Children's • 7:41

https://www.youtube.com/watch?v=CxQYNII3_14

WHEN TO WATCH

After “How your body works.” Listen for how early to start drinking before a game, how often to drink during it, and when water is enough.

Note: A conversation with a sports-medicine coordinator from Arkansas Children’s Hospital. Near the end the hosts chat briefly about an upcoming local high-school football game; you can stop when the hydration advice ends.

BACKUP VIDEO

Hydration tips every athlete needs to know

Mayo Clinic • 1:38

https://www.youtube.com/watch?v=hENp-vDW_H4

A quick summary to watch again before you write your plan.

KEY TERMS

dehydration

Having less water in the body than it needs, from sweating, illness or not drinking enough. Signs include thirst, dark yellow urine, headache, tiredness and dizziness.

heat stroke

A life-threatening emergency in which the body's cooling fails: very high body temperature, confusion, strange behavior or collapse, often with hot skin. Call 911 and cool the person right away.

electrolytes

Minerals such as sodium and potassium, dissolved in body fluids and lost in sweat, that help nerves and muscles work and help the body hold water.

heat exhaustion

Illness from heat and fluid loss: heavy sweating, cool clammy skin, weakness, dizziness, headache, nausea and a fast pulse. Stop, cool down in the shade, drink and tell an adult.

sweat rate

How much fluid you lose in sweat per hour of exercise, found from a before-and-after sweat check plus what you drank.

CORE IDEAS

The story. Jim Peters of England was the greatest marathon runner of his day. He broke the world record four times and was the first man to run a marathon in under 2 hours 20 minutes. On August 7, 1954, at the British Empire and Commonwealth Games in Vancouver, Canada, he ran the marathon on a hot, sunny afternoon. Peters ran a fast pace from the start and entered the stadium alone, believed to be about 17 minutes ahead of the next runner. Then the crowd watched in dismay as he staggered, fell, rose and fell again. He collapsed seven times and took about 11 minutes to cover the last 200 meters before he fell into the arms of an official and was carried away on a stretcher. He never finished, and he never raced again. "I was lucky not to have died that day," he said later.

How they figured it out. Peters had run hard in the heat, and in those days distance runners often drank little or nothing during a race; many believed drinking would

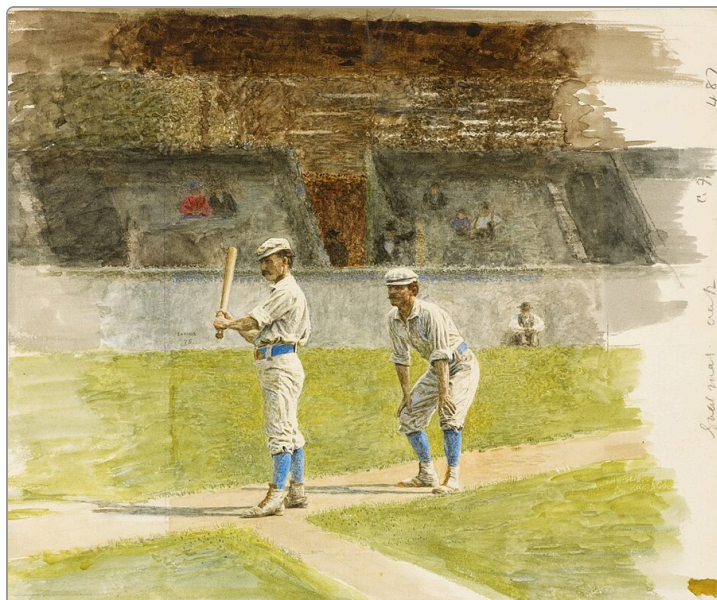
slow them down. Over the following decades, sports doctors and scientists studied what happens to athletes in the heat, measuring body temperature, sweat losses and performance. They learned that heat illness comes from a body producing heat faster than it can get rid of it, made worse by fluid loss, hot and humid weather, too fast a pace, and not being used to the heat. Today coaches schedule water breaks, practice in cooler hours, and teach athletes to drink before, during and after exercise.

How your body works. Sweat comes from your blood plasma. As you lose water, your blood volume shrinks, your heart beats faster to keep blood moving, your body has less fluid to send to the skin for cooling, and your temperature climbs. Even a small loss of body water makes exercise feel harder and slows your thinking and reactions. A good game-day plan has three parts. **Before:** drink water with every meal the day before and on game day; drink about 16 ounces (2 cups) 2 to 3 hours before play and about 8 ounces 10 to 20 minutes before. **During:** take a few big gulps, about 4 to 8 ounces, every 15 to 20 minutes, even if you are not very thirsty. **After:** drink to replace what you lost and eat a meal or snack; ordinary food restores the salt (sodium) and potassium lost in sweat. Your urine should be pale yellow. For most practices water is the best drink; a sports drink with sugar and electrolytes helps only in long, hard exercise of more than an hour, especially in heat. Do not force down huge amounts either; drinking much more than you sweat is also harmful.

Think it through. Everyone sweats a different amount. A sweat check tells you how much *you* lose. A parent weighs you in dry clothes before practice and again after, with you towed dry, and writes down only the difference. Because a pint of water weighs about a pound, every pound lost is about 16 ounces of sweat that you did not replace. **Sweat rate = (ounces lost + ounces drunk) ÷ hours.** Example: lost 1 pound (16 oz), drank 12 oz, practiced 1 hour: $(16 + 12) \div 1 = 28$ ounces per hour. To keep up, you would drink about 7 ounces every 15 minutes during a similar practice.

Try it. In Session 2 you will do a sweat check at a practice or a 45–60 minute backyard workout and calculate your sweat rate. Then you will write a game-day plan. In Session 3 you will follow your plan at a second practice, repeat the sweat check, and see whether you lost less.

PICTURE STUDY



Baseball Players Practicing, Thomas Eakins, 1875 · Watercolor on paper · Museum of Art, Rhode Island School of Design, Providence

Image: [Wikimedia Commons](#), public domain

Thomas Eakins of Philadelphia loved sport and painted rowers and ballplayers with great care for how the body moves. In this watercolor two players from a Philadelphia club practice on a bright day in 1875, when professional baseball was still young.

Look closely

- Look at the batter's stance. Where is his weight, and what is he getting ready to do?
- Look at the second player, crouched with his hands on his knees. What is he ready for?
- Look at the uniforms: caps, long sleeves rolled up, stockings. Would they be hot or cool in summer sun?
- Look at the stands. Where is the shade, and where would these players go to rest and drink?

Talk about it

1. Players in 1875 wore heavy wool uniforms. How would that affect sweating and cooling on a hot day?

2. Baseball has long stretches of waiting and short bursts of hard effort. How would you plan drinking for a baseball game compared with a soccer game?
3. What should a coach do if a player in the sun begins to look confused or stops sweating?

Safety first. A parent supervises the sweat check, does the weighing and records only the difference. Practice in shade or in the cooler part of the day, drink on your plan, and stop at once and tell an adult if you feel dizzy, sick, very weak, confused or get a headache. Heat stroke is an emergency: call 911 and cool the person with cold water and ice while waiting.

ACTIVITY

Sweat Check and Game-Day Hydration Plan

Jim Peters had no plan for fluids in the heat. You will measure your own sweat losses, write a plan for before, during and after exercise, and test it at a second practice.

You will need

- A bathroom scale (used by a parent) and a towel
- A water bottle with ounce marks or a measuring cup
- A team practice, or a 45–60 minute backyard workout or game
- A timer, and a urine color chart (pale yellow is the goal; dark yellow means drink more)
- Fitness journal with a sweat-check table: date, temperature, minutes of exercise, ounces drunk, fluid lost (oz), sweat rate (oz per hour), how you felt

Steps

1. **Before (Session 2).** Drink normally through the day. Two hours before exercise, drink about 16 oz of water and record it. Check your urine color.
2. **First weighing.** Just before exercise, empty your bladder, put on the clothes you will exercise in, and have a parent weigh you. The parent writes the number privately.
3. **Exercise for 45–60 minutes** at practice or in a backyard workout: 10 minutes of warm-up, then games or drills with steady effort. Measure every ounce you drink and note the times. Do not go to the bathroom during the test if you can help it (if you must, note it).
4. **Second weighing.** Towel off all sweat, keep the same dry clothes on (or change into an identical dry set) and have the parent weigh you again. The parent subtracts and tells you only the difference in pounds.
5. **Calculate.** Fluid lost (oz) = pounds lost $\times$ 16. Sweat rate (oz per hour) = (fluid lost + ounces drunk) $\div$ hours of exercise. Show your work.

6. **Write your game-day plan** on a card: what you will drink with meals and 2–3 hours before, 10–20 minutes before, every 15–20 minutes during (use your sweat rate, divided into 15-minute amounts), and after (drink plus a snack with some salt and carbohydrate, such as crackers and cheese or a sandwich and fruit). Add a heat-safety rule list: shade, rest, the warning signs and who to tell.
7. **Test the plan (Session 3).** Follow your plan exactly at a second practice or workout of about the same length, and repeat the sweat check with the parent. Did you lose less? How did you feel at the end compared with Session 2?
8. **Pack a game-day bag** list: full water bottle (or two), a snack, a towel, a hat and sunscreen for outdoor games, and your plan card.

Tips

- If you lost more than about a pound in an hour, plan to drink a little more next time. If you gained, you drank more than you sweated; drink a little less.
- Cold water is more pleasant to drink, so you will drink more of it. Freeze a half-full bottle the night before and top it up in the morning.
- A salty snack and a meal after practice restore the salt lost in sweat. Most teens do not need salt tablets or special drinks.

Check your work

- ☐ I can name the signs of heat exhaustion and heat stroke and say what to do.
- ☐ I calculated my sweat rate and showed my work.
- ☐ I wrote a game-day hydration plan, tested it at a second practice and wrote what I would change.

FITNESS JOURNAL

1. Copy your sweat-check table for both sessions and draw a bar graph comparing fluid lost and ounces drunk.
2. Write out your sweat-rate calculation for each session, step by step.
3. Make a two-column chart: Heat exhaustion (signs, what to do) and Heat stroke (signs, what to do).

4. Write a short letter to Jim Peters in 1954, explaining what scientists have learned since his race about running in the heat.

From history. The same day Peters collapsed, the same stadium saw the “Miracle Mile,” in which Roger Bannister of England beat John Landy of Australia, both running under four minutes. After Peters’s collapse, the Duke of Edinburgh sent him a special medal inscribed “To a most gallant marathon runner.”

COMMON MISTAKES

- Waiting until halftime or the end of practice to drink. Small, regular drinks work better than one huge one.
- Drinking far more than you sweat “to be safe.” Too much water can also make a person ill.
- Treating a teammate who is confused or stumbling in the heat as just tired. Confusion in the heat is an emergency.
- Reaching for sugary sports drinks or soda for an ordinary practice when water would do.

Make it a game • Game Day Hydration Pitch. Present a hydration plan for a tournament day to your parent, with when you drink, how much, and which electrolytes. She plays Jim Peters's marathon crowd and questions your plan. Name heat exhaustion and heat stroke signs and the first aid for each. Points for each correct warning sign. Beat your score.

HYDRATION

Working muscles turn most of the energy they use into heat, so a hard workout could raise your body temperature to dangerous levels within minutes if your body had no way to get rid of it. In 1774 the English physician Charles Blagden and his friends stepped into rooms heated hotter than boiling water and came out unharmed, and Blagden explained why: the body cools itself, largely by sweating. In this unit you will learn how sweat and blood flow carry heat out of the body, why humid air makes cooling harder, and you will run an evaporation lab and a sweat session of your own.

Then you will learn from a famous collapse. In 1954 the English marathon runner Jim Peters entered the stadium at Vancouver far ahead of everyone, but in the heat he fell again and again and never finished. You will learn the warning signs of heat illness, what to drink before, during and after exercise, and how to measure how much you sweat. With a parent's help you will do a sweat check at practice, calculate your sweat rate, and write and test a hydration plan for game day.

PREREQUISITES

- Knows that water makes up much of the body and that thirst, dark urine, headache and tiredness are signs of dehydration (earlier grades)
- Can take a pulse in beats per minute (Unit 1)
- Can convert cups to ounces (1 cup = 8 fluid ounces $\approx$ 240 mL) and divide to find a rate

MASTERY CHECKLIST

- ☐ I can tell the story of Charles Blagden's heated room and explain how sweating cools the body by evaporation.
- ☐ I can explain thermoregulation: the brain's thermostat, sweat glands and blood vessels in the skin, and why humidity matters.
- ☐ I can name the signs of heat exhaustion and heat stroke and say what to do for each.
- ☐ I can calculate a sweat rate from a sweat check and use it to plan how much to drink during practice.
- ☐ I can write and follow a game-day hydration plan for before, during and after exercise.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Dehydration” (Nemours KidsHealth):** Free. A clear article on the signs of dehydration and how to prevent it during sports. Read it with Lesson 2.2.
- **A reusable water bottle with ounce markings:** Makes the water logs and the game-day plan easy to measure. A measuring cup and any bottle work just as well.
- **Two inexpensive kitchen or outdoor thermometers:** For the evaporation lab in Lesson 2.1. One thermometer works if you test one condition at a time.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 How Sweat Cools You: Charles Blagden’s Hot Room	3 sessions of 40–45 minutes
2.2 A Hydration Plan for Game Day	3 sessions of 40–45 minutes

UNIT 2 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

- 5 pts**
Describe Charles Blagden’s heated-room experiment. Why did the eggs cook while the men stayed near normal temperature?
- 5 pts**
Explain thermoregulation during exercise. Name the part of the brain involved and two things it does when you get hot.
- 5 pts**
In the evaporation lab, which condition cooled the thermometer most: wet in still air, wet in front of a fan, or wet inside a plastic bag? Explain why each result happened.
- 5 pts**
Why is a hot, humid day more dangerous for exercise than a hot, dry day?

5. (5 pts)

What happened to Jim Peters at the 1954 Vancouver marathon, and what lessons did sports doctors draw from collapses like his?

6. (5 pts)

List three signs of heat exhaustion and three signs of heat stroke. What should you do for each?

7. (5 pts)

Calculation: At a 90-minute practice, Maria's sweat check showed she lost 1.5 pounds and drank 20 ounces. What is her fluid lost in ounces and her sweat rate in ounces per hour?

8. (5 pts)

Calculation: Using Maria's sweat rate of about 29 ounces per hour, about how much should she drink every 15 minutes at her next practice? Is it wise to drink more than this?

9. (5 pts)

Write a short game-day hydration plan for a two-hour soccer tournament game day, with before, during and after.

10. (5 pts)

Short written answer: In three or four sentences, explain why wearing heavy or plastic clothing to "sweat more" is a bad idea.

ANSWER KEY

1. In 1774 Blagden and his friends stepped into rooms heated as hot as about 260 °F (127 °C). Eggs left in the room cooked hard, but the men's body temperature stayed near normal. The living body can get rid of heat, especially by sweating: sweat evaporating from the skin carried heat away. An egg cannot sweat.
2. Working muscles make heat. The hypothalamus senses the warming blood and (1) widens blood vessels near the skin (vasodilation) so warm blood can lose heat to the air, and (2) signals the sweat glands to release sweat, which cools the skin as it evaporates.
3. Wet in front of the fan cooled most, because moving air carries away water vapor and speeds evaporation. Wet in still air cooled some. Wet in the bag cooled least, because the humid air inside slowed evaporation. Dry, the thermometer stayed at room temperature.
4. In humid air sweat evaporates slowly, so it carries away less heat. The body keeps heating up even though the athlete is dripping with sweat, and loses fluid without cooling. The heat index shows this combined effect.
5. On a hot day he entered the stadium about 17 minutes ahead but collapsed seven times, took about 11 minutes to cover 200 meters, and never finished or raced again. Lessons: running hard in heat without enough fluid is dangerous; athletes should drink before, during and after exercise, pace themselves, avoid the hottest hours and get used to the heat gradually.
6. Heat exhaustion: heavy sweating, cool clammy skin, weakness, dizziness, headache, nausea, fast pulse. Stop, move to shade, cool off, drink water, tell an adult. Heat stroke: very high body temperature, confusion or strange behavior, collapse, often hot skin. Call 911 and cool the person immediately with cold water or ice while waiting.
7. Fluid lost = $1.5 \times 16 = 24$ oz. Total sweat = $24 + 20 = 44$ oz. Time = 1.5 hours. Sweat rate = $44 \div 1.5 \approx 29$ oz per hour.
8. $29 \div 4 \approx 7$ oz every 15 minutes (a little under a cup). No; she should aim to replace what she sweats, not drink far more, because drinking much more than you sweat can also be harmful.
9. Before: water with meals; about 16 oz 2–3 hours before; about 8 oz 10–20 minutes before. During: 4–8 oz every 15–20 minutes and at every break. After: drink to replace losses and eat a meal or snack with carbohydrate and some salt; check that urine is pale yellow. Plus shade, rest and knowing the warning signs.

10. Heavy or plastic clothing traps heat and moist air against the skin, so sweat cannot evaporate and cool the body. The athlete loses large amounts of fluid without any cooling benefit, raising the risk of dehydration and heat illness. Sweating more is not a sign of a better workout. Light, loose, breathable clothing is safer.

UNIT CHALLENGE: TESTED GAME-DAY HYDRATION PLAN

Turn your Lesson 2.2 plan into a finished, tested plan. Over the unit, record at least two sweat checks (with a parent) and at least three days of a water log (cups and ounces drunk at each time of day, and urine color morning and afternoon). Use your sweat rate to write a final plan card for before, during and after exercise, with a heat-safety section. Include a chart of your two sweat checks and your water log, and a paragraph explaining what you changed after the first test and why.

LOOK FOR	WHAT IT MEANS
Careful measurement	Two sweat checks done the same way with a parent, recorded as fluid lost (not body weight), plus three days of water logs.
Correct calculations	Fluid lost and sweat rate worked out with every step shown, and turned into 15-minute drinking amounts.
Complete plan	A clear plan card covering before, during and after, sensible amounts, and the signs of heat illness with what to do.
Reflection	A paragraph explaining what changed between the tests and why. Effort and good habits count, not the size of the numbers.

UNIT 3

NUTRITION

A hundred years ago, many children in the crowded, smoky cities of Europe and North America grew up with soft, bent bones from a disease called rickets. Families had long known that a spoonful of cod-liver oil seemed to help, but no one knew why. In 1922 the American scientist Elmer McCollum showed that the oil held a new substance, which he named vitamin D. In this unit you will learn how calcium, vitamin D and iron build your bones and blood during the very years when you are growing fastest, read the minerals on Nutrition Facts labels in milligrams and percent Daily Value, and cook a bone-building lunch.

Then you will learn how food fuels sport. In the 1960s, Swedish scientists used a fine needle to take tiny samples from working thigh muscles and measured the fuel stored inside. They found that the food athletes ate in the days before exercise changed how long they could keep going. You will learn what to eat before a game and after it, why real food is all a growing athlete needs, and you will plan and cook a game-day meal and a recovery snack.

PREREQUISITES

- Knows the food groups and what carbohydrates, proteins and fats do (earlier grades)
- Can read serving size, grams and percent Daily Value on a Nutrition Facts label
- Can multiply and divide decimals and convert a percent to a number

MASTERY CHECKLIST

- ☐ I can tell the story of rickets, cod-liver oil and Elmer McCollum's discovery of vitamin D.
- ☐ I can explain what calcium, vitamin D and iron do and how much a teenager needs each day.
- ☐ I can convert percent Daily Value on a label into milligrams and plan a day that meets my calcium and iron needs.
- ☐ I can explain how carbohydrates are stored as glycogen and why the Swedish studies showed they matter for endurance.
- ☐ I can plan and cook a game-day meal and a recovery snack from ordinary food, with no pills, powders or special drinks.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Calcium” (Nemours KidsHealth, for teens)**: Free. Why the teen years matter so much for bones, and foods rich in calcium. Read it with Lesson 3.1.
- **“A Guide to Eating for Sports” (Nemours KidsHealth, for teens)**: Free. What and when to eat before, during and after sports. Read it with Lesson 3.2.
- **“How to Understand and Use the Nutrition Facts Label” (U.S. Food and Drug Administration)**: Free. The official guide to every line of the label, including percent Daily Value. Useful for both lessons.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 Iron, Calcium and Vitamin D

3 sessions of 40–45 minutes

3.2 Eating for Sport: Fuel Before, Repair After

3 sessions of 40–45 minutes

UNIT 3 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

What is rickets, and why was it common in industrial cities around 1900?

2. 5 pts

Describe McCollum's 1922 experiment with cod-liver oil. What did it prove?

3. 5 pts

State how much calcium, vitamin D and iron a 14-year-old needs each day, and say what each does.

4. 5 pts

Calculation: A cup of yogurt has 30% DV calcium and a bowl of cereal has 45% DV iron. How many milligrams of calcium and of iron are these?

5. 5 pts

Name two ways to help your body absorb iron from plant foods, and one reason spinach is not a good calcium source.

6. 5 pts

Describe the Swedish glycogen experiment of 1967 and its main finding.

7. 5 pts

Calculation: A game-day meal has 90 g of carbohydrate, 30 g of protein and 15 g of fat. How much food energy comes from each, and what is the total?

8. 5 pts

Write a good eating timeline for a soccer game at 10:00 a.m.

9. 5 pts

What would happen if an athlete skipped breakfast and lunch before a 3:00 p.m. practice?

10. **5 pts**

Short written answer: In three or four sentences, explain to a teammate why healthy teens do not need pills, powders or energy shakes to play well.

ANSWER KEY

1. Rickets is a disease of growing children in which bones become soft and may bend, mainly from too little vitamin D. It was common in smoky industrial cities where children got little sunlight (the skin makes vitamin D in sunlight) and often ate poorly.
2. He heated cod-liver oil and bubbled air through it to destroy its vitamin A. The treated oil still prevented rickets in laboratory animals, proving that the anti-rickets substance was a different vitamin. He named it vitamin D.
3. Calcium: 1,300 mg; hardens bones and teeth and helps muscles, nerves and clotting. Vitamin D: 600 IU (15 mcg); helps absorb calcium. Iron: 11 mg for boys, 15 mg for girls at 14–18 (8 mg at 9–13); forms hemoglobin to carry oxygen.
4. Calcium: $30 \times 13 = 390$ mg. Iron: $45 \times 0.18 = 8.1$ mg.
5. Eat a vitamin C food (orange, tomatoes, strawberries, peppers) at the same meal; include some meat, poultry or fish with beans or grains. Spinach's calcium is bound up and poorly absorbed.
6. Using a needle biopsy to measure muscle glycogen, researchers had the same men eat mostly fat and protein, a mixed menu, or mostly carbohydrate for several days, then ride at the same hard pace until exhausted. With full glycogen after high-carbohydrate eating they lasted roughly three times as long as after the fat-and-protein days. Starting muscle glycogen predicted endurance.
7. Carbohydrate: $90 \times 4 = 360$ calories. Protein: $30 \times 4 = 120$ calories. Fat: $15 \times 9 = 135$ calories. Total = 615 calories of food energy, most from carbohydrate.
8. About 7:00–7:30 a.m.: a balanced breakfast rich in carbohydrate with some protein (oatmeal with milk and a banana, toast with peanut butter). Water through the morning. 9:15–9:30: a small snack if hungry (banana or crackers). Water during the game. Within an hour after: recovery snack with carbohydrate and protein (chocolate milk, yogurt and fruit), then a balanced lunch.
9. Liver and muscle glycogen would be low, blood sugar could drop, and the athlete would tire early, feel weak or dizzy, think and react more slowly, and be more likely to get hurt. Recovery afterward would also be slower.
10. Answers will vary. Ordinary balanced meals give all the carbohydrate, protein, vitamins and minerals a growing athlete needs, and protein needs are easily met with food. Many such products are not checked for safety before they are sold and some contain things that can be harmful. Money is better spent on good

food, and regular meals, water, sleep and training are what really improve performance.

UNIT CHALLENGE: A PLANNED AND COOKED DAY OF FUEL

Plan one full day of meals and snacks for a day with a practice or game. Your plan must reach at least 1,300 mg of calcium and your iron target, include a vitamin D source, and time the meals well for the exercise (main meal 3–4 hours before, snack if needed, recovery snack after). Show the label arithmetic for calcium, iron and the food energy from carbohydrate, protein and fat. Cook at least two of the meals yourself with a parent’s supervision, eat the day as planned, and log your energy during the practice. Finish with a one-page summary and a photo or drawing of each meal you cooked.

LOOK FOR	WHAT IT MEANS
Sound plan	Meets calcium and iron targets with a vitamin D source, a carbohydrate-rich pre-exercise meal and a recovery snack, using everyday foods.
Accurate arithmetic	%DV converted to milligrams and grams converted to food energy, with work shown.
Cooking and safety	Two meals cooked with clean hands, safe knife and stove use, and allergies checked.
Record and reflection	An energy log during practice and a summary of what worked and what to change. Effort and good habits count.

3.1 IRON, CALCIUM AND VITAMIN D

OBJECTIVES

- Tell the story of rickets, cod-liver oil, sunlight and Elmer McCollum's discovery of vitamin D.
- Explain what calcium, vitamin D and iron do in the body and state a teenager's daily needs.
- Convert percent Daily Value into milligrams and plan a day of meals that meets calcium and iron needs.
- Cook a calcium- and iron-rich lunch and do a short bone-strengthening workout.

Warm-up. Bone-builder warm-up, about 5 minutes: 1 minute of easy jogging, 20 jumping jacks, 10 squat jumps (land softly), 20 quick hops in place on two feet, 10 hops on each foot, and 1 minute of walking. Think about it: why might jumping be better for building bones than swimming, even though both are good exercise?

WATCH

Iron Deficiency | Cells | Biology | FuseSchool

FuseSchool - Global Education · 4:15

<https://www.youtube.com/watch?v=H-IY53XBORo>

WHEN TO WATCH

After the “How your body works” paragraph. Watch for what hemoglobin does, what happens when the body is short of iron, and which foods are rich in iron.

Note: An animated biology lesson from a free online school. It uses British spellings (anaemia, haemoglobin) and briefly mentions vitamin B12 and blood loss as other causes of anemia.

KEY TERMS

rickets

A disease of growing children in which bones become soft and may bend, caused mainly by too little vitamin D (and sometimes too little calcium).

vitamin D

A vitamin that helps the body absorb calcium from food. The skin makes it in sunlight, and it is found in fortified milk, fatty fish and egg yolks.

calcium

The mineral that makes bones and teeth hard. It also helps muscles contract, nerves send signals and blood clot.

iron

A mineral at the center of hemoglobin, which carries oxygen in red blood cells, and of myoglobin, which holds oxygen in muscles.

hemoglobin

The iron-containing protein in red blood cells that picks up oxygen in the lungs and delivers it to the body.

percent Daily Value (%DV)

On a Nutrition Facts label, how much of a day's recommended amount of a nutrient one serving provides. For calcium the Daily Value is 1,300 mg; for iron, 18 mg; for vitamin D, 20 mcg.

CORE IDEAS

The story. In the 1800s and early 1900s, rickets was common among children in industrial cities, where smoke darkened the sky and families lived in narrow, sunless streets. Children with rickets had soft bones; their legs bowed under their weight and some never grew straight. Since the 1820s, doctors in Germany and then across Europe had noticed that young children given cod-liver oil, a fishy oil pressed from the livers of codfish, did not develop rickets. A spoonful a day became a family habit for generations. But why it worked was a mystery.

How they figured it out. Elmer McCollum grew up on a Kansas farm and became one of the first scientists to study nutrition with careful animal experiments, starting the first colony of laboratory rats in the United States for nutrition research. In 1913, at the University of Wisconsin, he and Marguerite Davis discovered the first vitamin to be named, vitamin A. Some scientists thought vitamin A was what cured rickets. In 1922, at Johns Hopkins University, McCollum tested the idea: he heated cod-liver oil and bubbled air through it until its vitamin A was destroyed. The treated oil still prevented rickets. So the cure had to be a different substance. Because it was the fourth vitamin discovered, he named it **vitamin D**. Meanwhile other researchers found that sunlight and ultraviolet lamps also cured rickets, and in the 1920s Harry Steenbock of Wisconsin showed that shining ultraviolet light on foods gave them vitamin D. From the 1930s, milk was fortified with vitamin D, and rickets became rare.

How your body works. Your bones are living tissue, constantly built up and broken down. During your teens you are building bone faster than at any other time: about a quarter of all the bone you will ever have is laid down in the two years around your growth spurt, and by your late teens you will have built most of your adult bone.

Calcium is the main mineral in bone; teenagers ages 9 to 18 need **1,300 milligrams a day**, more than adults. **Vitamin D** (600 IU, or 15 micrograms, a day) lets your intestines absorb that calcium; without it, much of the calcium you eat passes through unused. Good sources: milk, yogurt and cheese (a cup of milk has about 300 mg of calcium), calcium-set tofu, fortified juices and cereals, canned salmon or sardines with bones, beans and dark leafy greens such as kale and broccoli. **Iron** is the center of **hemoglobin**, which carries oxygen from your lungs to your muscles. Teens need more iron as blood volume and muscles grow: 8 mg a day at ages 9 to 13, then 11 mg for boys and 15 mg for girls at ages 14 to 18. Too little iron leaves you tired, pale and short of breath. Iron from meat, poultry and fish is absorbed most easily; iron from beans, lentils, spinach and fortified cereals is absorbed better when eaten with vitamin C, such as an orange or tomatoes. Jumping, running and other bone-strengthening activity tells your bones to grow stronger, so food and exercise work together.

Think it through. Labels list calcium, iron and vitamin D in milligrams or micrograms and as %DV. To turn %DV into milligrams, multiply by the Daily Value. Calcium: each percentage point = 13 mg, so 25% DV = $25 \times 13 = 325$ mg. Iron: each percentage point = 0.18 mg, so 45% DV = $45 \times 0.18 \approx 8.1$ mg. To reach 1,300 mg of calcium you need about 100% DV over the whole day, for example 3 servings of dairy (about 900 mg) plus other foods.

Try it. In Session 2 you will read labels, convert %DV to milligrams, and plan one full day of meals that meets your calcium and iron needs. In Session 3 you will cook a bone-building lunch from your plan and finish with a short bone-strengthening jump workout.

PICTURE STUDY



The White Cow (La Vache blanche), Julien Dupré, 1890 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Julien Dupré spent his career painting the farm country of northern France, especially the women who tended the cows and brought in the hay. Here, on a bright morning, a young farm woman kneels in the grass to milk a white cow straight into her pail. Sunlight falls across the yard, the cow's back and the milk itself.

Look closely

- Find the pail. How full is it already?
- Follow the sunlight. Where does it fall brightest, and where are the shadows?
- Look at how the young woman kneels and works. Is this light or steady, tiring work?
- Find the older woman in the doorway. What might her job be on this farm?

Talk about it

1. This picture holds two things McCollum and Steenbock studied: milk and sunshine. What does each one do for your bones?
2. Children on sunny farms got rickets far less often than children in smoky industrial cities. Why?

3. Dupré painted plain farm work as something worth honoring. How can preparing food for others be a way of serving God?

Safety first. A parent supervises the stove and knives, and checks for food allergies (milk, wheat and others) before cooking or tasting; swap foods as needed. Wash your hands before cooking. For the jump workout, use a flat, non-slip surface or grass, wear good shoes, and land softly with bent knees.

ACTIVITY

The Label Lab and a Bone-Building Lunch

McCollum found vitamin D by careful testing. You will use labels and arithmetic to plan a day that builds strong bones and healthy blood, and then cook part of it.

You will need

- Nutrition Facts labels from at least 8 foods in your kitchen (milk, yogurt, cheese, cereal, bread, beans, juice, tofu or canned fish)
- A calculator and the fitness journal with a label table: food, serving, calcium %DV, calcium mg, iron %DV, iron mg, vitamin D
- For the lunch (example): whole-wheat tortillas, canned black or pinto beans, grated cheese, a handful of spinach, salsa, an orange, and a glass of milk (or fortified soy milk)
- A skillet, a spatula, a cutting board and a knife (with a parent)

Steps

1. **Label lab (Session 2).** For each of your 8 labels, write the serving size and the %DV for calcium and iron (and vitamin D if listed). Convert each to milligrams: $\text{calcium \%DV} \times 13 = \text{mg}$; $\text{iron \%DV} \times 0.18 = \text{mg}$.
2. **Rank** your foods from most to least calcium per serving, and from most to least iron. Which foods were surprises?
3. **Plan a day** of breakfast, lunch, dinner and two snacks that reaches at least 1,300 mg of calcium and your iron target (8 mg at age 13; 11 mg for boys or 15 mg for girls at age 14 and up). Use your labels and these approximate values for foods without labels: 1 cup milk $\approx$ 300 mg calcium; 1 cup yogurt $\approx$ 300–400 mg; 1½ oz cheddar $\approx$ 300 mg; 3 oz lean beef $\approx$ 2 mg iron; 1 cup cooked beans $\approx$ 3–4 mg iron; ½ cup cooked spinach $\approx$ 3 mg iron.
4. **Add it up** and show your totals. Put a vitamin C food next to each plant source of iron, and include one source of vitamin D.
5. **Cook the lunch (Session 3).** Wash your hands. Warm a skillet over medium heat. Lay a tortilla in the pan, spread half of it with mashed beans, sprinkle with cheese and a few spinach leaves, fold it over and cook 2–3 minutes a

side until the cheese melts. Cut into wedges with a parent supervising. Serve with salsa, orange slices and a glass of milk.

6. **Tally your lunch:** estimate its calcium and iron in milligrams from the labels. What fraction of your daily calcium did one lunch provide?
7. **Bone-builder workout (after lunch has settled, or later in the day):** 3 rounds of 10 squat jumps, 20 two-foot hops, 10 hops on each foot and 1 minute of jump rope (or pretend rope), with 1 minute of rest between rounds. Land softly. Record your rounds.
8. **Clean up and write:** How close did your planned day come to 1,300 mg of calcium? What one change would make it easier to reach every day?

Tips

- Spreading calcium foods through the day works better than eating it all at once; the body absorbs calcium best in moderate amounts.
- Spinach contains calcium, but most of it is bound up and poorly absorbed. Count it for iron, not calcium.
- Milk is fortified with vitamin D in the United States; many cheeses and yogurts are not. Check the label.

Check your work

- ☐ I can tell how McCollum showed that vitamin D was different from vitamin A.
- ☐ I converted %DV to milligrams for 8 foods and planned a day with at least 1,300 mg of calcium and my iron target.
- ☐ I cooked a bone-building lunch safely and finished a bone-strengthening workout.

FITNESS JOURNAL

1. Copy your label table with every conversion shown.
2. Draw a bar graph of the calcium (mg) in each meal and snack of your planned day, with a line at 1,300 mg for the total.
3. Draw and label a red blood cell carrying oxygen, with hemoglobin and iron, and a bone with calcium and vitamin D.
4. Write a short paragraph: Why do your teen years matter more for your bones than any other time in your life?

From history. McCollum urged Americans to drink milk and to eat leafy green vegetables, and milk drinking in the United States roughly doubled between 1918 and 1928. He taught at Johns Hopkins for more than twenty-five years, and late in life he wrote a history of the science of nutrition.

COMMON MISTAKES

- Reading %DV as milligrams. Multiply by the Daily Value (13 for calcium, 0.18 for iron) to convert.
- Forgetting the serving size. If you drink 2 cups of milk and the label is for 1 cup, double the numbers.
- Counting spinach as a big calcium source. Its calcium is poorly absorbed.
- Thinking only athletes need iron. Every growing teenager needs more iron than a younger child.

Make it a game • Bone Builder Menu. Plan a bone-building lunch from pantry foods. Read labels for calcium, vitamin D and iron percent Daily Value. Race your parent to reach one hundred percent combined across the meal. Tell the rickets, cod-liver oil and McCollum story. Then explain what each nutrient does. Count mistakes and try a cleaner plan.

3.2 EATING FOR SPORT: FUEL BEFORE, REPAIR AFTER

OBJECTIVES

- Tell how Swedish scientists in the 1960s measured glycogen in working muscles and what they learned about carbohydrates and endurance.
- Explain what carbohydrates, protein and fat each do for an athlete, using grams and food energy in calories.
- Plan a game day of meals and snacks with good timing, and explain why real food is all a growing athlete needs.
- Cook a game-day meal and a recovery snack, and record energy during a workout.

Warm-up. Six-minute warm-up: 2 minutes easy jogging, 10 inchworms (walk hands out to a plank and back), 10 walking lunges with a twist, 10 side shuffles each way, and 3 build-up runs. Think about it: if your muscles were a car, what would be the gas, and what would be the repair shop?

WATCH

Sports Nutrition for Youth Athletes

Phoenix Children's • 3:49

<https://www.youtube.com/watch?v=cJ16BdzZ844>

WHEN TO WATCH

After “How your body works.” Listen for the doctor’s advice on balanced meals, timing and hydration for young athletes.

Note: A sports-medicine physician at Phoenix Children’s answers common questions. It ends with a short invitation to the hospital’s sports clinic.

KEY TERMS

glycogen

The stored form of carbohydrate, made from chains of glucose, kept in the muscles and liver as quick fuel for exercise.

carbohydrate

The body’s main fuel for hard exercise, found in grains, fruits, vegetables, beans and milk. It gives about 4 calories of energy per gram.

protein

The nutrient used to build and repair muscles, bones, blood and every cell. It gives about 4 calories of energy per gram.

fat

A concentrated fuel for long, easy activity and a building material for cells and hormones. It gives about 9 calories of energy per gram.

calorie

A unit of food energy. In this course we use it only to understand how much energy foods provide, never as something to count or cut.

recovery snack

Food eaten within about an hour after hard exercise, with carbohydrate to refill glycogen and protein to repair muscle.

CORE IDEAS

The story. For a long time, no one could see inside a working muscle. In the 1960s the Swedish physician Jonas Bergström brought back an old technique: a fine, hollow needle that could take a sample of muscle about the size of a grain of rice, under local anesthetic, through a tiny cut in the thigh. With his colleague Eric Hultman and others in Stockholm, he used it to measure **glycogen**, the stored carbohydrate in muscle, before and after exercise in volunteers riding exercise bicycles.

How they figured it out. In a famous study published in 1967, the researchers had the same men eat three different ways for several days each: mostly fat and protein, a normal mixed menu, and mostly carbohydrate. After each eating pattern, they measured the men's muscle glycogen and had them ride at the same steady, hard pace until they could not continue. The results were striking. After the fat-and-protein days, the men's muscles held little glycogen and they lasted roughly an hour. After the mixed menu they lasted roughly two hours, and after the high-carbohydrate days, with muscles full of glycogen, roughly three hours. The amount of glycogen in the muscles at the start predicted how long they could go. Coaches and athletes have used that lesson ever since: carbohydrate is the fuel for hard, long exercise.

How your body works. When you eat carbohydrates (bread, rice, pasta, oats, potatoes, fruit, beans, milk), your body breaks them into glucose, which travels in your blood. Whatever is not used right away is stored as glycogen in your muscles and liver. During hard exercise, your muscles burn glycogen fast; when it runs low,

you feel heavy and slow. **Protein** (meat, fish, eggs, milk, yogurt, beans, nuts) supplies the building blocks your body uses to repair and build muscle after work; teens need about 34 grams a day at ages 9 to 13 and about 46 to 52 grams at ages 14 to 18, which ordinary meals easily provide. **Fat** (nuts, oils, avocado, cheese) fuels long, easy activity and builds healthy cells, but it digests slowly, so a very fatty meal right before a game can sit heavy. The best plan: a balanced meal rich in carbohydrate, with some protein, 3 to 4 hours before a game; a small, easy snack (a banana, crackers, a granola bar) 30 to 60 minutes before if you are hungry; water throughout; and a recovery snack with carbohydrate and protein (chocolate milk, yogurt and fruit, a turkey sandwich) within about an hour after.

Think it through. Growing athletes need *enough* food. Skipping meals before practice leaves glycogen low and makes injuries more likely. Real food provides everything you need; pills, powders, special bars and energy shakes are not needed by healthy teenagers, and many are not checked for safety before they are sold. Food is also a gift to receive with thanks, at the table with your family. Whether you eat or drink, do it to the glory of God.

Try it. In Session 2 you will plan a full game day of eating, cook a carbohydrate-rich game-day meal, eat it about 3 hours before a workout, and rate your energy during the workout. Afterward you will make a recovery snack. In Session 3 you will try a second meal and compare.

PICTURE STUDY



Saying Grace, Jean-Baptiste-Siméon Chardin, 1740 · Oil on canvas · Musée du Louvre, Paris

Image: [Wikimedia Commons](#), public domain

Jean-Baptiste-Siméon Chardin painted simple kitchens and the quiet lives of ordinary Paris families. Here a mother serves the midday meal while her youngest child says grace before eating.

Look closely

- Look at the girl in the small chair. What is she doing with her hands, and how does the mother respond?
- Find the bowls and the dish on the table. What kind of meal might this be?
- Look at the faces. How would you describe the mood of this meal?
- Look at the room and the toy drum on the floor. Is this a rich or a modest home? How can you tell?

Talk about it

1. Why is it good to give thanks before eating, even before an ordinary meal?
2. A family meal is a time to refuel, but also to talk and rest. How could your family make a game-day meal a time together?
3. What would a balanced game-day plate look like on this table?

Safety first. A parent supervises the stove, boiling water and knives, and checks for food allergies before cooking. Eat your main meal 3 to 4 hours before hard exercise and only a light snack in the last hour, drink water, and stop and tell an adult if you feel dizzy or sick during the workout.

ACTIVITY

Game-Day Meal and Recovery Snack

The Swedish scientists measured fuel inside the muscle. You will plan the fuel, cook it, use it in a workout and record how your energy feels.

You will need

- For a pasta meal: whole-grain pasta, a jar of tomato sauce, cooked chicken or canned white beans, a vegetable (spinach, peppers or zucchini), fruit and milk
- For a second meal: rice or potatoes, eggs or chicken, vegetables and fruit (or oatmeal with milk, banana and peanut butter for a morning game)
- Recovery snack ingredients: chocolate milk, or yogurt and fruit, or bread with turkey or peanut butter
- A pot, a colander, a skillet, measuring cups and a timer
- Fitness journal with a game-day plan, a nutrient table (grams of carbohydrate, protein and fat per serving from labels) and an energy log

Steps

1. **Plan a game day (Session 2).** For a game at 4:00 p.m., write what you will eat and drink at breakfast, lunch (about 12:00–1:00), a pre-game snack (3:00–3:30), at halftime (water), a recovery snack (5:30) and dinner.
2. **Read labels** for your meal and find the grams of carbohydrate, protein and fat in your portion. Convert to food energy: carbohydrate $\times 4$, protein $\times 4$, fat $\times 9$. Which nutrient gives most of the meal's energy?
3. **Cook the game-day meal.** Wash your hands. Boil water and cook the pasta by the package directions (a parent handles draining). Warm the sauce with the chicken or beans and the vegetable. Serve with fruit and milk.
4. **Wait about 3 hours**, drinking water as in your hydration plan.
5. **Workout (30 minutes):** warm up 5 minutes, then 5 rounds of 3 minutes running or brisk stair climbing at a hard pace and 2 minutes walking, then cool down. At minutes 10, 20 and 30, rate your energy from 1 (empty) to 10 (full of energy) and write a word for how your legs feel.

6. **Recovery snack** within an hour: make and eat it, and note its carbohydrate and protein grams.
7. **Session 3:** cook your second meal, wait about 3 hours and repeat the same workout and energy ratings. Compare the two meals and write which left you feeling better fueled and why.
8. **Finish your plan card:** a game-day eating timeline you would actually follow, with backup snacks for an early game or a tournament with several games.

Tips

- Choose foods you know agree with your stomach. Game day is not the day to try something new and spicy.
- For a morning game, eat a lighter breakfast 2 to 3 hours before: oatmeal, toast, fruit and milk.
- Keep a portable snack in your bag (a banana, crackers, a peanut-butter sandwich) for long days.

Check your work

- ☐ I can explain what the Swedish glycogen studies showed and why carbohydrate matters for endurance.
- ☐ I planned a full game day of eating with good timing and calculated the food energy of my meal from grams.
- ☐ I cooked two meals safely, did the same workout after each, and compared my energy.

FITNESS JOURNAL

1. Draw a game-day timeline from breakfast to dinner, with each meal, snack and drink marked at its time.
2. Make a nutrient table for your game-day meal: grams of carbohydrate, protein and fat, and the energy from each ($\times 4$, $\times 4$, $\times 9$). Draw a pie chart of where the meal's energy comes from.
3. Graph your energy ratings at minutes 10, 20 and 30 for both workouts on the same axes.
4. Write a short paragraph explaining to a younger teammate why real food is better than pills and powders.

From history. After the glycogen studies, endurance athletes began “carbohydrate loading,” eating extra carbohydrate in the days before a marathon or long race. Bergström’s needle technique is still used by exercise scientists around the world.

COMMON MISTAKES

- Skipping lunch before an afternoon practice, then running out of fuel halfway through.
- Eating a large, greasy meal right before a game. Fat and very high-fiber foods digest slowly.
- Believing that more protein builds more muscle without limit. After needs are met, extra protein is simply used as fuel.
- Spending money on pills, powders or special drinks instead of eating regular, balanced meals.

Make it a game • Fuel and Repair Cards. Make cards for carbohydrate, protein and fat, with grams and calories per gram. Draw a food and say when an athlete should eat it: before, during or after, and why. Tell how glycogen was measured in the 1960s. Your parent scores answers. Design a recovery snack in sixty seconds and defend it.

Scripture. “Whether therefore ye eat, or drink, or whatsoever ye do, do all to the glory of God.” (1 Corinthians 10:31, KJV)

Even a game-day meal can be eaten with thanks and for God’s glory. Fueling your body well so that you can work, play and serve is part of that.

UNIT 3

NUTRITION

A hundred years ago, many children in the crowded, smoky cities of Europe and North America grew up with soft, bent bones from a disease called rickets. Families had long known that a spoonful of cod-liver oil seemed to help, but no one knew why. In 1922 the American scientist Elmer McCollum showed that the oil held a new substance, which he named vitamin D. In this unit you will learn how calcium, vitamin D and iron build your bones and blood during the very years when you are growing fastest, read the minerals on Nutrition Facts labels in milligrams and percent Daily Value, and cook a bone-building lunch.

Then you will learn how food fuels sport. In the 1960s, Swedish scientists used a fine needle to take tiny samples from working thigh muscles and measured the fuel stored inside. They found that the food athletes ate in the days before exercise changed how long they could keep going. You will learn what to eat before a game and after it, why real food is all a growing athlete needs, and you will plan and cook a game-day meal and a recovery snack.

PREREQUISITES

- Knows the food groups and what carbohydrates, proteins and fats do (earlier grades)
- Can read serving size, grams and percent Daily Value on a Nutrition Facts label
- Can multiply and divide decimals and convert a percent to a number

MASTERY CHECKLIST

- ☐ I can tell the story of rickets, cod-liver oil and Elmer McCollum's discovery of vitamin D.
- ☐ I can explain what calcium, vitamin D and iron do and how much a teenager needs each day.
- ☐ I can convert percent Daily Value on a label into milligrams and plan a day that meets my calcium and iron needs.
- ☐ I can explain how carbohydrates are stored as glycogen and why the Swedish studies showed they matter for endurance.
- ☐ I can plan and cook a game-day meal and a recovery snack from ordinary food, with no pills, powders or special drinks.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Calcium” (Nemours KidsHealth, for teens)**: Free. Why the teen years matter so much for bones, and foods rich in calcium. Read it with Lesson 3.1.
- **“A Guide to Eating for Sports” (Nemours KidsHealth, for teens)**: Free. What and when to eat before, during and after sports. Read it with Lesson 3.2.
- **“How to Understand and Use the Nutrition Facts Label” (U.S. Food and Drug Administration)**: Free. The official guide to every line of the label, including percent Daily Value. Useful for both lessons.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 Iron, Calcium and Vitamin D

3 sessions of 40–45 minutes

3.2 Eating for Sport: Fuel Before, Repair After

3 sessions of 40–45 minutes

UNIT 3 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

What is rickets, and why was it common in industrial cities around 1900?

2. 5 pts

Describe McCollum's 1922 experiment with cod-liver oil. What did it prove?

3. 5 pts

State how much calcium, vitamin D and iron a 14-year-old needs each day, and say what each does.

4. 5 pts

Calculation: A cup of yogurt has 30% DV calcium and a bowl of cereal has 45% DV iron. How many milligrams of calcium and of iron are these?

5. 5 pts

Name two ways to help your body absorb iron from plant foods, and one reason spinach is not a good calcium source.

6. 5 pts

Describe the Swedish glycogen experiment of 1967 and its main finding.

7. 5 pts

Calculation: A game-day meal has 90 g of carbohydrate, 30 g of protein and 15 g of fat. How much food energy comes from each, and what is the total?

8. 5 pts

Write a good eating timeline for a soccer game at 10:00 a.m.

9. 5 pts

What would happen if an athlete skipped breakfast and lunch before a 3:00 p.m. practice?

10. **5 pts**

Short written answer: In three or four sentences, explain to a teammate why healthy teens do not need pills, powders or energy shakes to play well.

ANSWER KEY

1. Rickets is a disease of growing children in which bones become soft and may bend, mainly from too little vitamin D. It was common in smoky industrial cities where children got little sunlight (the skin makes vitamin D in sunlight) and often ate poorly.
2. He heated cod-liver oil and bubbled air through it to destroy its vitamin A. The treated oil still prevented rickets in laboratory animals, proving that the anti-rickets substance was a different vitamin. He named it vitamin D.
3. Calcium: 1,300 mg; hardens bones and teeth and helps muscles, nerves and clotting. Vitamin D: 600 IU (15 mcg); helps absorb calcium. Iron: 11 mg for boys, 15 mg for girls at 14–18 (8 mg at 9–13); forms hemoglobin to carry oxygen.
4. Calcium: $30 \times 13 = 390$ mg. Iron: $45 \times 0.18 = 8.1$ mg.
5. Eat a vitamin C food (orange, tomatoes, strawberries, peppers) at the same meal; include some meat, poultry or fish with beans or grains. Spinach's calcium is bound up and poorly absorbed.
6. Using a needle biopsy to measure muscle glycogen, researchers had the same men eat mostly fat and protein, a mixed menu, or mostly carbohydrate for several days, then ride at the same hard pace until exhausted. With full glycogen after high-carbohydrate eating they lasted roughly three times as long as after the fat-and-protein days. Starting muscle glycogen predicted endurance.
7. Carbohydrate: $90 \times 4 = 360$ calories. Protein: $30 \times 4 = 120$ calories. Fat: $15 \times 9 = 135$ calories. Total = 615 calories of food energy, most from carbohydrate.
8. About 7:00–7:30 a.m.: a balanced breakfast rich in carbohydrate with some protein (oatmeal with milk and a banana, toast with peanut butter). Water through the morning. 9:15–9:30: a small snack if hungry (banana or crackers). Water during the game. Within an hour after: recovery snack with carbohydrate and protein (chocolate milk, yogurt and fruit), then a balanced lunch.
9. Liver and muscle glycogen would be low, blood sugar could drop, and the athlete would tire early, feel weak or dizzy, think and react more slowly, and be more likely to get hurt. Recovery afterward would also be slower.
10. Answers will vary. Ordinary balanced meals give all the carbohydrate, protein, vitamins and minerals a growing athlete needs, and protein needs are easily met with food. Many such products are not checked for safety before they are sold and some contain things that can be harmful. Money is better spent on good

food, and regular meals, water, sleep and training are what really improve performance.

UNIT CHALLENGE: A PLANNED AND COOKED DAY OF FUEL

Plan one full day of meals and snacks for a day with a practice or game. Your plan must reach at least 1,300 mg of calcium and your iron target, include a vitamin D source, and time the meals well for the exercise (main meal 3–4 hours before, snack if needed, recovery snack after). Show the label arithmetic for calcium, iron and the food energy from carbohydrate, protein and fat. Cook at least two of the meals yourself with a parent’s supervision, eat the day as planned, and log your energy during the practice. Finish with a one-page summary and a photo or drawing of each meal you cooked.

LOOK FOR	WHAT IT MEANS
Sound plan	Meets calcium and iron targets with a vitamin D source, a carbohydrate-rich pre-exercise meal and a recovery snack, using everyday foods.
Accurate arithmetic	%DV converted to milligrams and grams converted to food energy, with work shown.
Cooking and safety	Two meals cooked with clean hands, safe knife and stove use, and allergies checked.
Record and reflection	An energy log during practice and a summary of what worked and what to change. Effort and good habits count.

UNIT 4

STRENGTH

In 1944, at an Army hospital in Chicago, a young doctor named Thomas DeLorme was trying to help soldiers whose injured knees were healing far too slowly with the gentle exercises doctors then prescribed. DeLorme had lifted weights for years, and he tried something different: fewer repetitions against heavier resistance, increased step by step as the soldiers grew stronger, and carefully recorded. He called it progressive resistance exercise, and it is still the foundation of strength training and physical therapy. In this unit you will learn how muscles adapt to work, find your own “10-rep level” for five exercises with light household loads, and follow a two-week plan with a before-and-after test.

Then you will learn the two most useful movement patterns for life and sport: the squat and the hip hinge. A U.S. government study of workers’ back injuries showed how lifting with the load close to the body, without twisting, protects the back. You will practice the hinge with a broom handle, the squat to a chair, and real lifting and carrying with water jugs and a laundry basket, recording a form score you will work to improve.

PREREQUISITES

- Can do squats, push-ups, planks and lunges with good form (earlier grades)
- Knows the warm-up and cool-down and the talk test (Unit 1)
- Knows that protein, sleep and rest are needed for muscles to repair (Unit 3)

MASTERY CHECKLIST

- ☐ I can tell how Thomas DeLorme developed progressive resistance exercise and explain the principle of progressive overload.
- ☐ I can explain how muscles get stronger: first through the nervous system, then through larger muscle fibers, with rest, food and sleep.
- ☐ I can find a safe 10-rep level for an exercise and follow a three-set plan, adding resistance only when I have earned it.
- ☐ I can perform a hip hinge and a squat with good form, and explain the difference between them.
- ☐ I can lift an object from the floor and carry it safely, keeping it close and my back flat, and never twisting.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Strength Training” (Nemours KidsHealth, for teens):** Free. A clear article on safe strength training for teenagers: supervision, technique, rest and realistic goals. Read it with Lesson 4.1.
- **A light resistance band (loop or tube with handles):** Optional for rows and pull-aparts in Lesson 4.1. A backpack with books works just as well for every exercise in this unit.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1 Thomas DeLorme and Progressive Resistance

3 sessions of 40–45 minutes

UNIT 4 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

What problem was Thomas DeLorme trying to solve in 1944, and what did he change?

2. 5 pts

Describe DeLorme's three-set system. Why were the first two sets lighter?

3. 5 pts

Calculation: Your 10-rep level for the goblet squat is a backpack weighing 16 pounds. About how heavy should the load be for sets 1 and 2 in a DeLorme-style workout?

4. 5 pts

Explain why beginners get stronger quickly in the first few weeks, and what changes later.

5. 5 pts

Name four rules for safe strength training for teenagers.

6. 5 pts

What did NIOSH find about what makes lifting dangerous? Name three factors.

7. 5 pts

Describe the difference between a hip hinge and a squat, including which muscles each works most.

8. 5 pts

Explain how to pick up a laundry basket from the floor and set it on a table to your left.

9. **5 pts**

Calculation: In the workday circuit your round times were 3:40, 3:55 and 4:20 in Session 3, and in your retest a week later 3:30, 3:40 and 3:50. Find your total time each day and the improvement in seconds.

10. **5 pts**

Short written answer: In three or four sentences, explain why form must come before adding weight.

ANSWER KEY

1. Injured soldiers' leg muscles were recovering slowly with the usual light, many-repetition exercises. DeLorme had them work against heavier resistance for fewer repetitions, increasing the resistance step by step and recording it (progressive resistance exercise). They recovered much faster.
2. He found the 10-repetition maximum and had the patient do three sets of 10: at half, three-quarters and the full 10RM. The lighter sets warmed up the muscle and practiced the movement before the hardest set.
3. Set 1: $\frac{1}{2} \times 16 = 8$ pounds (for example, a full gallon jug of about 8.3 pounds). Set 2: $\frac{3}{4} \times 16 = 12$ pounds. Set 3: the full 16 pounds.
4. Early gains come mainly from the nervous system: the brain learns to switch on more motor units together and coordinate the muscles. Later, with continued overload, the muscle fibers grow larger (hypertrophy), which becomes easier during and after puberty. Tendons and bones also adapt, more slowly.
5. Any four: supervision by a knowledgeable adult; technique first; start light and progress gradually; 2–3 non-consecutive days a week with rest between; breathe out on effort, never hold breath; no maximum single-lift testing; stop for sharp or joint pain; warm up and cool down; eat well and sleep 8–10 hours.
6. Danger depends on how a load is lifted, not just its weight. Factors that lower the safe limit: the load held far from the body, lifting from near the floor, twisting while lifting, and lifting very often. (Its 1991 equation starts at 51 pounds in ideal conditions.)
7. In a hinge the hips move back with a flat back, knees only slightly bent and shins nearly vertical; it works mostly the hamstrings, glutes and back muscles (posterior chain). In a squat hips and knees bend together and the body lowers more straight down with the chest up; it works the quadriceps more, along with the glutes.
8. Stand close with the basket between or just in front of your feet; squat or hinge down with a flat back; grip, brace your middle, and stand by driving through your legs and hips, keeping the basket close; then turn your whole body by moving your feet toward the table and set it down, without twisting your back.
9. Session 3: $3:40 + 3:55 + 4:20 = 220 + 235 + 260 = 715$ seconds (11:55). Retest: $210 + 220 + 230 = 660$ seconds (11:00). Improvement = $715 - 660 = 55$ seconds.
10. Answers will vary. Good form spreads the work over the right muscles and keeps the spine and joints in safe positions; poor form under load strains discs,

ligaments and tendons and can cause injury. Form is also how the nervous system learns the movement, so practicing good reps builds strength faster. Adding weight to poor form only makes the poor pattern stronger and riskier.

UNIT CHALLENGE: TWO-WEEK STRENGTH PLAN WITH BEFORE-AND-AFTER TEST

Complete the two-week DeLorme's Ladder plan from Lesson 4.1, training every other day (about 7 workouts) with three sets of each exercise and adding resistance only when you have earned it. Add the hinge and squat practice from Lesson 4.2 to at least four of those workouts. At the end, repeat your before test at the same 10-rep levels and run the workday circuit once more with a form score. Make a before-and-after bar graph of your reps, and write a paragraph about what improved, what was hard and what you learned about progressive resistance.

LOOK FOR	WHAT IT MEANS
Faithful training	About 7 dated workouts in two weeks with every set recorded and rest days in between.
Safe progression and form	Resistance raised one small step at a time only when earned; a parent confirms good form, including the hinge and squat.
Fair before-and-after test	The same exercises, levels, order and rests for both tests, recorded honestly, plus a final circuit time and form score.
Graph and reflection	A neat before-and-after graph and a paragraph on what improved and what was learned. Effort and improvement count, not the size of the numbers.

4.1 THOMAS DELORME AND PROGRESSIVE RESISTANCE

OBJECTIVES

- Tell how Thomas DeLorme developed progressive resistance exercise to rehabilitate injured soldiers in 1944–45.
- Explain progressive overload, the role of the nervous system and muscle fibers in getting stronger, and the need for recovery.
- Find a safe 10-rep level for five exercises using body weight, light household loads or a band.
- Follow a DeLorme-style three-set plan for two weeks and record a before-and-after test.

Warm-up. Six-minute warm-up: 1 minute of marching or easy jogging, 10 arm circles each way, 10 bodyweight squats, 10 glute bridges, 10 incline push-ups on a counter, 10 band or towel pull-aparts (hold a towel taut at shoulder height and pull outward), and 10 walking lunges. Think about it: if lifting a little more each week makes you stronger, why not lift a lot more right away?

WATCH

Strength Training: First With Kids - Vermont Children's Hospital, Fletcher Allen

University of Vermont Health · 2:23

<https://www.youtube.com/watch?v=nPHfz1JmkGM>

WHEN TO WATCH

After “How your body works.” Listen for the pediatrician’s rules for safe strength training for teenagers.

Note: A pediatrician from Vermont Children’s Hospital. He warns teens to stay away from performance-enhancing drugs, which is good advice; in this course we use only body weight, household loads and bands.

BACKUP VIDEO

When Should Youth Athletes Begin Strength & Conditioning Training? | Youth Inc. Ask The Experts

Youth Inc. · 4:36

<https://www.youtube.com/watch?v=jmIWY652VbQ>

For parents and students together: how to choose a qualified coach and check progress over time.

KEY TERMS

progressive resistance exercise

DeLorme’s method: working muscles against a resistance that is increased step by step as they grow stronger.

10-repetition maximum (10RM)

DeLorme’s measure: the most resistance you could lift exactly 10 times with good form. In this course we use a safer “10-rep level”: a load or version you can do 10 times with good form and 2 reps still in reserve.

progressive overload

The principle that muscles grow stronger only when they are asked to do a little more than they are used to, a little at a time.

set

A group of repetitions done in a row before resting, such as 10 squats.

motor unit

One nerve cell and all the muscle fibers it controls. Training teaches your brain to switch on more motor units at once.

hypertrophy

The growth of muscle fibers in size after repeated training, which happens more as teenagers mature.

CORE IDEAS

The story. During World War II, thousands of injured soldiers filled Army hospitals. Many had damaged knees, and after surgery the big thigh muscles wasted away. The usual treatment was gentle exercise with light weights repeated many times, and recovery took months. Thomas DeLorme, a young Army medical officer at Gardiner General Hospital in Chicago, had trained with weights for years and believed muscles needed a real challenge to rebuild. In 1944 he met a soldier named Thaddeus Kawalek, a weightlifter himself, whose knee was healing slowly. DeLorme had him lift heavier loads for fewer repetitions, adding weight as his leg grew stronger. Kawalek recovered much faster than patients with similar injuries, and DeLorme went on to treat many more soldiers the same way. He published his results in 1945.

How they figured it out. DeLorme was careful and measured everything. He found each patient's **10-repetition maximum**, the heaviest load the patient could lift exactly 10 times. In the system he and Arthur Watkins later published (1948), the patient did three sets of 10: the first set at half of the 10RM, the second at three-quarters, and the third at the full 10RM. The first two sets served as a warm-up and practice. When the patient grew stronger, the 10RM was raised. He called the method **progressive resistance exercise**. Doctors at the time worried that hard effort was bad for the heart; DeLorme's records showed that carefully increased resistance rebuilt strength quickly and safely. The idea is the same one in the old legend of Milo and the calf, but DeLorme tested it and wrote down the numbers.

How your body works. Each muscle is made of thousands of long fibers grouped into **motor units**, each switched on by one nerve cell. When you begin training, most of your first gains in strength come from your **nervous system**: your brain learns to switch on more motor units at the same time and to coordinate the muscles that help and the ones that oppose. That is why beginners improve quickly. Over weeks and months, with enough challenge, the fibers themselves grow larger and stronger (**hypertrophy**), and during and after puberty the body's growing hormones make

this easier. Tendons, ligaments and bones adapt too, but more slowly than muscle, which is one reason to progress gradually. All of this happens during **recovery**: rest of at least a day between hard workouts for the same muscles, enough food with protein, and 8 to 10 hours of sleep. Strength-training experts recommend that young people train 2 to 3 non-consecutive days a week, with 1 to 3 sets of about 6 to 15 repetitions, technique first, under supervision, and with no testing of the heaviest possible single lift.

Good form. Control every rep: about 2 seconds down, 1 second up. Breathe out as you push or pull; never hold your breath. Keep your back flat and your core braced. End each set with 1 or 2 reps still “in the tank,” not with a grinding, form-breaking struggle. Sharp pain or joint pain means stop.

Try it. This week you will find your 10-rep level for five exercises using body weight, a backpack with books, water jugs or a band. Then you will train with DeLorme’s three sets, record every set, and add resistance only when you have earned it. In two weeks you will retest.

PICTURE STUDY



The Fog Warning, Winslow Homer, 1885 • Oil on canvas • Museum of Fine Arts, Boston

Image: [Wikimedia Commons](#), public domain

Fishermen from the coast of New England rowed small boats called dories away from their ship to catch halibut with long lines. In this painting a fisherman with two heavy fish in his boat glances at a bank of fog moving in. He must row hard to reach his ship before the fog hides it.

Look closely

- Look at how the fisherman sits and holds his oars. Which muscles will he use for each stroke?
- Find the two halibut. How do they change the work of rowing?
- Look at the waves and the fog. How much time does he have, and how far must he row?
- Find the ship on the horizon. Estimate how many strokes it might take to reach it.

Talk about it

1. A fisherman built his strength by rowing against heavy loads day after day. How is that like DeLorme's progressive resistance?
2. Why would endurance and strength both matter to this man?

3. Isaiah says those who wait on the Lord “shall renew their strength.” When have you needed strength that was more than physical?

Safety first. Use only body weight, light household loads and bands, never maximum lifts. Check that backpack straps and jug handles are secure, and that a band has no nicks or tears. A parent watches your form, especially on the first workouts. Rest at least one day between workouts, breathe out as you lift, and stop if you feel sharp pain, joint pain, dizziness or chest pain.

ACTIVITY

DeLorme's Ladder at Home

You will use DeLorme's system with one important change for safety: instead of a true 10-repetition maximum, you will find a "10-rep level," a version or load you can do 10 times with good form and about 2 reps left in reserve.

You will need

- A backpack and books (a parent can weigh the loaded backpack on a bathroom scale and write the weight on a tag)
- One or two gallon water jugs (a full gallon of water weighs about 8.3 pounds), or a light resistance band
- A sturdy chair pushed against a wall, a towel or mat, a timer
- Fitness journal with a training chart: date, exercise, level or load, set 1, set 2, set 3, notes

Steps

1. **Learn the five exercises (Session 2), with a parent watching:** (1) *Goblet squat*: hold a water jug or the backpack against your chest, feet shoulder-width apart, sit back and down until thighs are about level with the floor, chest up, knees over toes. (2) *Push-up* at your level (counter, chair against the wall, knees or toes). (3) *One-arm row*: left hand and knee on a sturdy chair, back flat, pull a jug or the backpack from a straight arm up to your hip, elbow close to your side; then switch sides. (4) *Split squat*: one foot about 2–3 feet in front of the other, lower straight down until the back knee nearly touches the floor, body upright; hold jugs at your sides if ready. (5) *Glute bridge* with the backpack resting across your hips.
2. **Find your 10-rep level.** For each exercise, try a version or load for 10 reps. If you could clearly do 13 or more, make it a little harder (more books, a full jug, a lower push-up level). If you could not do 10 with good form, make it easier. Stop at the level where 10 reps are hard but leave about 2 more in reserve. Rest 2 minutes between tries. Record each 10-rep level.
3. **Before test.** At each 10-rep level, do one set of as many good-form reps as you can, stopping when form begins to slip. Record these numbers.

4. **Workout plan (Session 3 and then every other day for two weeks):** warm up, then for each exercise do 3 sets of 10: set 1 at about half your 10-rep level (half the books, a half-full jug, an easier push-up), set 2 at about three-quarters, set 3 at your full 10-rep level. Rest 60–90 seconds between sets.
5. **Earn your progress.** When you can do 12 good reps on set 3 in two workouts in a row, raise your 10-rep level a small step: one or two more books (about 1–2 pounds), a fuller jug or the next push-up level. Never add more than one step at a time.
6. **Record every set** and a note on how it felt and how your form looked.
7. **Cool down** after each workout: 2 minutes of walking and 20-second stretches for thighs, hips, chest and upper back.
8. **After test (end of the two weeks):** at your original 10-rep levels, repeat the as-many-good-reps set for each exercise. Compare with your before test.

Tips

- Pack books flat and tight in the backpack so the load does not shift. Put heavier books nearest your back.
- If a jug is too heavy for the row, pour some water out. If it is too light, add a second jug or move to the backpack.
- Tired, burning muscles near the end of a set are normal. Pain in a joint, or pain that is sharp, is not.

Check your work

- ☐ I can tell how DeLorme developed progressive resistance exercise and how his three sets worked.
- ☐ I found a safe 10-rep level for five exercises and recorded every set for two weeks.
- ☐ I raised my level only when I earned it and compared a before and after test done the same way.

FITNESS JOURNAL

1. Copy your training chart for every workout. Highlight each time you raised a 10-rep level.
2. Draw a line graph of your before-and-after test reps for all five exercises, or a bar graph with two bars for each.

3. Draw a diagram of a motor unit: one nerve cell branching to several muscle fibers. Write how training changes the way your brain uses motor units.
4. After each workout, write one sentence on how you felt and one on what you will do next time.

From history. DeLorme went on to become a surgeon and a leader in rehabilitation medicine in Boston. His ideas were at first doubted by many doctors, who thought heavy exercise would strain the heart, but the results in his patients changed medical practice.

COMMON MISTAKES

- Testing a one-rep maximum or lifting “as heavy as possible.” It adds risk and is not needed to get stronger.
- Raising the load before form is solid, or adding several steps at once.
- Training the same muscles hard every day. Strength is built during recovery.
- Holding your breath and straining. Breathe out on the effort.

Make it a game • DeLorme's Ladder Run. Do a bodyweight move for ten reps at easy effort, then moderate, then hard, as DeLorme's ladder. Record sets, reps and rest. Explain progressive overload, motor units and why recovery matters. Your parent plays a nervous patient and you coach her through the idea. She scores your explanation. Retest after a week.

Scripture. “But they that wait upon the LORD shall renew their strength; they shall mount up with wings as eagles; they shall run, and not be weary; and they shall walk, and not faint.” (Isaiah 40:31, KJV)

Muscles are renewed during rest after work. Isaiah reminds us that the deepest strength, the strength to keep going in every part of life, is renewed by trusting the Lord.

4.2 THE HINGE AND THE SQUAT

OBJECTIVES

- Explain what the U.S. government's studies of workers' lifting found about protecting the back.
- Describe and perform the hip hinge and the squat with good form, and explain how they differ.
- Use a broom handle and a wall to learn a flat-back hinge, and a chair to learn a controlled squat.
- Lift, lower and carry household loads safely in a timed circuit, scoring and improving your form.

Warm-up. Six-minute warm-up: 1 minute brisk walking, 10 bodyweight squats to a chair (touch and stand), 10 standing toe reaches with soft knees, 10 glute bridges, 10 hip circles each way, 10 “good mornings” with hands on hips (push hips back, chest forward, back flat), and 10 walking lunges. Think about it: how do you usually pick up a heavy laundry basket or a bag of groceries?

WATCH

Hip hinge versus squat technique for daily life

Virginia Center for Spine & Sports Therapy • 2:00

<https://www.youtube.com/watch?v=Pz3yexifDH0>

WHEN TO WATCH

After “Good form.” Watch the physical therapist show both patterns from the side, then copy each one slowly.

Note: A short clinic video from a physical therapy practice (a smaller channel), chosen because it shows both movements clearly and plainly, for everyday lifting.

BACKUP VIDEO

Teaching the Hip Hinge

Muscle & Motion • 1:14

<https://www.youtube.com/watch?v=t4ouk4TmrS8>

Before the broom-handle drill. An animated model shows a good hinge, common faults and the three points of contact on a dowel.

KEY TERMS

hip hinge

A movement pattern in which you bend mainly at the hips, pushing them back with a flat back and only slightly bent knees, as in picking something up from a low table or a Romanian deadlift.

neutral spine

Your back in its natural, gently curved position, neither rounded forward nor arched far back.

posterior chain

The muscles on the back of the body (hamstrings, glutes and back muscles) that do most of the work in a hinge.

squat

A movement pattern in which hips and knees bend together and the body lowers more straight down, with the chest fairly upright, as in sitting into a chair.

brace

To tighten the muscles around your middle, as if ready for a small push, to keep the spine steady while lifting.

CORE IDEAS

The story. Back injuries from lifting have long been among the most common injuries of working people: warehouse workers, nurses, farmers, builders and movers. In the 1970s the U.S. National Institute for Occupational Safety and Health (NIOSH), a government agency that studies workplace safety, gathered research on how the spine is loaded during lifting and how often workers were hurt. In 1981 it published a guide for safe manual lifting, and in 1991 it revised it into the NIOSH Lifting Equation, which employers still use today.

How they figured it out. NIOSH researchers combined laboratory measurements of the forces on the spine, studies of workers' injuries and studies of how much people could lift without strain. They found that the danger depends not only on how heavy an object is, but on *how* it is lifted. The 1991 equation starts with 51 pounds as the safe limit for an adult worker in ideal conditions, and then lowers that limit when the load is held far out from the body, lifted from near the floor, lifted with a twist, or lifted very often. In other words: keep it close, start from a good height when you can, face the load, and do not twist while lifting.

Good form. Hip hinge: feet about hip-width apart, knees soft (slightly bent), push your hips straight back as if closing a car door with your seat; your chest moves forward and down while your back stays flat; shins stay nearly vertical; you feel a stretch in the back of your thighs; drive your hips forward to stand. **Squat:** feet about shoulder-width, toes turned out a little; sit back and down between your heels; knees track over your toes; chest up; heels down; go as low as you can with a flat back (thighs about level with the floor), then stand. In both: brace your middle, keep a **neutral spine**, keep any load close, and breathe out as you rise. To pick something up from the floor, squat or hinge down to it with the load between or just in front of your feet, brace, and stand up with it close; turn by moving your feet, never by twisting your back.

How your body works. The hinge works mostly the **posterior chain**: the hamstrings, the glutes (the biggest muscles in your body) and the long back muscles that hold the spine steady. The squat shares the glutes but uses the quadriceps on the front of the thigh much more. Your spine is a stack of 33 vertebrae with cushioning discs between most of them; it handles load best in its neutral position, with the core muscles bracing it like the guy-wires on a tent pole. A rounded back under a load puts much more strain on the discs and ligaments. Learning to hinge and squat well protects your back for a lifetime of carrying children, groceries, luggage and tools.

Try it. In Session 2 you will learn both patterns with a broom handle, a wall and a chair, then add light loads, and video yourself from the side to score your form. In Session 3 you will run a “workday circuit” of lifting, lowering and carrying, and work to raise both your form score and your rounds.

PICTURE STUDY



The Gleaners, Jean-François Millet, 1857 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

After the harvest, poor families were allowed to glean, picking up the leftover grain from the field, as Ruth did in the field of Boaz in the Bible. Millet painted three women gleaning in a field in France, bending again and again through the long day.

Look closely

- Look closely at how each woman bends. Is she squatting, hinging at the hips, or rounding her back?
- Which of the three looks most likely to have a sore back by evening? Why?
- Find what each woman is holding. How does she keep the gathered grain close to her body?
- Look at the distant harvesters and the great haystacks. How is their work different from the gleaners'?

Talk about it

1. If you could coach these women, what would you tell them about protecting their backs as they bend all day?
2. God's law told farmers to leave the edges of their fields for the poor to glean (Leviticus 19:9-10). What does this painting show about work and kindness?

3. What jobs at your house require bending and lifting? Which pattern, hinge or squat, fits each one best?

Safety first. Learn each movement with a broom handle or body weight first, and add only light loads (a water jug, a laundry basket, a backpack) once your form is good. Keep loads close, keep your back flat, and never twist while lifting. Stop and tell an adult if you feel pain in your back, knees or hips.

ACTIVITY

Hinge and Squat Clinic and the Workday Circuit

Good lifting is a skill. You will learn it step by step, score yourself honestly from video, and then put it to work in a circuit that looks a lot like real chores.

You will need

- A broom handle or dowel, a wall and a sturdy chair
- Two gallon water jugs, a laundry basket with a few towels or books in it, and a backpack
- A phone or camera to video from the side, and a timer
- Fitness journal with a form checklist (10 points: see Step 4) and a circuit chart

Steps

1. **Broom-handle hinge (Session 2).** Hold a broom handle along your back so it touches three points: the back of your head, between your shoulder blades and your tailbone. Push your hips back and hinge forward, keeping all three points touching. Stop when you feel a stretch in your hamstrings or the stick starts to leave a point. Do 3 sets of 8, resting 30 seconds.
2. **Wall hinge.** Stand with your heels about a foot from a wall, facing away. Hinge until your seat touches the wall, then stand. Step a few inches farther away and repeat. Do 2 sets of 8.
3. **Chair squat and goblet squat.** Squat to a chair until your seat lightly touches, then stand without rocking: 2 sets of 10. Then hold a water jug at your chest and do 2 sets of 8 goblet squats to the chair.
4. **Form check.** Video yourself from the side doing 5 hinges with the broom and 5 goblet squats. Score yourself using the checklist, 1 point each: hinge: (1) back flat, (2) hips move back, (3) shins nearly vertical, (4) knees soft, (5) stand by driving hips forward; squat: (6) chest up, (7) knees over toes, (8) heels down, (9) depth with flat back, (10) controlled speed. Write your score out of 10 and one cue to fix.
5. **Add light loads.** Romanian deadlift: hold a water jug in each hand in front of your thighs, hinge with a flat back until the jugs reach about knee height,

then stand: 2 sets of 8. Floor lift: squat down to the laundry basket, brace, lift it to your waist keeping it close, then lower it the same way: 2 sets of 5.

6. **Workday circuit (Session 3).** Warm up, then do 3 rounds: 10 goblet squats with a jug, 10 jug Romanian deadlifts, 6 laundry-basket floor-to-waist lifts, and a 40-yard farmer's carry (a jug in each hand, walking tall, shoulders back). Rest 90 seconds between rounds and record your time for each round.
7. **Re-score your form** by video during round 3, when you are tired. Did your score hold? Write which cue slipped first.
8. **Cool down** with 3 minutes of walking and stretches for hamstrings, hips and lower back (knees to chest), and write a goal for the unit challenge.

Tips

- If your back rounds in the hinge, shorten the range: stop higher, and let your hamstrings loosen over time.
- For the farmer's carry, pretend you are trying to look tall while carrying full buckets of water from a well.
- When lifting a box or basket, first slide it close to you. A load twice as far from your body strains your back far more.

Check your work

- ☐ I can explain what NIOSH found about safe lifting: keep it close, start from a good height, and do not twist.
- ☐ I can perform a hip hinge and a squat with good form and explain how they differ.
- ☐ I scored my form from video, completed the workday circuit and recorded my rounds.

FITNESS JOURNAL

1. Draw two stick figures from the side, one in a hip hinge and one in a squat. Label the hip angle, knee angle, shin angle and back position on each.
2. Copy your form checklist with your Session 2 score and your round-3 score. Write the cue you will practice.
3. Make a circuit chart with your time for each round, and write how it felt.
4. List five chores or jobs at your house that involve lifting. For each, write whether you would hinge or squat, and one safety rule.

From history. The NIOSH Lifting Equation is used to design jobs so that workers can lift safely day after day, by changing shelf heights, box sizes and how often lifts happen. Good design and good technique together have helped protect millions of workers' backs.

COMMON MISTAKES

- Rounding the back to reach the floor instead of bending at the hips and knees.
- Turning a hinge into a squat (knees shoot forward) or a squat into a hinge (chest falls forward).
- Holding the load far out in front of the body.
- Twisting to set something down instead of turning the feet.

Make it a game • Hinge or Squat Judge. Take turns performing a hip hinge or a squat while the other judges neutral spine, brace and range. Use a broom handle on your back to check alignment. Call out the differences between the two moves. Tell what workers' lifting studies found. Switch roles. Most correct calls out of ten wins the round.

UNIT 4

STRENGTH

In 1944, at an Army hospital in Chicago, a young doctor named Thomas DeLorme was trying to help soldiers whose injured knees were healing far too slowly with the gentle exercises doctors then prescribed. DeLorme had lifted weights for years, and he tried something different: fewer repetitions against heavier resistance, increased step by step as the soldiers grew stronger, and carefully recorded. He called it progressive resistance exercise, and it is still the foundation of strength training and physical therapy. In this unit you will learn how muscles adapt to work, find your own “10-rep level” for five exercises with light household loads, and follow a two-week plan with a before-and-after test.

Then you will learn the two most useful movement patterns for life and sport: the squat and the hip hinge. A U.S. government study of workers’ back injuries showed how lifting with the load close to the body, without twisting, protects the back. You will practice the hinge with a broom handle, the squat to a chair, and real lifting and carrying with water jugs and a laundry basket, recording a form score you will work to improve.

PREREQUISITES

- Can do squats, push-ups, planks and lunges with good form (earlier grades)
- Knows the warm-up and cool-down and the talk test (Unit 1)
- Knows that protein, sleep and rest are needed for muscles to repair (Unit 3)

MASTERY CHECKLIST

- ☐ I can tell how Thomas DeLorme developed progressive resistance exercise and explain the principle of progressive overload.
- ☐ I can explain how muscles get stronger: first through the nervous system, then through larger muscle fibers, with rest, food and sleep.
- ☐ I can find a safe 10-rep level for an exercise and follow a three-set plan, adding resistance only when I have earned it.
- ☐ I can perform a hip hinge and a squat with good form, and explain the difference between them.
- ☐ I can lift an object from the floor and carry it safely, keeping it close and my back flat, and never twisting.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **“Strength Training” (Nemours KidsHealth, for teens):** Free. A clear article on safe strength training for teenagers: supervision, technique, rest and realistic goals. Read it with Lesson 4.1.
- **A light resistance band (loop or tube with handles):** Optional for rows and pull-aparts in Lesson 4.1. A backpack with books works just as well for every exercise in this unit.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1 Thomas DeLorme and Progressive Resistance

3 sessions of 40–45 minutes

UNIT 4 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. 5 pts

What problem was Thomas DeLorme trying to solve in 1944, and what did he change?

2. 5 pts

Describe DeLorme's three-set system. Why were the first two sets lighter?

3. 5 pts

Calculation: Your 10-rep level for the goblet squat is a backpack weighing 16 pounds. About how heavy should the load be for sets 1 and 2 in a DeLorme-style workout?

4. 5 pts

Explain why beginners get stronger quickly in the first few weeks, and what changes later.

5. 5 pts

Name four rules for safe strength training for teenagers.

6. 5 pts

What did NIOSH find about what makes lifting dangerous? Name three factors.

7. 5 pts

Describe the difference between a hip hinge and a squat, including which muscles each works most.

8. 5 pts

Explain how to pick up a laundry basket from the floor and set it on a table to your left.

9. **5 pts**

Calculation: In the workday circuit your round times were 3:40, 3:55 and 4:20 in Session 3, and in your retest a week later 3:30, 3:40 and 3:50. Find your total time each day and the improvement in seconds.

10. **5 pts**

Short written answer: In three or four sentences, explain why form must come before adding weight.

ANSWER KEY

1. Injured soldiers' leg muscles were recovering slowly with the usual light, many-repetition exercises. DeLorme had them work against heavier resistance for fewer repetitions, increasing the resistance step by step and recording it (progressive resistance exercise). They recovered much faster.
2. He found the 10-repetition maximum and had the patient do three sets of 10: at half, three-quarters and the full 10RM. The lighter sets warmed up the muscle and practiced the movement before the hardest set.
3. Set 1: $\frac{1}{2} \times 16 = 8$ pounds (for example, a full gallon jug of about 8.3 pounds). Set 2: $\frac{3}{4} \times 16 = 12$ pounds. Set 3: the full 16 pounds.
4. Early gains come mainly from the nervous system: the brain learns to switch on more motor units together and coordinate the muscles. Later, with continued overload, the muscle fibers grow larger (hypertrophy), which becomes easier during and after puberty. Tendons and bones also adapt, more slowly.
5. Any four: supervision by a knowledgeable adult; technique first; start light and progress gradually; 2–3 non-consecutive days a week with rest between; breathe out on effort, never hold breath; no maximum single-lift testing; stop for sharp or joint pain; warm up and cool down; eat well and sleep 8–10 hours.
6. Danger depends on how a load is lifted, not just its weight. Factors that lower the safe limit: the load held far from the body, lifting from near the floor, twisting while lifting, and lifting very often. (Its 1991 equation starts at 51 pounds in ideal conditions.)
7. In a hinge the hips move back with a flat back, knees only slightly bent and shins nearly vertical; it works mostly the hamstrings, glutes and back muscles (posterior chain). In a squat hips and knees bend together and the body lowers more straight down with the chest up; it works the quadriceps more, along with the glutes.
8. Stand close with the basket between or just in front of your feet; squat or hinge down with a flat back; grip, brace your middle, and stand by driving through your legs and hips, keeping the basket close; then turn your whole body by moving your feet toward the table and set it down, without twisting your back.
9. Session 3: $3:40 + 3:55 + 4:20 = 220 + 235 + 260 = 715$ seconds (11:55). Retest: $210 + 220 + 230 = 660$ seconds (11:00). Improvement = $715 - 660 = 55$ seconds.
10. Answers will vary. Good form spreads the work over the right muscles and keeps the spine and joints in safe positions; poor form under load strains discs,

ligaments and tendons and can cause injury. Form is also how the nervous system learns the movement, so practicing good reps builds strength faster. Adding weight to poor form only makes the poor pattern stronger and riskier.

UNIT CHALLENGE: TWO-WEEK STRENGTH PLAN WITH BEFORE-AND-AFTER TEST

Complete the two-week DeLorme's Ladder plan from Lesson 4.1, training every other day (about 7 workouts) with three sets of each exercise and adding resistance only when you have earned it. Add the hinge and squat practice from Lesson 4.2 to at least four of those workouts. At the end, repeat your before test at the same 10-rep levels and run the workday circuit once more with a form score. Make a before-and-after bar graph of your reps, and write a paragraph about what improved, what was hard and what you learned about progressive resistance.

LOOK FOR	WHAT IT MEANS
Faithful training	About 7 dated workouts in two weeks with every set recorded and rest days in between.
Safe progression and form	Resistance raised one small step at a time only when earned; a parent confirms good form, including the hinge and squat.
Fair before-and-after test	The same exercises, levels, order and rests for both tests, recorded honestly, plus a final circuit time and form score.
Graph and reflection	A neat before-and-after graph and a paragraph on what improved and what was learned. Effort and improvement count, not the size of the numbers.

UNIT 5

AEROBIC TRAINING

How much blood does your heart pump in a minute? In 1870 the German scientist Adolf Fick worked out a way to calculate it, but no one could measure it in a living person until 1929, when a young German doctor, Werner Forssmann, slid a narrow tube through a vein in his own arm into his heart. In this unit you will learn the equation for **cardiac output**, stroke volume $\times$ heart rate, and why training makes the heart pump more blood with each beat, so that a fit heart beats more slowly at rest. You will keep a week of morning heart rates, build a heart-rate table from rest to hard running, and calculate how many liters of blood your heart moves.

Then you will meet Bill Bowerman, the Oregon track coach who in the 1960s taught ordinary people of all ages to jog, starting slowly and building up week by week. You will plan a four-week run-walk program to a 5K (3.1 miles), run a timed mile with splits as your baseline, make a pacing chart, and end the course with a family fitness day.

PREREQUISITES

- Can take a pulse for 15, 30 or 60 seconds and convert to beats per minute (Unit 1)
- Knows the talk test and the warm-up and cool-down (Unit 1), and has a hydration plan (Unit 2)
- Can multiply, divide and convert minutes and seconds, milliliters and liters

MASTERY CHECKLIST

- ☐ I can tell how Fick, Forssmann, Cournand and Richards made it possible to measure the heart's output.
- ☐ I can use cardiac output = stroke volume $\times$ heart rate and explain why training lowers resting heart rate.
- ☐ I can measure resting, exercise and recovery heart rates and graph them against effort.
- ☐ I can tell how Bill Bowerman brought jogging to ordinary Americans and explain the hard-easy principle and gradual progress.
- ☐ I can follow a run-walk training plan, run with even pacing, keep a pacing chart and lead a family fitness day.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **A simple sports watch or stopwatch:** For splits on the timed mile and the run-walk intervals. A phone timer with an interval setting works too.
- **A measured route:** A school track (4 laps is about a mile), or a neighborhood loop measured with a car's odometer or a free online map tool. No purchase needed.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 Your Heart's Output

3 sessions of 40–45 minutes

5.2 Training for a 5K: Bill Bowerman and the Joggers

3 sessions of 40–45 minutes

UNIT 5 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. (5 pts)

What was Adolf Fick's idea in 1870, and why could it not be used in living people until much later?

2. (5 pts)

What did Werner Forssmann do in 1929, and what did Cournand and Richards later do with his method?

3. (5 pts)

Calculation: At rest, Ana's heart pumps 70 mL per beat at 72 beats per minute. What is her cardiac output in liters per minute?

4. (5 pts)

Calculation: After months of training, Ana's stroke volume at rest rises to 84 mL. If her body still needs about 5,040 mL per minute at rest, what will her resting heart rate be?

5. (5 pts)

Explain in your own words why regular aerobic training lowers resting heart rate.

6. (5 pts)

What does a one-minute heart-rate recovery measure, and what would you expect to happen to it after four weeks of training?

7. (5 pts)

How did Bill Bowerman bring jogging to ordinary Americans? Name two lessons he and Dr. Harris taught about starting to run.

8. (5 pts)

Calculation: Your mile splits were 2:45, 2:55, 3:05 and 3:15. What is your total time and average split? Was your pacing even? What would you change?

9. **5 pts**

Calculation: You want to run a 5K (3.1 miles) in 37 minutes. What pace per mile is that, and what should your time be at mile 2?

10. **5 pts**

Short written answer: In three or four sentences, explain why a beginner's plan increases running time gradually, using what you know about the heart, muscles and bones.

ANSWER KEY

1. Fick showed that blood flow (cardiac output) could be calculated from the oxygen taken in per minute divided by the difference in oxygen between blood leaving and returning to the lungs. To know the oxygen in returning blood, a sample from inside the heart was needed, which was not possible until catheters could be passed safely into the heart (Forssmann 1929; Cournand and Richards, 1940s).
2. Forssmann numbed his own arm, passed a catheter through a vein into his heart and proved it with an X-ray. Cournand and Richards refined the method in the 1940s and used catheters safely in patients to measure cardiac output and pressures in the living heart. All three shared the 1956 Nobel Prize.
3. $70 \text{ mL} \times 72 = 5,040 \text{ mL per minute} = \text{about } 5.0 \text{ L per minute.}$
4. $\text{Heart rate} = \text{cardiac output} \div \text{stroke volume} = 5,040 \div 84 = 60 \text{ beats per minute.}$
5. Training makes the left ventricle larger and stronger and increases blood volume, so each beat pumps more blood (higher stroke volume). The body needs about the same cardiac output at rest, so the heart can beat fewer times per minute.
6. It measures how much heart rate drops in the first minute after exercise stops. With training the drop usually becomes larger, because a fitter heart and nervous system return toward rest more quickly.
7. After seeing ordinary people of all ages jogging in New Zealand in 1962, he started a jogging program in Eugene in 1963 and in 1966 published the book *Jogging* with cardiologist W. E. Harris, which sold over a million copies. Lessons: start gently with jog-walk intervals; add a little each week; follow hard days with easy days (hard-easy principle); avoid doing too much too soon.
8. $\text{Total} = 165 + 175 + 185 + 195 = 720 \text{ seconds} = 12:00. \text{ Average split} = 720 \div 4 = 180 \text{ s} = 3:00. \text{ Not even: each split was 10 seconds slower than the one before (30 seconds between first and last). Start slower, closer to 3:00 per quarter, and hold it.}$
9. $37 \div 3.1 \approx 11.94 \text{ minutes per mile} \approx 11:56 \text{ per mile. At mile 2: } 2 \times 11.94 \approx 23.9 \text{ minutes} \approx 23:52.$
10. Answers will vary. The heart's stroke volume, the muscles' capillaries and mitochondria, and blood volume all improve over weeks, not days. Bones, tendons and joints adapt even more slowly to the pounding of running, so most injuries come from doing too much too soon. Gradual progress with easy days

lets the body recover and adapt, and keeps the runner healthy and willing to continue.

UNIT CHALLENGE: FOUR-WEEK 5K PLAN, PACING CHART AND FAMILY FITNESS DAY

Follow your four-week run-walk plan from Lesson 5.2, three workouts a week with easy days in between, and log every workout. At the end, run a 5K (3.1 miles) on a measured route at even pace, recording your mile splits and comparing them with your pacing chart. Repeat your morning resting heart rate for a week and your one-minute heart-rate recovery, and compare with Lesson 5.1. Include your plan and notes from the family fitness day, and write a paragraph about what you learned this quarter about caring for the body God gave you.

LOOK FOR	WHAT IT MEANS
Faithful training	Twelve logged workouts (or as many as the plan and weather allowed), with hard-easy spacing and honest talk-test notes.
Pacing chart and splits	A pacing chart with arithmetic shown and actual 5K splits compared with it.
Heart-rate comparison	Morning resting heart rate and heart-rate recovery measured the same way before and after, with the change explained.
Family fitness day and reflection	A clear plan with stations from every unit, notes on how the day went, and a thoughtful reflection on the quarter. Effort and improvement count, not speed.

5.1 YOUR HEART'S OUTPUT

OBJECTIVES

- Tell how Adolf Fick's principle and Werner Forssmann's catheter made it possible to measure the heart's output.
- Use cardiac output = stroke volume $\times$ heart rate and explain how training changes each part.
- Measure a week of morning resting heart rates and a heart-rate table from rest to hard effort, and calculate cardiac output.
- Do a 20-minute steady aerobic session and measure one-minute heart-rate recovery.

Warm-up. Five-minute warm-up: 1 minute walking, 1 minute brisk walking, 30 seconds of easy jogging in place, 10 arm circles each way, 10 squats and 10 skips. Then put two fingers on your neck beside your windpipe and count for 15 seconds. Think about it: your heart just sped up. Is it also pushing out more blood with each beat?

WATCH

What Happens to your Heart when you Exercise - The Human Body - A User's Guide

Frome Digital · 2:43

<https://www.youtube.com/watch?v=O8ttt3M8qZM>

WHEN TO WATCH

After “How your body works.” Watch the blood flow through the four chambers and listen for heart rate and stroke volume.

Note: A short animated diagram from a British teaching series (a smaller channel), narrated by a rugby coach. It shows the path of blood clearly and ends with what changes during exercise.

BACKUP VIDEO

Cardiovascular System Physiology - Cardiac Output (stroke volume, heart rate, preload and afterload)

Armando Hasudungan · 5:13

<https://www.youtube.com/watch?v=hpQFToprlH8>

For an advanced student who wants more: a hand-drawn explanation of cardiac output and what controls stroke volume.

KEY TERMS

cardiac output

The volume of blood the heart pumps in one minute, usually in liters per minute. Cardiac output = stroke volume × heart rate.

left ventricle

The heart's thickest, strongest chamber, which pumps oxygen-rich blood out to the whole body.

stroke volume

The volume of blood the left ventricle pumps out with each beat, in milliliters (mL).

Fick principle

Adolf Fick's 1870 idea: blood flow can be calculated from the oxygen the body takes in each minute and the difference in oxygen between blood going to and coming from the lungs.

cardiac catheter

A narrow, flexible tube passed through a blood vessel into the heart to measure pressures, take blood samples or give medicine.

heart-rate recovery

How much your heart rate drops in the first minute after exercise stops. A bigger drop is a sign of good fitness.

CORE IDEAS

The story. In 1870 Adolf Fick, a German professor of physiology, published a short paper with a clever idea. If you know how much oxygen a person takes in each minute, and how much oxygen each liter of blood picks up as it passes through the lungs, you can divide one by the other and find how many liters of blood the heart pumps in a minute. There was one problem: to know the oxygen in the blood returning to the heart, you would need a sample from inside the heart itself, and that seemed impossible in a living person. In 1929 Werner Forssmann, a young surgical trainee in Eberswalde, Germany, believed a narrow tube could be passed safely through a vein into the heart. His chief refused permission, so Forssmann numbed his own arm, slid a narrow catheter into a vein near his elbow, and pushed it about 60 centimeters toward his heart. Then he walked to the X-ray room and took a picture showing the tube resting inside his heart. He was not hurt.

How they figured it out. Forssmann was criticized for his daring and left heart research for years. But in the 1940s two physicians in New York, André Cournand and Dickinson Richards, refined the catheter method and used it safely in patients at Bellevue Hospital. Taking blood from inside the heart, they could finally use Fick's principle to measure cardiac output and pressures in the living heart, in health, in disease and during exercise. In 1956 Forssmann, Cournand and Richards shared the Nobel Prize in Physiology or Medicine. (Forssmann's self-experiment was dangerous and would never be allowed today; modern heart catheterization is done by trained teams with careful safety rules.)

How your body works. **Cardiac output = stroke volume × heart rate.** At rest a teenager's heart pumps roughly 70 milliliters with each beat, about 70 times a minute: $70 \text{ mL} \times 70 = 4,900 \text{ mL}$, or about 5 liters a minute, close to all the blood in your body every minute. During hard exercise your muscles need far more oxygen, so both parts rise: heart rate may climb toward 190 to 200 beats per minute in a teenager, and stroke volume increases as the ventricles fill more fully and squeeze harder. Cardiac output can reach 15 to 20 liters a minute, and even more in trained

endurance athletes. With regular aerobic training, the left ventricle grows a little larger and stronger and your blood volume increases, so **stroke volume goes up**. Because you need about the same 5 liters a minute at rest, a bigger stroke volume means your heart can beat **more slowly at rest**. A trained person might pump 100 mL per beat at only 50 beats a minute, still 5 liters a minute. Your resting heart rate is a simple window on your heart's fitness, though it also varies with age, sleep, illness, stress and heredity. A normal resting rate for teens is about 60 to 100 beats per minute.

Think it through. These numbers are estimates: no one can measure your stroke volume at home. But you can measure your heart rate accurately, see how it rises with effort, and watch your resting rate and recovery change as you train over weeks and months.

Try it. For seven mornings you will measure your resting heart rate before getting out of bed. In Session 2 you will build a heart-rate table at four levels of effort and estimate your cardiac output at each. In Session 3 you will do a steady 20-minute aerobic session and measure your one-minute heart-rate recovery.

PICTURE STUDY



The Champion Single Sculls (Max Schmitt in a Single Scull), Thomas Eakins, 1871 · Oil on canvas · The Metropolitan Museum of Art, New York
Image: [Wikimedia Commons](#), public domain

Thomas Eakins painted his friend Max Schmitt, a champion rower, on the Schuylkill River in Philadelphia. Eakins put himself in the picture too: he is the rower in the second boat. Rowing a racing shell is one of the most demanding aerobic sports, using the legs, back and arms together.

Look closely

- Look at Max Schmitt. Is he rowing hard or resting? How would his heart rate compare at this moment with during a race?
- Find the second rower. What is he doing, and how can you tell he is working?
- Look at the water and the reflections. What do they tell you about the weather and the time of day?
- Find the bridges. How far might a rower travel in a training session on this river?

Talk about it

1. Rowing uses nearly every major muscle. Why would that demand a very high cardiac output?
2. A champion rower's heart pumps far more blood with each beat than an untrained person's. What would you expect his resting heart rate to be like?

3. Eakins and Schmitt were friends who trained together. How does a training partner help you stay faithful to a plan?

Safety first. Measure your morning pulse before getting up, not after jumping out of bed. During the heart-rate ladder, warm up first, run on a flat, safe route away from traffic with a buddy or an adult, and slow down if you cannot speak a few words. Stop and tell an adult right away if you feel chest pain, a pounding or fluttering heartbeat that does not settle, dizziness or faintness.

ACTIVITY

Heart-Rate Ladder and Cardiac Output Table

Fick and Forssmann measured what the heart does. You will measure your own heart at rest and at four levels of effort, estimate its output, and watch how quickly it recovers.

You will need

- A timer or watch with a seconds display
- A flat, safe route, yard or track, or a sturdy bottom stair
- A water bottle
- Fitness journal with three tables: morning resting heart rate (7 days), heart-rate ladder (effort, talk test, heart rate, estimated stroke volume, cardiac output), and recovery (heart rate at stop, after 1 minute, drop)

Steps

1. **Morning resting heart rate (start now, for 7 days).** Each morning, as soon as you wake and before you sit up, count your pulse for a full 60 seconds. Record it. At the end of the week, find your average.
2. **Warm up (Session 2)** for 5 minutes with walking and easy jogging.
3. **Heart-rate ladder.** Do 3 minutes at each of four levels without stopping between them: (1) easy walk, (2) brisk walk, (3) steady jog where you can talk in sentences, (4) hard run where you can say only a few words. At the end of each 3 minutes, count your pulse for 15 seconds while walking slowly, multiply by 4, and record it with your talk-test result. Then go straight into the next level.
4. **Estimate cardiac output.** Use these rough stroke volumes for an untrained teenager: rest 70 mL, easy walk 80 mL, brisk walk 90 mL, jog 100 mL, hard run 100 mL. Multiply by your heart rate and divide by 1,000 to get liters per minute. Example: $160 \text{ bpm} \times 100 \text{ mL} = 16,000 \text{ mL} = 16 \text{ L per minute}$.
5. **Cool down** with 3 minutes of walking and stretches, and drink water.
6. **Steady session (Session 3).** Warm up, then run or run-walk for 20 minutes at a steady pace where you can talk in short sentences. Take a 15-second pulse

at minutes 10 and 20.

7. **Heart-rate recovery.** At the end of the 20 minutes, stop and count your pulse for 15 seconds right away ($\times 4$). Walk slowly for 1 minute, then count again ($\times 4$). Subtract to find your one-minute drop. Record it, and plan to repeat this test at the end of the 5K plan in Lesson 5.2.

Tips

- Keep a pencil and your journal by your bed for the morning pulse so you do not have to get up.
- Count pulses at the neck gently with two fingers; pressing hard can slow the heart.
- Your numbers are your own. Heart rates differ a lot from person to person and say nothing about who is “better.”

Check your work

- ☐ I can explain Fick’s principle and why Forssmann’s catheter mattered.
- ☐ I used cardiac output = stroke volume $\times$ heart rate to fill in my ladder table, showing my work.
- ☐ I recorded seven morning heart rates, a heart-rate ladder and a one-minute recovery.

FITNESS JOURNAL

1. Graph your heart-rate ladder: effort level on the horizontal axis, heart rate on the vertical axis. Add a second line for estimated cardiac output in liters per minute.
2. Make a table of your seven morning heart rates and find the average. Which day was highest? Was anything different that day (poor sleep, a cold, a big test)?
3. Draw the heart’s four chambers with arrows showing blood from the body to the lungs and back to the body. Label the left ventricle and where stroke volume leaves the heart.
4. Write a paragraph explaining to a younger brother or sister why a fit person’s heart can beat more slowly at rest.

From history. Forssmann gave up heart research and became a urologist. When the Nobel Prize came in 1956, more than twenty-five years after his experiment, he was working as a doctor in a small German town.

COMMON MISTAKES

- Taking a “resting” pulse right after walking around or climbing stairs.
- Pressing hard on the neck to find the pulse, or counting the thumb’s own pulse.
- Thinking a lower heart rate is always better. Heart rates vary from person to person; compare only with yourself.
- Treating estimated stroke volumes as exact measurements.

Make it a game • Cardiac Output Math. Measure your resting pulse and estimate stroke volume with a given number from your parent. Multiply for cardiac output. Then jog two minutes, count your pulse again and recalculate with a higher stroke volume. Explain how training changes each part. Tell Forssmann's catheter story. First to the correct number wins.

5.2 TRAINING FOR A 5K: BILL BOWERMAN AND THE JOGGERS

OBJECTIVES

- Tell how Bill Bowerman brought jogging to ordinary Americans in the 1960s and what his “hard-easy” approach teaches.
- Plan a four-week run-walk program to a 5K (3.1 miles), starting at the right level and building gradually.
- Run a timed mile with splits, calculate pace, and make a pacing chart for a 5K.
- Plan and lead a family fitness day using what you learned in all five units.

Warm-up. Runner’s warm-up, about 6 minutes: 2 minutes brisk walking, 1 minute easy jogging, 10 walking knee hugs, 10 leg swings each way on each leg (hold a wall), 10 butt kicks, 10 high-knee skips and 2 relaxed 50-yard build-up runs. Think about it: if you ran your very first mile as fast as you possibly could, what would happen in the second half?

WATCH

This is TrackTown: Bowerman's Jogging Class

TrackTown USA • 7:41

<https://www.youtube.com/watch?v=nK4aCSvxKUc>

WHEN TO WATCH

After “The story” and “How they figured it out.” Listen to people who were there describe the first jogging classes in Eugene, Oregon, and the little booklet that started it all.

Note: A local history film from Eugene, Oregon, with interviews and old photographs and film of the 1960s joggers.

KEY TERMS

aerobic endurance

The ability to keep moving at a steady pace for a long time, using oxygen to make energy.

pace

How long it takes to cover a set distance, such as 11 minutes per mile. A lower pace number means faster.

split

The time for one part of a run, such as each lap or each quarter mile.

even pacing

Running each part of a race at about the same pace, rather than starting fast and slowing down.

hard-easy principle

Bowerman's rule that a hard training day should be followed by one or more easy days so the body can recover and adapt.

5K

A race of 5 kilometers, about 3.1 miles, the most popular race distance for beginners and families.

CORE IDEAS

The story. Bill Bowerman coached track and field at the University of Oregon for twenty-four years, beginning in 1948, and trained many champion runners. In 1962 he traveled to New Zealand with his team and visited his friend, the coach Arthur Lydiard. There Bowerman was surprised to see crowds of ordinary men and women, some of them old, running together through the parks of Auckland for their health. He joined them and found the running much harder than he expected. Back home in Eugene, Bowerman started a jogging program for ordinary people in 1963. Many people came. In the America of that time almost no adults ran for exercise, and some people thought joggers were odd.

How they figured it out. Bowerman and a cardiologist, Dr. W. E. Harris, studied how beginners responded. They found that people progressed best when they started gently, alternating jogging and walking, and added a little each week, with easy days after harder ones. Overdoing it led to soreness, injury and quitting. In 1966 the two men published a short book, *Jogging*, with simple week-by-week plans for people of every age and fitness level. It sold more than a million copies and helped start the running movement in America. Bowerman's teams were also famous for his **hard-easy principle**: after a hard day of training, rest with one or more easy days.

How your body works. Steady running trains your whole oxygen delivery system. Your heart's stroke volume rises (Lesson 5.1); your lungs and breathing muscles grow more efficient; your blood volume increases; and inside your muscles, more tiny blood vessels (capillaries) grow and the mitochondria, the cell's energy factories, multiply, so the muscles can use more oxygen. These changes build over weeks, which is why a plan must be gradual. Your bones, tendons and joints need

even more time to adapt to the pounding of running, so most running injuries come from doing too much too soon. **Even pacing** is the most efficient way to race: starting too fast uses up energy quickly and forces you to slow down far more later. To find pace, divide time by distance. A 5K run in 36 minutes is $36 \div 3.1 \approx 11.6$ minutes per mile, or about 11 minutes 35 seconds per mile.

Try it. In Session 2 you will run a timed mile (or a run-walk mile) with quarter-mile splits as your baseline, then do the first workout of a four-week run-walk plan. In Session 3 you will do the second workout. At the end of the week you will lead your family fitness day. Then you will keep going for three more weeks to finish a 5K, the unit challenge. Hebrews calls us to run with patience the race set before us: steady, faithful and not giving up.

PICTURE STUDY



The Finish of the 5,000 Meters, Stockholm Olympics, Unknown photographer, 1912 · Photograph · Stockholm, Sweden

Image: [Wikimedia Commons](#), public domain

At the 1912 Olympics in Stockholm, the 5,000 meters, the same distance as a modern 5K, was run for the first time. Hannes Kolehmainen of Finland and Jean Bouin of France ran far ahead of everyone else, and this news photograph caught the finish. Kolehmainen won by a tenth of a second, in a world-record time of 14 minutes 36.6 seconds.

Look closely

- Look at the two runners' arms, legs and faces. How can you tell how hard they are working at the very end?
- Find the officials. What are they doing, and what equipment can you see?
- Look at the track surface and the runners' shoes. How is this different from a modern race?

Talk about it

1. Kolehmainen averaged under 3 minutes per kilometer. How long does it take you to walk a kilometer? Why is it foolish to compare yourself with a champion?
2. Two runners pushed each other to a world record. How can running with a friend or family member help you?

3. What would even pacing look like in a race as close as this one?

Safety first. Run with a buddy or an adult on a safe route away from traffic, in daylight or with reflective clothing, and carry water. In hot weather run early or late in the day, in shade, and follow your hydration plan. Follow the plan's gradual steps, and stop and tell an adult if you feel chest pain, dizziness, faintness or sharp pain in a foot, shin or knee.

ACTIVITY

Timed Mile, Four-Week 5K Plan and the Family Fitness Day

Bowerman's joggers started slowly and kept going. You will measure your starting point, follow the first week of a four-week plan, and lead your family in a fitness day that brings the whole quarter together.

You will need

- A measured route: a track (4 laps $\approx$ 1 mile) or a measured neighborhood loop
- A stopwatch, water bottles and good running shoes
- Fitness journal with a split chart, a four-week training log and a pacing chart
- For the family fitness day: cones or markers, a timer, water, and ingredients for a snack you will make

Steps

1. **Timed mile (Session 2).** After the runner's warm-up, run (or run-walk) one mile as evenly as you can. A helper calls out or records your time at each quarter mile (each lap of a track). Record your four splits and total time. Walk 5 minutes to cool down.
2. **Calculate** your average quarter-mile split ($\text{total} \div 4$) and how much your fastest and slowest splits differed. Even pacing means a small difference.
3. **Choose your starting level.** If you ran the whole mile comfortably, start the plan at Week 2. Otherwise start at Week 1. *Week 1:* 8 rounds of 1 minute jog and 2 minutes walk (3 times this week). *Week 2:* 6 rounds of 2 minutes jog and 1 minute walk. *Week 3:* 4 rounds of 5 minutes jog and 1 minute walk. *Week 4:* 2 rounds of 10 minutes jog and 2 minutes walk, then a 5K (3.1 miles) run-walk at an even pace at the end of the week. Always warm up with 5 minutes of brisk walking and cool down with 5 minutes of walking and stretches.
4. **Do the first workout** of your week after the timed mile if you feel fresh, or on the next day. Use the talk test: jog slowly enough to speak in short sentences.
5. **Session 3:** do the second workout of the week, with at least one easy or rest day after Session 2 (Bowerman's hard-easy principle).

6. **Make a pacing chart** for your 5K: choose a realistic goal time from your mile (a beginner's 5K pace is often 1 to 2 minutes per mile slower than a hard mile), divide by 3.1 for your pace per mile, and write the target time at mile 1, mile 2, mile 3 and the finish.
7. **Plan the family fitness day** for the end of the week: a warm-up you lead; stations from every unit (a step test or skill test from Unit 1, a water table with your hydration plan from Unit 2, a snack you cook from Unit 3, a hinge-and-squat or carry station from Unit 4, and a heart-rate check from Unit 5); and a family run-walk over a measured course where everyone goes at his or her own pace. Finish with a cool-down, the snack and thanks.
8. **Lead the day**, then keep training for the rest of the four weeks, logging every workout and finishing with your 5K. Repeat the heart-rate recovery test from Lesson 5.1 at the end and compare.

Tips

- Start each run slower than you think you need to. You can always speed up at the end.
- Run tall, relax your shoulders and hands, and let your arms swing forward and back, not across your body.
- If a week feels too hard, repeat it. Finishing a plan a week later is far better than getting hurt.

Check your work

- ☐ I can tell how Bill Bowerman brought jogging to ordinary people and explain the hard-easy principle.
- ☐ I ran a timed mile with splits, calculated my pace, and made a pacing chart for a 5K.
- ☐ I followed the first week of my plan and planned and led a family fitness day.

FITNESS JOURNAL

1. Copy your mile split chart and graph your four quarter-mile splits as a bar graph. Were they even?
2. Make a four-week training log with every workout: date, plan, what you did, how it felt (talk test), and notes.

3. Write your 5K pacing chart with the arithmetic shown: $\text{goal time} \div 3.1 = \text{pace per mile}$, and the target time at each mile.
4. After the family fitness day, write a paragraph: What went well, who surprised you, and what would you change next time?

From history. Bowerman's jogging program in Eugene became a model for fitness programs across the country. He also experimented with lighter, better running shoes for his athletes, famously pouring rubber into his wife's waffle iron to make a new kind of sole.

COMMON MISTAKES

- Starting too fast in the first quarter mile and having to walk early.
- Skipping the walk breaks in the early weeks because you feel good. Bones and tendons need time even when your lungs feel ready.
- Running hard every day. Follow a hard day with an easy day.
- Running in worn-out or poorly fitting shoes, or on uneven ground in the dark.

Make it a game • Five K Planner. Plan a four-week run-walk program to a 5K on paper. Present it to your parent as Bill Bowerman would to a jogging class. She asks about hard-easy days and pacing. Run a timed mile now to set a baseline. Compare it to the pace you need for 3.1 miles. Defend each week.

Scripture. "let us run with patience the race that is set before us" (Hebrews 12:1, KJV)

A 5K plan is won by patience: steady, faithful steps day after day. The Christian life is run the same way, with our eyes on Christ.

UNIT 5

AEROBIC TRAINING

How much blood does your heart pump in a minute? In 1870 the German scientist Adolf Fick worked out a way to calculate it, but no one could measure it in a living person until 1929, when a young German doctor, Werner Forssmann, slid a narrow tube through a vein in his own arm into his heart. In this unit you will learn the equation for **cardiac output**, stroke volume $\times$ heart rate, and why training makes the heart pump more blood with each beat, so that a fit heart beats more slowly at rest. You will keep a week of morning heart rates, build a heart-rate table from rest to hard running, and calculate how many liters of blood your heart moves.

Then you will meet Bill Bowerman, the Oregon track coach who in the 1960s taught ordinary people of all ages to jog, starting slowly and building up week by week. You will plan a four-week run-walk program to a 5K (3.1 miles), run a timed mile with splits as your baseline, make a pacing chart, and end the course with a family fitness day.

PREREQUISITES

- Can take a pulse for 15, 30 or 60 seconds and convert to beats per minute (Unit 1)
- Knows the talk test and the warm-up and cool-down (Unit 1), and has a hydration plan (Unit 2)
- Can multiply, divide and convert minutes and seconds, milliliters and liters

MASTERY CHECKLIST

- ☐ I can tell how Fick, Forssmann, Cournand and Richards made it possible to measure the heart's output.
- ☐ I can use cardiac output = stroke volume $\times$ heart rate and explain why training lowers resting heart rate.
- ☐ I can measure resting, exercise and recovery heart rates and graph them against effort.
- ☐ I can tell how Bill Bowerman brought jogging to ordinary Americans and explain the hard-easy principle and gradual progress.
- ☐ I can follow a run-walk training plan, run with even pacing, keep a pacing chart and lead a family fitness day.

OPTIONAL BOOKS AND GEAR FOR THIS UNIT

- **A simple sports watch or stopwatch:** For splits on the timed mile and the run-walk intervals. A phone timer with an interval setting works too.
- **A measured route:** A school track (4 laps is about a mile), or a neighborhood loop measured with a car's odometer or a free online map tool. No purchase needed.

Not required. Every activity in this unit works without them. School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 Your Heart's Output

3 sessions of 40–45 minutes

5.2 Training for a 5K: Bill Bowerman and the Joggers

3 sessions of 40–45 minutes

UNIT 5 REVIEW

Answer each question. The review is worth 50 points. Show your work on calculations; you earn points for correct steps as well as the answer.

1. (5 pts)

What was Adolf Fick's idea in 1870, and why could it not be used in living people until much later?

2. (5 pts)

What did Werner Forssmann do in 1929, and what did Cournand and Richards later do with his method?

3. (5 pts)

Calculation: At rest, Ana's heart pumps 70 mL per beat at 72 beats per minute. What is her cardiac output in liters per minute?

4. (5 pts)

Calculation: After months of training, Ana's stroke volume at rest rises to 84 mL. If her body still needs about 5,040 mL per minute at rest, what will her resting heart rate be?

5. (5 pts)

Explain in your own words why regular aerobic training lowers resting heart rate.

6. (5 pts)

What does a one-minute heart-rate recovery measure, and what would you expect to happen to it after four weeks of training?

7. (5 pts)

How did Bill Bowerman bring jogging to ordinary Americans? Name two lessons he and Dr. Harris taught about starting to run.

8. (5 pts)

Calculation: Your mile splits were 2:45, 2:55, 3:05 and 3:15. What is your total time and average split? Was your pacing even? What would you change?

9. **5 pts**

Calculation: You want to run a 5K (3.1 miles) in 37 minutes. What pace per mile is that, and what should your time be at mile 2?

10. **5 pts**

Short written answer: In three or four sentences, explain why a beginner's plan increases running time gradually, using what you know about the heart, muscles and bones.

ANSWER KEY

1. Fick showed that blood flow (cardiac output) could be calculated from the oxygen taken in per minute divided by the difference in oxygen between blood leaving and returning to the lungs. To know the oxygen in returning blood, a sample from inside the heart was needed, which was not possible until catheters could be passed safely into the heart (Forssmann 1929; Cournand and Richards, 1940s).
2. Forssmann numbed his own arm, passed a catheter through a vein into his heart and proved it with an X-ray. Cournand and Richards refined the method in the 1940s and used catheters safely in patients to measure cardiac output and pressures in the living heart. All three shared the 1956 Nobel Prize.
3. $70 \text{ mL} \times 72 = 5,040 \text{ mL per minute} = \text{about } 5.0 \text{ L per minute.}$
4. $\text{Heart rate} = \text{cardiac output} \div \text{stroke volume} = 5,040 \div 84 = 60 \text{ beats per minute.}$
5. Training makes the left ventricle larger and stronger and increases blood volume, so each beat pumps more blood (higher stroke volume). The body needs about the same cardiac output at rest, so the heart can beat fewer times per minute.
6. It measures how much heart rate drops in the first minute after exercise stops. With training the drop usually becomes larger, because a fitter heart and nervous system return toward rest more quickly.
7. After seeing ordinary people of all ages jogging in New Zealand in 1962, he started a jogging program in Eugene in 1963 and in 1966 published the book *Jogging* with cardiologist W. E. Harris, which sold over a million copies. Lessons: start gently with jog-walk intervals; add a little each week; follow hard days with easy days (hard-easy principle); avoid doing too much too soon.
8. $\text{Total} = 165 + 175 + 185 + 195 = 720 \text{ seconds} = 12:00. \text{ Average split} = 720 \div 4 = 180 \text{ s} = 3:00. \text{ Not even: each split was 10 seconds slower than the one before (30 seconds between first and last). Start slower, closer to 3:00 per quarter, and hold it.}$
9. $37 \div 3.1 \approx 11.94 \text{ minutes per mile} \approx 11:56 \text{ per mile. At mile 2: } 2 \times 11.94 \approx 23.9 \text{ minutes} \approx 23:52.$
10. Answers will vary. The heart's stroke volume, the muscles' capillaries and mitochondria, and blood volume all improve over weeks, not days. Bones, tendons and joints adapt even more slowly to the pounding of running, so most injuries come from doing too much too soon. Gradual progress with easy days

lets the body recover and adapt, and keeps the runner healthy and willing to continue.

UNIT CHALLENGE: FOUR-WEEK 5K PLAN, PACING CHART AND FAMILY FITNESS DAY

Follow your four-week run-walk plan from Lesson 5.2, three workouts a week with easy days in between, and log every workout. At the end, run a 5K (3.1 miles) on a measured route at even pace, recording your mile splits and comparing them with your pacing chart. Repeat your morning resting heart rate for a week and your one-minute heart-rate recovery, and compare with Lesson 5.1. Include your plan and notes from the family fitness day, and write a paragraph about what you learned this quarter about caring for the body God gave you.

LOOK FOR	WHAT IT MEANS
Faithful training	Twelve logged workouts (or as many as the plan and weather allowed), with hard-easy spacing and honest talk-test notes.
Pacing chart and splits	A pacing chart with arithmetic shown and actual 5K splits compared with it.
Heart-rate comparison	Morning resting heart rate and heart-rate recovery measured the same way before and after, with the change explained.
Family fitness day and reflection	A clear plan with stations from every unit, notes on how the day went, and a thoughtful reflection on the quarter. Effort and improvement count, not speed.