Exercise Optimized: Training for a Long, Healthy Life

Figures current as of October 2026

How to train for the most health exercise can give: what it buys and how much is enough, how to build aerobic fitness and strength, how to put a routine together and keep it balanced, how to recover and eat for it, what it treats, how it changes across a life, what can go wrong, what to measure, and how to build the week, the year, and the decade. Complete routines to follow are at the back.

MODULE 1 — What Exercise Buys

Goal: Know what training does, how much it takes, and how sure the evidence is.

What training changes in the body; the abilities that predict a long life; the guidelines and how few people meet them; the dose-response curve for minutes, steps, intensity, and timing; whether exercise causes the benefit or healthy people exercise; the hours it costs against the years it buys, worked.

MODULE 2 — Aerobic Fitness: Building the Engine

Goal: Train the strongest single predictor of survival.

Maximal oxygen uptake and what it predicts; how it falls with age and how much genes decide; intensity and how to gauge it; the menu of sessions from easy hours to the Norwegian 4×4; the argument over Zone 2; estimating fitness from a 12-minute run, worked.

MODULE 3 — Strength and Muscle

Goal: Understand muscle as an organ and the dose that builds it.

Muscle, strength, and survival; muscle loss with age; bone and heavy loading; how muscle grows; the dose in numbers, from sets and loads to effort and rest; muscle on the new weight-loss drugs; the argument over heavy lifting for thin bones; one lift's twelve weeks, worked.

MODULE 4 — The Routine: Movement Patterns, Push and Pull, and Balance

Goal: Build a strength routine that covers the body and stays balanced.

The movement patterns every routine covers; what push and pull mean and how to balance them; quadriceps against hamstrings; choosing exercises; building a session; splits compared; whether pulling needs to outweigh pushing; a lopsided week rebalanced, worked.

MODULE 5 — Power, Balance, and Mobility

Goal: Keep the abilities that fail first.

Power and why it fades fastest; balance and falls; what stretching does and does not do; mobility for daily life; a functional check with norms by age, worked.

MODULE 6 — Recovery

Goal: Get the adaptation the training paid for.

How adaptation happens between sessions; overreaching and overtraining; lighter weeks; sleep; heart-rate variability and readiness scores; the recovery industry graded; the argument over cold plunges and saunas; a week of heart-rate data read, worked.

MODULE 7 — Fuel

Goal: Eat to support the training.

Energy, and the cost of eating too little; protein and how to spread it; carbohydrate, fluids, and heat; the supplements with evidence and the ones without; the argument over how much protein; one day's protein for a lifter of 60, worked.

MODULE 8 — Exercise as Medicine

Goal: Know what exercise treats, and how well.

Blood pressure, blood sugar, the heart, cancer, depression, dementia, joints and the back, the lungs, condition by condition with grades; the argument over graded exercise for chronic fatigue; the colon-cancer trial in absolute numbers, worked.

MODULE 9 — Through the Lifespan

Goal: Fit the dose to the stage of life.

Children and teenagers; pregnancy; menopause; old age and frailty; starting from zero; a 70-year-old's first six months, worked.

MODULE 10 — Risk: Injury, the Heart, and Enhancement

Goal: Weigh what can go wrong, and what is sold to speed things up.

How people get hurt and the training-load error; the heart during exercise and at races; the argument over too much endurance; testosterone, steroids, and peptides; a marathon's risk beside a sedentary year's, worked.

MODULE 11 — Measuring

Goal: Track the few numbers that predict.

The tests that matter and how often to take them; what wearables measure well and badly; body composition; the argument over whether wearables make people healthier; a personal baseline in an hour, worked.

MODULE 12 — The Program: A Week, a Year, a Decade

Goal: Put it together and keep doing it.

Weekly plans for 2, 4, 6, and 10 hours; combining strength and endurance; progression, interruptions, and detraining; why people quit and what keeps them; the argument over training beyond the guidelines; the four-hour week, session by session, worked.

MODULE 13 — Where Things Stand, and What to Watch

Goal: Assemble the picture and name what moves next.

The course's argument on a page, the contradictions its evidence leaves open, the dated watch list, and the last word.

A note on evidence and on what this course is. Exercise is a field where a few strong findings sit beside a large industry of weak claims, so the course grades what it reports as settled, probable, contested, or marketing, and Module 1 defines the grades. Where the evidence is in dispute, the course makes each side's case as its advocates make it before giving its own reading. The routines at the back put the modules into practice. The course is education, not medical advice: it describes what studies find on average and cannot know any reader's history, medications, or risks. Anyone with heart, lung, kidney, or metabolic disease, or with symptoms during exertion, should see a clinician before starting a program or moving to vigorous training (Module 9).

The Prescription on One Page

What to Do Each Week, and How Sure the Evidence Is

The course's conclusions as weekly targets, each with its grade (Module 1) and the module that gives the evidence.

Component	Weekly target	Grade	Module
Aerobic, in total	150-300 moderate minutes, or half as many vigorous, or a mix; four to six hours of all exercise, about twice the minimum, captures nearly all the benefit	Settled; probable above the minimum	1, 12
Aerobic, hard	One or two interval or tempo sessions	Probable	2
Aerobic, easy	The rest of the aerobic time, at a pace that allows full sentences	Probable	2
Strength	Every major muscle group on two or more days: one to three hard sets per exercise for health, about ten per muscle for size, heavy loads for strength	Settled	3
Movement patterns	Squat, hinge, single leg, horizontal and vertical push and pull, carry, and trunk bracing, every week	Probable	4
Power	After a few months of strength work, fast lifts, jumps, or fast chair rises, twice a week	Probable	5
Balance	A few minutes most days; after a fall, about three hours a week of challenging balance and strength work	Settled, for falls	5
Mobility	A ten-minute daily sequence; stretching only for a specific need	Probable	5
Daily movement	About 7,000 steps or more, and breaks in long spells of sitting	Probable	1
Recovery	Seven or more hours of sleep; hard sessions for the same muscles about two days apart; a lighter week when fatigue builds	Settled, for sleep	6
Protein	1.2-1.6 grams per kilogram of body weight a day, spread over three or four meals	Probable	7
Measuring	A baseline, then the same tests every three months	Course's practice	11

The Ratios

The balances a routine should keep, counted in weekly hard sets or minutes, not in weights lifted.

Ratio	What it compares	Target	Grade	Module
Push to pull	Hard sets of pushing and pulling exercises, in each plane	At least 1:1; up to 2:1 in favor of pulling for sore shoulders or desk-bound days	Settled for coverage; contested for preventing injury	4
Squat to hinge	Knee-dominant and hip-dominant sets	About 1:1, plus some knee-bending hamstring work	Probable	4
Easy to hard aerobic	Time at each intensity	Mostly easy, with one or two hard sessions; about 80:20 at high volumes	Probable at high volumes; unsettled below four hours	2
Strength to aerobic	Share of weekly exercise time on strength	From over half at two hours a week to about a quarter at ten	Course's synthesis	12
Left to right	Strength of the two sides	Some single-limb work every week, to expose and close gaps	Probable	4
Hard to easy days	The order of the week	The same muscles about two days apart; easy days between hard ones where the week allows	Probable	6, 12

Terms

The Vocabulary of Training

Term	Meaning
1RM (one-repetition maximum)	The heaviest load a person can lift once with good form; loads are often prescribed as a share of it
4×4	An interval session of four 4-minute efforts near maximum heart rate, with 3 minutes easy between them
Cohort study	An observational study: it follows a group of people over time without assigning them a treatment, so it shows associations, not causes
Concurrent training	Aerobic and strength training combined in one program
Deload	A planned lighter period, with fewer sets or lower loads, to let fatigue clear
Double progression	Adding repetitions at a fixed weight until the top of a range is reached, then adding weight and starting again at the bottom
DXA (dual-energy X-ray absorptiometry)	A low-dose scan that measures bone density, fat, and lean mass
Hard set	A set that ends within about three repetitions of failure; the unit in which strength volume is counted
HRmax (maximum heart rate)	The highest heart rate a person can reach, measured or estimated by formula
HRV (heart-rate variability)	The variation in the time between heartbeats, used to gauge recovery
Hypertrophy	Growth of muscle fibers, and so of muscle
Isometric	A contraction in which a muscle holds a position without moving
Lactate thresholds	The two intensities that divide easy from moderately hard effort and moderately hard from very hard effort
MET (metabolic equivalent)	A unit of energy use, set at the rate of sitting quietly
Meta-analysis	A study that pools the results of earlier studies of the same question
Overreaching	A short-term drop in performance from hard training, recovered within days to weeks
Power	Force times speed: the ability to produce force quickly
Randomized trial	A study that assigns people to a treatment or a comparison by chance, so that differences in outcome can be credited to the treatment
RIR (reps in reserve)	The number of further repetitions a person could have done when a set ended
Sarcopenia	The loss of muscle mass and function with age, once it impairs function
Superset	Two exercises done back to back, with rest only after the pair
Systematic review	A review that searches out every study of a question by set rules
VO2 max	Maximal oxygen uptake: the most oxygen the body can take in and use, per kilogram of body weight per minute
Volume	In strength training, hard sets per muscle group per week; in aerobic training, minutes per week
Zone 2	Easy aerobic intensity just below the first lactate threshold

Module 1 — What Exercise Buys

The Dose, the Evidence, and What to Aim For

Recommended Reading / Reference

Book: Daniel E. Lieberman, *Exercised: Why Something We Never Evolved to Do Is Healthy and Rewarding* (2021)

Reference: World Health Organization, *Guidelines on Physical Activity and Sedentary Behaviour* (2020), the evidence tables behind the global recommendations

1a. What Training Does

The body adapts to the demands placed on it, and only to those. A heart asked to pump more blood for long periods grows a larger chamber and beats more slowly at rest. A muscle asked to lift a heavy load adds contractile protein. Bone that is jolted adds mineral, and bone that is spared loses it. Physiologists call this the principle of specificity: the adaptation matches the stress, so a program has to ask for what it wants to build.

The effects come on two clocks: each session acts for hours to a couple of days: blood pressure falls after a workout, and muscle takes up sugar more readily for a day or two. Training repeated over weeks builds the slower changes, such as more mitochondria (the parts of cells that use oxygen to make energy), more capillaries, larger muscle fibers, denser bone, and less fat around the organs. Both kinds fade when training stops, so the habit matters more than any single session.

The result spreads to nearly every system: trained people have lower blood pressure and resting heart rates, better control of blood sugar, healthier blood fats, less inflammation, and better sleep and mood. The course aims at five abilities that carry those benefits and that later modules train one by one: aerobic fitness (Module 2), strength and muscle mass (Modules 3 and 4), power, balance, and mobility (Module 5), and body composition, which follows from the others and from diet.

A note on grades: exercise attracts strong claims on weak evidence, so the course grades what it reports. **Settled** means randomized trials, or evidence so consistent that no serious researcher disputes it. **Probable** means consistent observational evidence with a known mechanism and some supporting trials. **Contested** means the evidence conflicts or the experts disagree. **Marketing** means a claim sold well beyond what the evidence shows.

1b. The Guidelines and Who Meets Them

Intensity is measured in metabolic equivalents (METs), multiples of the energy a person burns sitting quietly. Moderate activity runs from about 3 to 6 METs: brisk walking is about 4, and a person can talk but not sing. Vigorous activity is above 6 METs, such as running or hard cycling, and leaves a person able to say only a few words between breaths. The guidelines count a minute of vigorous activity as two of moderate.

The World Health Organization's 2020 guidelines ask for the following each week.

Group	Aerobic activity	Strength and other
Adults 18-64	150-300 minutes moderate, or 75-150 vigorous, or a mix; more brings additional benefit	Muscle-strengthening work at moderate or greater intensity on 2 or more days

Group	Aerobic activity	Strength and other
Adults 65 and over	The same as adults	Varied multicomponent activity (balance, strength, functional training) on 3 or more days, to keep function and prevent falls
Children and teenagers 5-17	An average of 60 minutes a day of moderate-to-vigorous activity	Vigorous activity and muscle- and bone-strengthening work on 3 days a week
Everyone	Less sitting; no safe limit was set because the evidence was too thin	Some activity is better than none

Source: World Health Organization, 2020. The American Physical Activity Guidelines (second edition, 2018) give the same adult targets; the government's prevention office says the third edition is not expected before 2028.

Few people meet them: worldwide, 31% of adults, about 1.8 billion people, were insufficiently active in 2022, five points more than in 2010, and the World Health Organization projects 35% by 2030 if the trend holds. Women are less active than men (34% against 29% insufficiently active). In the United States, 47.2% of adults met the aerobic guideline in their leisure time in 2024, falling to 38.4% after 65. The latest federal figure for meeting both the aerobic and the strength guideline is 24.2%, from 2020.

1c. How Much Is Enough

The curve that links activity to risk is steep at the start and flat at the end. A 2015 pooled analysis of six cohorts and 661,137 adults by Hannah Arem and colleagues is the standard picture; the table gives its results against people who did no leisure activity.

Activity (multiple of the guideline minimum)	Risk of death against no activity
Some, but below 150 moderate minutes	20% lower
1-2 times (150-300 minutes)	31% lower
2-3 times	37% lower
3-5 times	39% lower; the benefit stops growing
10 times or more	31% lower; no sign of harm

Source: Arem et al., JAMA Internal Medicine, 2015; 116,686 deaths. Observational: these are associations, and Section 1d weighs how much of them exercise causes.

Steps tell the same story: a 2025 analysis of 57 studies that counted steps with devices, led by Melody Ding in *The Lancet Public Health*, compared 7,000 steps a day with 2,000. At 7,000, the risk of death was 47% lower, dementia 38% lower, falls 28% lower, and depressive symptoms 22% lower, while the incidence of cancer did not differ. Most of the gain came by about 5,000 to 7,000 steps. The authors kept 10,000 as a reasonable target for people who already do more.

How the minutes are packed matters less than the total. In 2023 a team at Massachusetts General Hospital used wrist accelerometers worn by 89,573 people in the UK Biobank to compare those who did most of their weekly 150 minutes on one or two days, the weekend warriors, with those who spread them out. Both groups had about the same lower risk of heart attack, heart failure, atrial fibrillation (an irregular heart rhythm), and stroke than inactive people.

Even very short bursts count. In a 2022 study in *Nature Medicine*, Emmanuel Stamatakis and colleagues found that UK Biobank participants who did no formal exercise but had about three bursts a day of vigorous everyday activity, each lasting a minute or two, such as climbing stairs fast or carrying shopping uphill, had about 40% lower risk of death than those with none. That finding is observational and needs trials, but it fits the physiology of intensity.

Sitting is a separate question. In a 2016 analysis of more than a million adults in *The Lancet*, Ulf Ekelund and colleagues found that the higher risk of death linked to sitting more than eight hours a day disappeared among people who also did about 60 to 75 minutes of moderate activity a day. Among heavy television watchers the extra risk shrank but did not vanish. Less sitting helps, but activity does most of the work.

1d. Does Exercise Cause the Benefit?

Almost every number above comes from following people over time rather than from assigning exercise at random, so the question at the base of the subject is whether exercise causes the benefit or healthy people simply exercise.

The case that it does, as most exercise scientists make it. The association holds across hundreds of cohorts, millions of people, and every measure of activity, and it shows a dose-response. The mechanisms are tested in trials: training lowers blood pressure, improves blood sugar and blood fats, and raises fitness in randomized experiments. Trials of hard outcomes agree where they exist. In the LIFE trial (Lifestyle Interventions and Independence for Elders) of 2014, 1,635 sedentary adults aged 70 to 89 were randomized to a structured program or to health education, and major mobility disability fell from 35.5% to 30.1%. In 2025 the CHALLENGE trial (Colon Health and Life-Long Exercise Change) found that structured exercise after treatment for colon cancer lengthened survival (Module 8).

The case that the benefit is overstated, as a group of epidemiologists and twin researchers make it. Illness lowers activity years before it kills, so the sick look inactive, and the associations in large cohorts are strongest in the first years of follow-up, which is the mark of that reverse causation. Genes shape both fitness and health: in a 2025 study of 22,750 Finnish twins followed for decades, the moderately active had only 7% lower mortality than the sedentary, the most active did no better in the long run, and twins who met the guidelines did not outlive their less active co-twins. A 2026 genetic analysis found no causal effect of activity on mortality.

Norway's Generation 100 trial randomized 1,567 people aged 70 to 77 to five years of supervised training or to the national advice. It found no overall effect on deaths, with a trend favoring the interval group that the authors called exploratory: against the advice group, its risk of death was 37% lower, but the plausible range ran from 67% lower to 20% higher.

The evidence between them. Each side's best evidence has a weakness: mortality trials are small for their purpose, and their control groups exercise too, because people who volunteer for exercise trials are active. Genetic analyses of activity rest on weak genetic signals, and twin pairs who differ in activity are few. The cohorts' effect sizes, however, cannot all be causal: a 47% lower risk of death from walking 5,000 more steps a day is larger than any trial has shown.

The course's reading. That exercise improves fitness, function, blood pressure, blood sugar, mood, and the course of several diseases is settled by trials. That it extends life is probable, but the true effect is likely a fraction of the 30-50% the cohorts suggest. The practical conclusion is the same either way: train for fitness and function, which trials show exercise changes, and read the lifespan numbers as an upper bound.

1e. The Hours and the Years

Worked example — The hours it costs against the years it buys

A 45-year-old who trains four hours a week until 80 spends 4 × 52 × 35 = 7,280 hours, about 300 days, or 0.83 years. A 2017 review of running cohorts by Duck-chul Lee and colleagues estimated that runners live about three years longer than non-runners, with the gain capped near that figure however much they run. If that holds, the return is about 3.6 years of life for every year spent training. If, as Section 1d suggests, only half of the cohort effect is real, the return is still about 1.8 to one, before counting years of better function, such as the mobility disability the LIFE trial prevented. The hours are also not lost: they are spent walking, riding, lifting, or playing, and many people enjoy them. The arithmetic turns against more training only at volumes far above this course's targets, where the extra hours buy little extra life (Module 12).

Module 1 Key Points

What Exercise Buys

• The body adapts only to what it is asked to do, and the effects fade within weeks, so the habit matters more than any session.

• Guidelines ask for 150-300 moderate minutes a week plus strength work twice; about a quarter of American adults do both.

• Most of the gain comes early: about 7,000 steps a day or the guideline minimum captures most of the lower risk.

• Packing activity into one or two days, or into minute-long bursts, appears to work about as well as spreading it out.

• Exercise's effects on fitness and function are settled; its effect on lifespan is probable but smaller than cohort studies suggest.

Module 1 Quiz

Check Your Understanding

1. What do the World Health Organization's 2020 guidelines ask of adults each week?

A) 150-300 moderate minutes, plus strength work twice
B) 10,000 steps on most days
C) 60 minutes of vigorous activity every day, with strength work on any three of them
D) 300 minutes of vigorous activity, with stretching and strength work on each of the other days

2. In the 2025 analysis of 57 step-count studies, how did 7,000 steps a day compare with 2,000?

A) No difference once age was counted
B) Only the risk of cancer fell
C) Benefits appeared only above 10,000 steps, the long-standing popular target
D) The risk of death was about 47% lower

3. In the 2023 UK Biobank study, how did weekend warriors compare with people who spread their 150 minutes over the week?

A) Higher heart-rhythm risk than inactive people
B) About the same lower risk
C) Half the benefit of the daily exercisers
D) Benefit only when every session was vigorous

4. Why do studies of twins carry weight in the argument over whether exercise extends life?

A) Twins exercise more than other people
B) Twin studies are randomized trials
C) Twins share genes, so comparing a more active twin with a less active co-twin separates exercise from the genes that shape both fitness and health
D) Twins live longer, so the effect of exercise on lifespan is easier to measure in them

5. What did Norway's Generation 100 trial in adults aged 70 to 77 find?

A) Deaths halved among those who trained
B) No clear effect on deaths
C) More deaths among those assigned to interval training
D) Fewer deaths only among those who walked every day for an hour

Module 2 — Aerobic Fitness: Building the Engine

The Strongest Predictor, and How to Train It

Recommended Reading / Reference

Book: Alex Hutchinson, *Endure: Mind, Body, and the Curiously Elastic Limits of Human Performance* (2018)

Reference: Kaminsky and colleagues, "Updated Reference Standards for Cardiorespiratory Fitness Measured with Cardiopulmonary Exercise Testing: Data from the Fitness Registry and the Importance of Exercise National Database (FRIEND)," *Mayo Clinic Proceedings* (2022)

2a. What VO2 Max Is

Aerobic fitness is measured as maximal oxygen uptake (VO2 max): the most oxygen the body can take in and use in a minute of all-out effort, expressed per kilogram of body weight. It is set by how much blood the heart can pump, which is heart rate times the volume of each beat, and by how much oxygen the muscles can pull out of that blood. Training raises both, but mostly the volume of each beat.

Fitness is often quoted in METs: since one MET is about 3.5 milliliters of oxygen per kilogram per minute, a VO2 max of 35 is a capacity of 10 METs. The table gives the median for American adults who were tested on a treadmill in the FRIEND registry, the largest reference set in the United States, with the 90th percentile beside it.

Age	Men: median	Men: 90th percentile	Women: median	Women: 90th percentile
20-29	46.5	58.6	36.6	49.0
30-39	39.7	55.5	28.3	42.1
40-49	35.3	50.8	25.7	37.8
50-59	29.2	43.4	22.9	32.4
60-69	24.6	37.1	19.6	27.3
70-79	20.6	29.4	17.2	22.8
80-89	17.6	22.8	15.4	20.8

VO2 max in milliliters of oxygen per kilogram per minute, measured on a treadmill. Source: FRIEND registry reference standards, Kaminsky et al., Mayo Clinic Proceedings, 2022. Cross-sectional: each row is a different group of people.

Fitness falls with age even in people who keep training, but not at a steady rate. In the Baltimore Longitudinal Study of Aging, which retested 810 healthy adults over years, peak oxygen uptake fell 3-6% a decade in the twenties and thirties and more than 20% a decade from the seventies on. Active people declined too, but from a higher level, so at every age they were fitter than the inactive. Training does not stop the slope; it lifts the whole curve.

2b. What It Predicts

No single measure predicts survival as strongly: a 2024 overview in the *British Journal of Sports Medicine*, led by Justin Lang, gathered 26 meta-analyses covering 199 cohorts and more than 20.9 million observations. People with high fitness had about half the risk of death of those with low fitness, and each

one-MET step up in fitness went with an 11-17% lower risk. The risk of heart failure was 69% lower in the fittest group.

Clinic data show the same gradient at the top. Of 122,007 patients who took treadmill tests at the Cleveland Clinic between 1991 and 2014, those in the lowest quarter of fitness for their age and sex died at five times the rate of the elite, the top 2.3%. Being below rather than above average for fitness carried about the same extra risk as smoking or diabetes. The authors found no level of fitness above which the benefit stopped.

A 2022 study of 750,302 American veterans aged 30 to 95, followed for a median of ten years, agreed. The least fit fifth had about four times the risk of death of the fittest 2%, the pattern held for women, older people, and every racial group, and extreme fitness showed no sign of extra risk. The caveat from Module 1 applies with special force here: fitness reflects genes and health as well as training, so it predicts more strongly than training alone can change.

2c. Genes and Trainability

People differ in how much they gain from the same program. In the HERITAGE Family Study (Health, Risk Factors, Exercise Training and Genetics) of 1999, 481 sedentary adults from 98 families did the same 20 weeks of supervised cycling. Their average gain in VO2 max was about 400 milliliters a minute, but individuals ranged from almost nothing to more than a liter, and gains clustered in families. About half of the difference in response appeared to be inherited.

A smaller response is not no response: in a 2017 trial, David Montero and Carsten Lundby put 78 adults through six weeks of training at one to five hour-long sessions a week. The share who failed to improve their peak power fell from 69% at one session to 40% at two, 29% at three, and none at four or five. The non-responders then added two sessions a week for six more weeks, and every one of them improved. The answer for a slow responder is more training, not a different body.

2d. Intensity and How to Gauge It

Intensity is anchored by two thresholds: below the first, roughly the hardest pace at which a person can still speak in full sentences, the body clears lactate as fast as it makes it, and effort can last for hours. Above the second, roughly the hardest pace a person could hold for about an hour, lactate builds until the effort has to stop. Watches split the same range into five heart-rate zones, of which Zone 2 sits just below the first threshold.

Heart-rate zones need a maximum heart rate, and the familiar formula of 220 minus age misleads older people. A 2001 analysis of 351 studies by Hirofumi Tanaka found that 208 minus 0.7 times age fits better: at 70 the old formula gives 150 beats a minute and the newer one 159. Individuals scatter about ten beats either way around any formula, so a measured maximum, or a scale of perceived effort, is more reliable.

Effort	Talk test	Approximate % of maximum heart rate	Perceived effort (0-10)	Examples
Easy (below the first threshold; Zones 1-2)	Full sentences	60-75%	2-4	Brisk walk, easy cycle or jog
Comfortably hard (between thresholds; Zones 3-4)	A few words at a time	80-88%	5-7	Tempo run, steady climb
Very hard (above the second threshold; Zone 5)	A word or two	90-100%	8-10	Intervals, sprints

The percentages are approximate and vary between people; the talk test and perceived effort track the thresholds more closely than a formula does.

2e. The Session Menu

A small number of session types covers almost every program. They differ in how long the effort lasts and how hard it is, and the evidence on each is below.

Session	How	What it trains
Easy	30-90 minutes in the easy range	Builds volume and the heart's stroke volume with little fatigue; can be done most days
Long	60-120 minutes easy, once a week	Endurance and the muscles' use of fat
Tempo	20-40 minutes comfortably hard, or 3 × 10 minutes	Raises the thresholds, so a faster pace stays sustainable
4×4	4 minutes at 90-95% of maximum heart rate, 3 minutes easy, four times, after a warm-up	The largest gains in VO2 max per minute in the trials that compare intervals
30-30s	30 seconds hard, 30 seconds easy, repeated 10-20 times	VO2 max, with less discomfort than long intervals
Sprints	Three to six all-out efforts of 20-30 seconds, with 2-4 minutes easy between	Fitness and blood-sugar control in very little time

The case for intervals rests on trials that hold total work constant. In a Norwegian study led by Jan Helgerud, 40 young men trained three times a week for eight weeks with one of four programs matched for work. VO2 max rose by roughly 5-8% in the 4×4 group and in a group doing 15-second intervals, and by less in the groups that ran steadily at easy or threshold pace. In a 2016 trial at McMaster University, three 20-second sprints, ten minutes a session with warm-up, raised fitness 19% in twelve weeks, the same as 45 minutes of steady cycling, and improved insulin sensitivity at least as much, in a fifth of the time.

Elite endurance athletes train differently from these trials: they spend about 80% of their sessions at easy intensity and the rest hard, a pattern Stephen Seiler documented in rowers, skiers, and runners. That split lets them train ten or more hours a week without breaking down. Whether it beats other mixes for people training three or four hours a week is unsettled, because the comparisons have mostly been run in athletes.

2f. Is Zone 2 Special?

The case for Zone 2, as its advocates make it. The physiologist Iñigo San Millán and the physician Peter Attia, among others, define Zone 2 as the highest effort at which blood lactate stays low and the body burns the most fat. Training there, they argue, builds the mitochondria of the slow-twitch muscle fibers, improves the clearance of lactate and the use of fat, and so repairs the metabolic flexibility that diabetes and inactivity destroy. They point to elite athletes, who do most of their training at that effort, and Attia recommends about three hours a week of it as the base of a program built for long life.

The case against its special status, as its critics make it. A 2025 review in *Sports Medicine* by Kristi Storoschuk, Martin Gibala, Brendon Gurd, and colleagues, titled "Much Ado About Zone 2," found the zone defined in incompatible ways, by lactate, by heart rate, or by talk. It found no good evidence that Zone 2 is the best intensity for building mitochondria or raising VO2 max in the general population. Higher intensities produced similar or larger gains, usually in less time, and in trained people Zone 2 alone may not raise VO2 max at all.

The evidence between them. The trials that compare intensities at equal work favor intervals for VO2 max. Zone 2's real advantage is that it can be done in large amounts without much fatigue or injury, which is why athletes use it. The elite pattern pairs those easy hours with hard sessions and very high volume, so it cannot show that easy training alone does the work.

The course's reading. Easy aerobic training is valuable mainly as the way to accumulate volume safely; it is not uniquely potent. A person with two or three hours a week gets more fitness per minute by spending part of them hard. The best plan for most people is plenty of easy time with one or two hard sessions a week (Module 12 builds the week).

2g. Estimating Your VO2 Max

Worked example — A 12-minute run, then three weekly plans

In the Cooper test, devised for the US Air Force in 1968, a person covers as much distance as possible in 12 minutes on a flat course. Estimated VO2 max is the distance in meters minus 504.9, divided by 44.73. A 50-year-old man who covers 2,400 meters scores (2,400 − 504.9) ÷ 44.73 = 42.4, which is 12.1 METs. Against the table in Section 2a, that sits far above the median of 29.2 for his decade and near the 90th percentile of 43.4. A 50-year-old woman who covers 1,800 meters scores 29.0, above her decade's median of 22.9. The test is all-out, so a sedentary or high-risk person should start with brisk walking for a few weeks, or use a walk test, before running it. Gaining two METs would, on the 2024 overview's figures, go with a risk of death about 21-31% lower (0.89 squared and 0.83 squared), if the association were all causal; Module 1 explains why it is not. Three weekly plans that apply this module: with 90 minutes, two 4×4 sessions of about 35 minutes with warm-up and one easy 20-minute session; with 150 minutes, one 4×4 session and three easy sessions of about 40 minutes; with 300 minutes, one interval session, one tempo session, three easy sessions, and a long one of 75 to 90 minutes. Retest every three months (Module 11).

Module 2 Key Points

Aerobic Fitness: Building the Engine

• VO2 max predicts survival more strongly than most risk factors; in a 2024 overview the fittest had about half the death rate.

• Fitness falls with age, slowly at first and faster after 70; training lifts the whole curve rather than stopping the slope.

• Nearly everyone responds to a high enough dose: in a 2017 trial, every non-responder improved after adding two sessions a week.

• Intervals such as the 4×4 raise VO2 max more per minute than easy training; easy hours add volume with little fatigue.

• Zone 2 is useful but not uniquely potent: combine plenty of easy time with one or two hard sessions a week.

Module 2 Quiz

Check Your Understanding

1. In the 2024 overview of 199 cohorts, how did the risk of death compare between the most and least fit?

A) The most fit had about half the risk
B) A tenth lower
C) No difference after age
D) The most fit had a higher risk of sudden death during exercise

2. What did Montero and Lundby's 2017 trial show about people who did not improve on one to three sessions a week?

A) They carried a gene that blocks training
B) They improved only with strength training
C) Their fitness fell when sessions were added
D) They all improved once they added two more sessions a week, so the dose, not their genes, was the problem

3. Which formula estimates maximum heart rate better in older adults than 220 minus age?

A) 200 − age
B) 226 − age for women and 220 − age for men
C) 208 − 0.7 × age
D) 180 minus half of age, rounded to the nearest five

4. What did the 2016 McMaster sprint-interval trial find?

A) No change in fitness
B) Similar fitness gains in a fifth of the time
C) Larger gains for the continuous group in every measure taken
D) Better insulin sensitivity only for the men who cycled steadily for 45 minutes

5. What did the 2025 review "Much Ado About Zone 2" conclude?

A) Zone 2 harms the heart
B) Zone 2 should replace all interval training
C) Zone 2 is the only intensity that builds mitochondria
D) Zone 2 is useful, but the evidence does not show it beats higher intensities for mitochondria or VO2 max

Module 3 — Strength and Muscle

Muscle as an Organ, and the Dose That Builds It

Recommended Reading / Reference

Book: Brad J. Schoenfeld, *Science and Development of Muscle Hypertrophy* (second edition, 2020)

Reference: American College of Sports Medicine, "Resistance Training Prescription for Muscle Function, Hypertrophy, and Physical Performance in Healthy Adults: An Overview of Reviews," *Medicine & Science in Sports & Exercise* (2026)

3a. Muscle, Strength, and Survival

Skeletal muscle makes up nearly two-fifths of body weight in men and about three-tenths in women, and it does far more than move the skeleton. When insulin is raised in laboratory tests, muscle takes up most of the glucose cleared from the blood, so more muscle, and better-trained muscle, helps keep blood sugar under control. Working muscle also releases signaling molecules, called myokines, that act on fat, the liver, bone, and the brain, which is one way exercise reaches organs it does not move.

The evidence that strength work protects health is younger than the evidence for aerobic exercise, but it points the same way. A 2022 meta-analysis in the *British Journal of Sports Medicine*, led by Haruki Momma, pooled 16 cohort studies and found that people who did any muscle-strengthening activity had a 15% lower risk of death than those who did none, 17% lower risks of cardiovascular disease and of diabetes, and a 12% lower risk of cancer. Most of the reduction, 10-20% depending on the outcome, came at 30 to 60 minutes a week. Beyond an hour the benefit shrank without turning into harm, and above about two and a quarter hours the data were too thin to judge.

The two kinds of exercise add up: in the same analysis, people who did both muscle-strengthening and aerobic activity had a 40% lower risk of death than people who did neither. The authors rated the certainty of all this evidence very low, because the studies were observational and mostly relied on people's own reports of their training, so these figures carry the same caution as the aerobic ones in Module 1.

Strength itself predicts survival: the Prospective Urban Rural Epidemiology (PURE) study measured the grip strength of 139,691 adults aged 35 to 70 in 17 rich and poor countries and followed them for a median of four years. Each 5 kilograms less grip went with a 16% higher risk of death and a 17% higher risk of cardiovascular death, and grip predicted both more strongly than systolic (upper) blood pressure did. Grip is a marker of overall strength and health rather than a target in itself: squeezing a hand gripper will not buy the years that a strong body predicts.

3b. Losing Muscle with Age

Comparisons of young and old adults put the average loss of muscle at about 0.4-0.5% a year across adult life, and long-term studies show it speeding up in old age; when the loss is advanced enough to impair function, it is called sarcopenia. Strength falls faster than mass: in a 2012 review of the long-term studies, people of 75 lost 0.64-0.70% of their muscle mass a year if they were women and 0.80-0.98% if men, but 2.5-3% and 3-4% of their strength.

Where the same people were measured both ways, strength fell two to five times faster than mass, because muscle also loses quality: the nerves that drive it die back, the fast-twitch fibers that produce force and

speed shrink first, and fat infiltrates the tissue. The review found that the loss of strength predicted disability and death more consistently than the loss of muscle, which is why researchers increasingly measure strength, not just mass. Inactivity, too little protein, and spells of illness or bed rest, which strip muscle quickly and are regained slowly, all speed the decline.

None of this is fixed: in a 1990 study, Maria Fiatarone and colleagues put ten frail nursing-home residents with an average age of 90 on eight weeks of high-intensity training of the thigh muscles. The nine who finished increased their strength by an average of 174%, the area of muscle at mid-thigh by 9%, and their walking speed in a heel-to-toe test by 48%. Larger trials since have confirmed that heavy training builds strength and function at any age when it is supervised and progressed gradually, so the dose in this module applies to older adults as well as the young.

3c. Bone and Loading

Bone is living tissue that is constantly broken down and rebuilt, and like muscle it responds to the strain placed on it. What builds bone is high or sudden load, from heavy lifting, jumping, and impact, which bends the bone very slightly and signals it to add mineral where the strain is greatest. Activities that carry the body without jolting it, such as swimming and cycling, do little for bone, and walking does less for it than for the heart.

The skeleton reaches its peak mass in early adulthood and loses it gradually afterward, quickly in the years after menopause, so the aim in adulthood is to slow the loss and, where possible, to reverse some of it. The changes that training produces in bone density are small in percentage terms, a few percent at most, because bone turns over slowly. They matter because the alternative is steady loss, and because the same training builds the strength and balance that prevent falls, which cause most fractures outside the spine (Module 5). Section 3g weighs the trials of heavy loading in people whose bones are already thin, from low bone mass to osteoporosis, in which bone is thin enough to break easily.

3d. How Muscle Grows

Muscle grows in response to tension: when a fiber contracts hard against a load, sensors in it set off signals that raise the rate at which it builds new protein, and the rate stays raised for a day or more. Repeated over weeks, building outpaces breakdown and the fibers thicken; eating protein adds to the response, and Module 7 covers how much and when.

The nervous system recruits fibers in order of size. A light effort uses only the small, slow-twitch fibers, and as effort rises, or as fatigue sets in during a set, it calls up the larger fast-twitch fibers, which have the most capacity to grow and are the first to be lost with age. This is why a light weight lifted until the last repetitions are a struggle can build muscle about as well as a heavy one: by the end of the set, the same fibers are working.

Strength rises faster than size at first. In the first weeks of training most of the gain comes from the nervous system learning the movement, by recruiting more fibers at once, firing them faster, and coordinating the muscles around the joint, while growth takes several weeks to show. Strength is also specific: it rises most in the movement trained, at the load and speed trained, which is why a program aimed at daily life includes the movements of daily life (Module 4).

3e. The Dose in Numbers

In 2026 the American College of Sports Medicine (ACSM) published its first major update on resistance training in 17 years, an overview of 137 systematic reviews covering more than 30,000 people. The table gives its recommendations for healthy adults, with the course's ranges for the details it leaves open; the evidence behind each lever follows. Load is given as a share of the one-repetition maximum (1RM), the most a person can lift once with good form, and effort as reps in reserve, the number of further repetitions a person could have done when the set ended.

Goal	Load	Sets	Effort	Rest between sets	Sessions a week
Health minimum	Moderate to heavy: 8-15 repetitions	1-3 per exercise, one exercise or more for each major muscle group	1-3 reps in reserve	1-2 minutes	2, covering every major muscle group
Strength	About 80% of 1RM or more: roughly 3-8 repetitions	2-3 per exercise	1-3 reps in reserve; rarely to failure	2-3 minutes or more	2-3 for each main lift
Muscle size	Anything from about 30% to 85% of 1RM: roughly 6-30 repetitions	About 10 per muscle group a week; more adds a little	0-3 reps in reserve	More than a minute; 1.5-3 minutes is typical	2 or more for each muscle group
Power	30-70% of 1RM, lifted as fast as possible	2-3 sets of 3-6 repetitions	Stop while the speed holds, well short of failure	2-3 minutes	2
Maintenance	Keep the load heavy	About a third of the building dose	1-3 reps in reserve	As above	1 for younger adults; 2 for older adults

Frequency, the strength load and sets, the weekly sets for size, and the power load are the ACSM's 2026 recommendations; the other cells are the course's synthesis of the evidence in this section. The health minimum is the amount linked to the lowest risk in Section 3a.

Volume, counted as hard sets per muscle group per week, is the strongest lever for size. A 2017 meta-analysis by Brad Schoenfeld and colleagues found a graded response: muscle grew about 5.4% in programs with fewer than five weekly sets, 6.6% with five to nine, and 9.8% with ten or more. A 2026 analysis of 67 studies and 2,058 people in *Sports Medicine* found that both size and strength kept rising with volume, with diminishing returns that set in much sooner for strength. It counted a set that works a muscle indirectly, such as the triceps in a bench press, as half a set, the convention this course follows.

Load matters less for size than was long believed. A 2017 meta-analysis of 21 studies by Schoenfeld's group found that light loads, at or below 60% of 1RM, built about as much muscle as heavy ones when sets were taken to or near failure, but heavy loads built more maximal strength. Loads down to about 30% of 1RM have worked in trials, and below that the evidence is thin. Light loads cost more repetitions and more discomfort per set, but they spare the joints, which makes them useful for older or injured people and for exercises where heavy loads are awkward.

How close a set comes to failure matters more for size than for strength. A 2024 analysis by Zac Robinson and colleagues found that muscle growth increased as sets ended closer to failure, while strength gains were similar across a wide range of efforts. The ACSM found that training to complete failure did not consistently improve results, which is compatible: sets need to end close to failure, but reaching it adds little and costs extra fatigue.

Rest and frequency are the smaller levers: a 2024 meta-analysis found that resting longer than a minute between sets produced slightly more growth than shorter rests, with little difference beyond about 90 seconds; heavy lifts that use several large muscles usually need longer to repeat good sets. Once weekly volume is equal, the 2026 analysis found the number of sessions had a negligible effect on size and a modest one on strength, so training each muscle at least twice a week mainly makes the volume easier to fit (Module 4 compares the ways of splitting it).

The minimum dose is small: a 2020 meta-analysis found that in men who already trained, a single set of 6 to 12 repetitions at about 70-85% of 1RM, two or three times a week for eight to twelve weeks, still raised their maximum. Keeping gains takes less than making them: in a 2011 trial by Scott Bickel and colleagues, 70 adults trained three days a week for 16 weeks and then either stopped or cut their weekly dose to a third or a ninth. Strength held up well for the next 32 weeks, even in those who stopped, but only the young kept their new muscle size on the reduced doses, so the authors concluded that older adults need more weekly loading to keep it.

3f. Muscle on the New Weight-Loss Drugs

The drugs that copy the gut hormone glucagon-like peptide-1 (GLP-1), such as semaglutide (Wegovy, Ozempic) and tirzepatide (Zepbound, Mounjaro), which also acts on a second gut hormone, produce weight losses of 15-20% or more. In the 2021 trial that led to semaglutide's approval for obesity, about two-fifths of the weight lost in the subgroup that was scanned was lean mass, which raised fears that the drugs strip muscle along with fat.

Lean mass, however, is everything that is not fat: muscle, but also organs, water, and stored carbohydrate, all of which shrink as a body gets smaller. Dieting alone typically takes about a quarter of lost weight from lean tissue. The question is whether the drugs take more muscle than the weight loss itself requires, and whether the muscle that remains works less well.

A study published in *Cell Reports Medicine* in March 2026, by researchers at the Charité hospital in Berlin and the University of California, Davis, found that they do not. In obese mice, semaglutide and tirzepatide did not cause a disproportionate loss of muscle, and strength relative to body weight rose. In a 12-week pilot in about ten adults with type 2 diabetes who took semaglutide, fat made up about 70% of the weight lost, and the strength of the thigh and of the grip did not decline. Only male mice were studied, and the human pilot was small, short, and did not include older or frail patients, so the findings reassure without settling the question.

Drug makers are testing ways to protect muscle directly. In the BELIEVE trial, published in *Nature Medicine* in March 2026, 507 adults with obesity received bimagrumab, an experimental antibody that blocks signals that limit muscle growth, alone or with semaglutide. At its highest dose the combination cut body weight by 22.1%, against 15.7% with semaglutide alone, and more than nine-tenths of the weight it removed was fat. Bimagrumab alone cut weight by 10.8% while raising lean mass, but it caused muscle spasms and acne, and it remains experimental. For anyone losing weight on these drugs now, the means at hand are the ones in this module and Module 7: train every muscle group at least twice a week, and eat enough protein, which matters more while eating less.

3g. Should People with Thin Bones Lift Heavy?

The case for heavy loading, as its researchers make it. The LIFTMOR trial (Lifting Intervention For Training Muscle and Osteoporosis Rehabilitation), published in 2018 by Belinda Beck's group at Griffith University in Australia, randomized 101 postmenopausal women with low bone mass, average age 65, to eight months of twice-weekly 30-minute supervised sessions or to a light home program. After a month of technique work, the lifting group did deadlifts, overhead presses, and back squats for five sets of five repetitions at over 80-85% of 1RM, plus jumping chin-ups with drop landings. Spine bone density rose 2.9% in the lifting group and fell 1.2% in the home group, and the thigh bone's neck rose 0.3% against a fall of 1.9%.

The lifters also gained more in leg and back strength, rising from a chair, and jumping, and they lost no height while the home group lost a little. In eight months there was one injury, a mild back strain on the last deadlift repetition that cost two sessions, and no fractures. A companion trial in 93 men over 45 with low bone mass, LIFTMOR-M, found the cortex of the thigh bone's neck thickened 5.6% with the same program while it was unchanged in controls. The UK consensus on exercise for osteoporosis, published in 2022 under the title "Strong, Steady and Straight," now recommends strength training on two or three days a week, building up to the most a person can lift 8 to 12 times for three sets. It adds impact exercise on most days, at least 50 impacts per session for those without spinal fractures, and it teaches safe lifting technique instead of setting weight limits.

The case for caution, as many clinicians make it. Fractures of the vertebrae are the most common osteoporotic fractures, and they can follow lifting or bending forward under load, so guidance for people with osteoporosis long stressed avoiding heavy lifting and loaded forward bending. The trials of heavy loading are small and short, recruited screened volunteers, and ran under close supervision by specialists, a setting most people will not have. None has been large enough to show fewer fractures, the outcome that matters, and a bone-density gain of 3% is not proof that bones break less.

The evidence between them. Under supervision, heavy training raised bone density and function in people with thin bones, and injuries were rare, but its effect on fractures is untested. The advocates of heavy loading agree on one form of caution: the UK consensus still advises against movements that bend the spine forward to its end range, repeatedly, or under load, such as sit-ups and toe touches with weights. Because strength and balance training also prevents falls (Section 3c), the case for training of some kind holds whatever the bone density.

The course's reading. Probable: for people with low bone mass who have been assessed and taught to lift, progressive heavy training is likely to help bone and function, and its risk under supervision appears low. People with spinal fractures or very low bone density should start under a physiotherapist or in a supervised program, and everyone with thin bones should avoid loaded forward bending of the spine.

3h. One Lift's Twelve Weeks

Worked example — Double progression on the goblet squat

A 55-year-old woman new to lifting does the goblet squat, holding a dumbbell at her chest, twice a week, for three sets of 8 to 12 repetitions, each set ending with about two in reserve. The method is double progression: add repetitions at a fixed weight until all three sets reach the top of the range, then add the smallest available step of weight and drop back to the bottom. In week 1 she lifts 12 kilograms for 8, 8, and 8. By week 4 she manages 12, 12, and 11, and in week 5 she completes 12 in all three sets, so she moves to 14 kilograms and drops back to 8. She reaches 12, 12, and 12 at 14 kilograms in week 8, moves to 16, and in week 12 lifts 16 kilograms for 11, 10, and 10. A common estimate of the maximum, the Epley formula, multiplies the weight by one plus the repetitions possible divided by 30; counting the two in reserve, she could have done 10 repetitions with 12 kilograms at the start and 13 with 16 at the end. Her estimated maximum rose from 12 × (1 + 10 ÷ 30) = 16.0 kilograms to 16 × (1 + 13 ÷ 30) = 22.9 kilograms, a gain of about 43% in twelve weeks, much of it from the nervous system learning the movement. The jumps in dumbbell weight are large, 2 kilograms being 17% of 12, which is why the method climbs through repetitions before it adds weight. The lift gives her six weekly sets for the front of the thighs; a lunge or step-up done twice a week for two sets brings her to the ten in the table. When she stalls for three sessions in a row, the remedies are, in order, better sleep (Module 6), a lighter week, and then a different range of repetitions or a variation of the lift.

Module 3 Key Points

Strength and Muscle

• Muscle-strengthening work of 30-60 minutes a week went with 10-20% lower risks; grip strength predicted death better than blood pressure.

• Strength falls two to five times faster than muscle mass in old age, yet frail 90-year-olds nearly tripled their strength in eight weeks.

• For size, volume leads: about 10 hard sets per muscle a week, with any load from about 30% of maximum if sets end near failure.

• Heavy loads, around 80% of maximum, build the most strength; gains can be kept on about a third of the building dose.

• GLP-1 drugs take some lean mass with the fat, but recent studies find no disproportionate loss of muscle or strength.

• Heavy, supervised lifting raised spine bone density in women with low bone mass; whether it prevents fractures is untested.

Module 3 Quiz

Check Your Understanding

1. In the 2022 meta-analysis of 16 cohort studies, how much weekly muscle-strengthening activity went with most of the reduction in risk?

A) About 30-60 minutes
B) At least three hours, with more always better
C) Any amount, as long as it was done every single day
D) Only sessions of an hour or more done with heavy weights

2. What did the LIFTMOR trial find in postmenopausal women with low bone mass?

A) Heavy lifting caused several spinal fractures
B) Light home exercise worked just as well
C) Heavy lifting raised spine bone density, with one minor injury in eight months
D) Bone density rose only in women who also took calcium and vitamin D, and fell in the rest of the group

3. According to the 2017 meta-analysis of 21 studies, how do light loads compare with heavy loads for building muscle?

A) Light loads build no muscle
B) Similar growth if sets end near failure
C) Heavy loads build about twice as much muscle, whatever the effort
D) Light loads build more muscle and more strength in every group studied

4. What happened when frail nursing-home residents with an average age of 90 trained their thighs for eight weeks in a 1990 study?

A) The training proved unsafe at their age and was stopped early
B) Their muscle grew, but strength did not, because nerves stop adapting after 85
C) Their strength rose by 174%
D) Only the residents who could already walk unaided gained any strength

5. What did the March 2026 study in Cell Reports Medicine conclude about GLP-1 drugs and muscle?

A) Lean mass fell faster than fat
B) Grip strength fell by half in twelve weeks
C) Most of the weight lost was muscle, so resistance training during treatment cannot help
D) They did not cause a disproportionate loss of muscle mass or strength

Module 4 — The Routine: Movement Patterns, Push and Pull, and Balance

Covering the Body and Keeping It in Proportion

Recommended Reading / Reference

Book: Eric Helms, Andy Morgan, and Andrea Valdez, *The Muscle and Strength Pyramid: Training* (second edition, 2019)

Reference: National Strength and Conditioning Association, *Essentials of Strength Training and Conditioning*, edited by G. Gregory Haff and N. Travis Triplett (fourth edition, 2016)

4a. The Movement Patterns

A strength routine is easiest to build from movements rather than muscles. Nearly every exercise is a variation of a handful of patterns, and a week that trains each of them works every major muscle group in the combinations that daily life and sport demand. The table lists the patterns, with a version to start with at home, a gym version, and a way to make each harder.

Pattern	Main muscles	Home or starting version	Gym version	Harder
Squat (knee-dominant)	Front of the thighs, buttocks	Sit-to-stand from a chair; goblet squat with a dumbbell or loaded backpack	Back or front squat; leg press	More load; a pause at the bottom
Hinge (hip-dominant)	Buttocks, hamstrings, back extensors	Hip bridge; Romanian deadlift with a dumbbell or kettlebell	Deadlift; Romanian deadlift; hip thrust	Single-leg Romanian deadlift; heavier pulls
Single leg	Thighs, buttocks, and balance	Step-up onto a low step; split squat holding a support	Walking lunge; split squat with the rear foot raised	Higher step; added load
Horizontal push	Chest, front of the shoulders, triceps	Push-up against a wall, then a bench, then the floor	Bench press; dumbbell press; chest-press machine	Feet raised; added load
Vertical push	Shoulders, triceps	Pike push-up; dumbbell or band press overhead	Overhead press, standing or seated	More load; one arm at a time
Horizontal pull	Upper back, rear of the shoulders, biceps	Band row; inverted row under a sturdy table	Seated cable row; one-arm dumbbell row; chest-supported row	Inverted row with the feet raised; heavier rows
Vertical pull	Latissimus dorsi, biceps	Band pulldown; pull-up with a band or a foot on a chair for help	Lat pulldown; pull-up	Pull-up with added weight
Carry	Grip, trunk, shoulders	Carrying shopping bags or dumbbells	Farmer's carry with both hands; suitcase carry with one	Heavier and longer
Trunk bracing	Abdominals, obliques, back extensors	Plank; side plank; dead bug; bird dog	Cable press-out (resisting rotation); ab wheel	Longer holds; longer levers

The latissimus dorsi are the broad muscles at the sides of the back. Each pattern has many more variations; any that fits the pattern and can be loaded progressively will serve.

The patterns overlap: a squat trains the hips as well as the thighs, and a row trains the biceps as well as the back. That is why a routine built on them needs little isolation work for health, and why curls, calf raises, and the like are optional extras rather than the base.

4b. Push and Pull

Push and pull describe the direction of force: a pushing exercise moves a load away from the body, or the body away from a surface, as in a push-up, a bench press, or an overhead press; it trains the chest, the front of the shoulders, and the triceps. A pulling exercise draws a load toward the body, or the body toward a bar, as in a row, a pull-up, or a pulldown; it trains the upper back, the latissimus dorsi, the rear of the shoulders, and the biceps. Each comes in two planes, horizontal and vertical, and a balanced routine covers all four.

The ratio of push to pull compares weekly hard sets, not the weights lifted. The loads a person can press and pull differ for mechanical reasons, and there is no established normal ratio between them, so matching weights is not the aim. A ratio of 1:1 means as many pulling sets as pushing sets; 2:1 in favor of pulling means twice as many. Sets are counted by the pattern they train, so a biceps curl is not a pulling set and a triceps extension is not a pushing one.

Gym routines drift toward pushing: the bench press is the lift people ask about, the chest and arms are the muscles in the mirror, and pressing is easy to load, while the upper back is out of sight. The cost is a gap in coverage, since pressing does little for the muscles of the upper back, and, many clinicians argue, a higher risk of shoulder pain; Section 4g weighs that argument.

4c. Front and Back of the Legs

The legs have their own balance: squats and lunges load the quadriceps at the front of the thigh heavily, while the hamstrings at the back do most of their work in hinges and in bending the knee, so a routine that squats but never hinges leaves them undertrained. A balanced week has about as many hinge sets as squat sets, plus some work in which the hamstrings bend the knee, such as a leg curl.

Clinicians compare the two muscle groups on machines that measure force at a fixed speed, and a hamstring strength of about 60% of the quadriceps' has long been quoted as a minimum. The measurement predicts less than it promises: a 2018 meta-analysis in the *British Journal of Sports Medicine* found that such strength tests, the ratio included, have limited value for predicting which athletes will strain a hamstring.

The Nordic hamstring exercise, in which a person kneels with the ankles held and lowers the body forward as slowly as possible, is the most studied way to protect the hamstrings. A 2019 meta-analysis of 8,459 athletes by Nicol van Dyk and colleagues concluded that programs including it halve the rate of hamstring injuries. A 2021 reappraisal of the same evidence by Franco Impellizzeri and colleagues, using different statistical methods, judged the preventive effect inconclusive. The exercise is hard and leaves the hamstrings sore at first, so it is introduced gradually, and for people who do not sprint, the point is simply to train the hamstrings, which a leg curl also does.

Two other balances deserve a check: left and right sides can differ after an injury or from years of favoring one hand, and single-leg and one-arm exercises reveal and correct the difference, since the stronger side cannot help. The trunk is covered by bracing exercises that resist movement in each direction, which is why the table includes the side plank and the press-out as well as the plank.

4d. Choosing Exercises

Within each pattern, the choice of exercise matters less than doing it consistently and progressively. A 2023 meta-analysis by Haugen and colleagues found that free weights and machines built similar amounts of

muscle, with strength gains largest when tested on the kind of equipment used in training. The ACSM's 2026 overview likewise found no consistent difference between them.

Body weight and bands work too: in a 2017 Japanese trial, push-ups and a light bench press taken to failure produced similar growth and strength, and a 2015 Spanish trial found that push-ups loaded with elastic bands to match the muscle activity of a bench press built similar strength. The ACSM overview found that bands, body weight, and home routines all produce meaningful gains, so a gym is a convenience rather than a requirement.

Each kind of equipment has its uses: free weights train balance and coordination and need little equipment, while machines are easier to learn, safer to push close to failure without a spotter, and let a person load one muscle hard. Compound exercises, which move several joints at once, train the most muscle per minute and suit people short of time; single-joint exercises fill gaps, such as the hamstrings' role in bending the knee or the rear of the shoulder.

Four questions settle a choice: does the exercise fit the pattern, is it pain-free through its range, can it be loaded progressively, and will it be available every week? An exercise that fails the second test can almost always be swapped for another in the same pattern that passes, so pain in one lift is rarely a reason to drop a pattern.

4e. Building a Session

A session has four parts: a warm-up, the main lifts, secondary work, and a short finish. The warm-up takes five to ten minutes, with a few minutes of easy aerobic work to raise body temperature, a few movements through the ranges the session will use, and one to three lighter sets of the first lift, which rehearse the movement as they warm the tissues. Long static stretches beforehand add little (Module 5).

Order follows priority: a 2021 meta-analysis found that strength rose more in exercises done early in a session, while muscle growth was similar whatever the order. So the lift a person most wants to improve comes first, while fresh, and exercises that move several joints usually come before those that move one.

Supersets save time: a superset pairs two exercises done back to back, with rest only after the pair, and pairing exercises that do not compete, such as a press with a row or a squat with a pull-up, lets each muscle rest while the other works. Reviews published in 2025 found that supersets finished sessions in far less time, in some studies about half, with similar gains in strength and size over the short trials available, at the cost of more effort and fatigue in the moment. Pairing two exercises for the same muscle, by contrast, cuts the repetitions of the second.

Part	What it contains	Time
Warm-up	Easy aerobic work, movements through the session's ranges, 1-3 lighter sets of the first lift	5-10 minutes
Main lifts	Two compound lifts, often paired so they do not compete: a squat with a row, or a press with a pulldown	15-25 minutes
Secondary work	Two or three more patterns, paired the same way: a hinge with a press, a single-leg exercise with a pull	10-20 minutes
Finish	A carry, a bracing exercise, or one isolation exercise for a gap	5-10 minutes

The parts add up to 35-65 minutes; a typical full-body session runs 45-60. The routines at the back follow it.

Trunk training has its own argument: one school, associated with the spine researcher Stuart McGill, favors bracing exercises over sit-ups and crunches, because in laboratory studies animal spines bent thousands of times under load developed disc injuries. The other school notes that living tissue adapts between sessions,

and a 2020 systematic review found no evidence that bending the lower back while lifting leads to back pain. For healthy people, both kinds of exercise are reasonable in moderate amounts, and for people with osteoporosis the advice against loaded forward bending in Section 3g holds.

4f. Splits Compared

A split is the way a week's training is divided among days. The table compares the common ones.

Split	Days a week	Each muscle trained	Suits	Drawback
Full body	2-3	2-3 times a week	Beginners, older adults, and anyone with two or three free slots	Long sessions once volume is high
Upper and lower	4	Twice a week	People with four days who want shorter sessions	Needs four days; a missed day unbalances the week
Push, pull, legs	3 or 6	Once (3 days) or twice (6 days) a week	People who like focused sessions	On three days, each muscle is trained only once a week
Body part (chest day, back day, and so on)	5-6	Once a week	Experienced lifters chasing size	A missed day leaves a muscle untrained for two weeks

The evidence says the choice matters little when volume is equal. In a 2021 Brazilian trial, 67 untrained young men did the same 16 weekly sets per muscle group for eight weeks, either as a split that trained each muscle twice a week or as full-body sessions four times a week. Strength rose about equally, the bench press by about 18% in both groups and the squat by about 28%, and muscle thickness grew similarly at all four sites measured. Together with the frequency evidence in Module 3, this means the best split is the one that fits a person's week and gets done.

Schedules decide most cases: people who can train only two or three times a week do best with full-body sessions, since any split would leave muscles trained once a week or not at all. People with four or more days can use an upper and lower split for shorter sessions, and body-part splits make sense mainly for those who already train five or six days and enjoy it.

4g. Does Pulling Need to Outweigh Pushing?

The case for more pulling, as many physical therapists and coaches make it. Shoulder pain is common among people who lift, and the routines most people follow are heavy on pressing. In a 2014 study of 77 men by Morey Kolber and colleagues, 46 of whom trained with weights at least twice a week, signs of shoulder impingement, a pinching of the tendons under the bony roof of the shoulder, were more common among the lifters. The signs were linked to lateral raises and upright rows taken above shoulder height, and they were less common in men who strengthened the muscles that rotate the arm outward. Coaches add that desks and phones draw the shoulders forward all day and that rows cost nothing, so they recommend at least as many pulling sets as pushing sets, and often twice as many.

The case against a required ratio, as researchers skeptical of ratio and posture claims make it. No trial has assigned people to different push-to-pull ratios and counted shoulder injuries, so the case rests on associations. The 2014 study compared lifters with non-lifters at a single point in time and cannot show which came first. Reviews have found little evidence linking a rounded upper back to shoulder pain, and where a forward head and neck pain go together in adults, the pain may cause the posture as easily as the

reverse. In an Australian study of teenagers, slumped neck posture was not linked with neck pain. Where strength ratios between opposing muscles have been tested as predictors of injury, as with the hamstrings in Section 4c, they have predicted poorly.

The evidence between them. What is settled is coverage: pressing does not train the upper back, so a routine without pulling leaves major muscles untrained. Whether any particular ratio prevents shoulder pain is unknown. The exercises most clearly linked with signs of impingement are raises and upright rows taken above shoulder height, and strengthening the outward rotators is linked with fewer signs, but neither link has been shown to be causal.

The course's reading. Settled that a routine should include pulling in both planes; contested that a ratio prevents injury. At least as many pulling sets as pushing sets, in both planes, is the sensible default, and more pulling, up to twice as much, is a cheap precaution for people with sore shoulders, desk-bound days, or a sport heavy in pressing or throwing. People whose shoulders hurt during raises or upright rows can stop below shoulder height, and a few sets a week of outward rotation, such as band pull-aparts or cable external rotations, cost little.

4h. A Lopsided Week Rebalanced

Worked example — The bench-and-curls week, counted and rebuilt

A 40-year-old trains three hours a week. On Monday he does five sets of bench press, four of incline dumbbell press, four of triceps pushdowns, and four of curls; on Wednesday, four sets of overhead press, four of lateral raises, three of close-grip bench press, and three of curls; on Friday, five sets of bench press, three of push-ups, and three of back squats. Counted by pattern, as in the table, that is 42 sets: 24 pushing and none pulling, three for the legs and all of them squats, and 15 of isolation for the arms and shoulders. The chest gets 20 direct sets, twice the ten that Module 3 suggests for size, while the upper back, the hamstrings, and the buttocks get almost nothing. The rebuilt week keeps three sessions of about an hour, full body, with presses and pulls paired as supersets. Day A: squat 3 sets; bench press 3 paired with chest-supported row 3; Romanian deadlift 3; curls 2. Day B: overhead press 3 paired with lat pulldown 3; split squat 3; one-arm row 3 paired with push-ups 2; face pulls 2. Day C: deadlift 3; leg press 3; incline dumbbell press 3 paired with pull-ups 3; leg curl 3; triceps pushdowns 2. The new week has 47 sets, and the pairing lets them fit in about the same time. Pushing falls to 11 sets and pulling rises to 14, which is 1:1 in the horizontal plane and 2:1 in favor of pulling in the vertical. The chest keeps eight direct sets, enough for strength and close to the size target, and the legs go from 3 sets to 18, half for the front of the thighs and half for the hinge and hamstrings.

Pattern	Before (sets a week)	After (sets a week)
Horizontal push	20	8
Vertical push	4	3
Horizontal pull	0	8
Vertical pull	0	6
Squat and single leg	3	9
Hinge and hamstring curl	0	9
Isolation for arms and shoulders	15	4
Total	42	47

Face pulls count as a horizontal pull; curls and triceps pushdowns count as isolation, not as pulling or pushing.

Module 4 Key Points

The Routine: Movement Patterns, Push and Pull, and Balance

• Build a routine from movement patterns: squat, hinge, single leg, horizontal and vertical push and pull, carry, and trunk bracing.

• Push-to-pull ratios compare weekly hard sets, not weights; do at least as many pulling sets as pushing sets in both planes.

• Balance the legs with about as many hinge sets as squat sets; strength ratios between muscles predict injury poorly.

• Free weights, machines, bands, and body weight all build muscle; pick exercises that fit the pattern, cause no pain, and can progress.

• At equal weekly volume, split and full-body routines gave similar gains, so choose the split that fits the week.

• Supersets of non-competing exercises, such as a press with a row, cut session time with similar gains in short trials.

Module 4 Quiz

Check Your Understanding

1. What did Kolber and colleagues' 2014 study of recreational weight trainers find about shoulder impingement?

A) Its signs were linked to lateral raises and upright rows above shoulder height, and were less common in men who strengthened their outward rotators

B) Bench pressing caused most of the cases

C) Lifters had healthier shoulders than non-lifters

D) Pull-ups doubled the risk of shoulder impingement

2. In the 2021 trial of 67 untrained men doing 16 weekly sets per muscle group, how did a twice-weekly split compare with full-body sessions four times a week?

A) Full-body training doubled the gains in muscle thickness

B) The split built more strength but less muscle

C) Only the full-body group gained strength in the squat

D) Similar gains

3. What does a 1:1 push-to-pull ratio mean in a routine?

A) Rowing the same weight as you bench press

B) One pushing day for every leg day

C) As many weekly hard sets of rows, pull-ups, and other pulling exercises as of presses, push-ups, and other pushing exercises

D) Pushing and pulling in the same set of each exercise

4. How did the 2019 meta-analysis and the 2021 reappraisal differ on the Nordic hamstring exercise?

A) One found it halves injuries; the other judged that inconclusive

B) Both found it raised injuries

C) Both found it halved hamstring injuries in every sport that was studied

D) One found it worked only in women; the other found it worked only in sprinters

5. Why do coaches pair a press with a row in a superset?

A) To build more muscle

B) To finish sooner with similar gains, at least in short trials

C) To raise the heart rate

D) Because the pairing doubles each exercise's effect, so half as many sets are needed

Module 5 — Power, Balance, and Mobility

The Abilities That Fail First

Recommended Reading / Reference

Book: Kelly Starrett and Juliet Starrett, *Built to Move: The Ten Essential Habits to Help You Move Freely and Live Fully* (2023)

Reference: Manuel Montero-Odasso and colleagues, "World Guidelines for Falls Prevention and Management for Older Adults: A Global Initiative," *Age and Ageing* (2022)

5a. Power: Why It Fades Fastest

Power is force times speed: how much force a muscle can produce, and how quickly. It is what lifts a body out of a low chair, carries it up a step, and catches it when a foot slips. Power declines earlier and faster with age than strength does, because the fast-twitch fibers and the nerves that drive them are the first to go (Module 3), and in studies of older adults it predicts the ability to climb stairs, rise, and walk better than strength alone.

Power is trained by moving moderate loads fast: the lifting phase is as quick as possible and the lowering phase stays controlled, with the loads given in Module 3's table. A 2022 meta-analysis in *JAMA Network Open* pooled 20 trials in 566 adults over 60 and found that power training improved physical function more than traditional slow strength training, by an amount statisticians class as small, on evidence the authors rated low in certainty.

In practice, power work comes after a few months of ordinary strength training, and early in a session, before fatigue slows the movement. For younger and fitter people it means jumps, medicine-ball throws, kettlebell swings, and sprints. For older adults it means rising from a chair as fast as possible and sitting down slowly, quick step-ups, and fast presses against a band, and these are among the safest ways to begin.

5b. Balance and Falls

Falls are the main threat that balance training answers. In the United States, more than 14 million adults aged 65 and over, one in four, report a fall each year, and falls are the leading cause of injury and of injury-related death at those ages, according to the Centers for Disease Control and Prevention (CDC). The age-adjusted death rate from falls among older adults rose 21% between 2018 and 2024, to 78.4 per 100,000.

That exercise prevents falls is settled: a 2019 Cochrane review of 108 randomized trials with 23,407 people, average age 76, found that exercise programs cut the rate of falls by 23% and the number of people who fell by 15%, both on high-certainty evidence. The kinds of exercise differed, as the table shows.

Program	Rate of falls against control	Certainty of the evidence
Balance and functional exercise	24% lower	High
Several types combined, mainly balance and functional exercise plus resistance training	34% lower	Moderate

Program	Rate of falls against control	Certainty of the evidence
Tai chi	19% lower (and 20% fewer people falling)	Low (high for the number of people falling)
Resistance training alone, dance, or walking	Too few trials to judge	Not rated

Source: Sherrington et al., Cochrane Database of Systematic Reviews, 2019; community-dwelling adults, average age 76. No trials compared flexibility or endurance training alone with a control group.

Exercise also appeared to cut fractures by about a quarter, on low-certainty evidence from ten trials. The programs that work challenge balance progressively, by narrowing the base of support, shifting weight, stepping, turning, and taking away vision or the hand on a support, and the best combine that with leg strength. For people who have already fallen, the UK consensus on exercise for osteoporosis advises highly challenging balance and strength training for three hours a week for at least four months. The best-known home program, New Zealand's Otago Exercise Programme, combines leg strengthening and balance exercises with walking.

Balance is a skill, and like strength it is specific: it improves in the tasks practised. A few minutes a day of standing on one leg while brushing the teeth, walking heel to toe along a hallway, or stepping over and around objects keeps it trained between sessions, and the routines at the back include a balance sequence.

5c. What Stretching Does and Does Not Do

Stretching has been oversold: it increases range of motion, but a 2014 meta-analysis of 25 trials with 26,610 participants found that it did not prevent sports injuries, while strength training cut injuries to about a third and balance and coordination training cut them by about half. Across the programs studied, overuse injuries fell by nearly half, so exercise of the right kind does prevent injuries; stretching was simply not that kind.

Static stretching just before exercise costs a little performance. A 2016 review by David Behm and colleagues found that holding stretches immediately before testing lowered performance by an average of 3.7%: by 4.6% for holds of a minute or more, and by only 1.1% for shorter holds. Dynamic stretching, moving through a range repeatedly, raised performance by 1.3%. The extra range from a single session of stretching lasted less than half an hour, and the review concluded that short stretches followed by dynamic movement cost almost nothing.

Strength training builds range as well: a 2021 meta-analysis of 11 randomized trials with 452 people found no significant difference between strength training and stretching in the range of motion gained. The range gained from a few weeks of stretching comes mostly from a greater tolerance of the stretch sensation, not from longer muscles, according to the leading account of the research, which is why it fades when stretching stops.

The practical conclusion is modest: stretching is worth doing for a specific need, such as a hip that blocks a deep squat, shoulders that cannot reach overhead, or a stiff ankle that limits a lunge. It is not a substitute for a warm-up or a way to prevent injury, and lifting through a full range of motion does much of the same work.

5d. Mobility for Daily Life

Mobility is the range of motion a person can use under control, as distinct from flexibility, the range a joint allows when it is moved passively. Daily life asks for particular ranges: getting down to the floor and back up, squatting to lift something, reaching overhead, turning the head to reverse a car, and stepping onto a high

step. Losing them narrows life before any disease does, because people who cannot get up from the floor stop getting down to it, and people who cannot reach overhead stop using the high shelves.

The ranges are kept by using them: strength exercises done through a full range, a short daily sequence that takes the main joints through their ranges, and the habit of sitting on the floor and getting up again cover most needs, and the routines at the back include a ten-minute daily sequence. Getting down to the floor and up again unaided turns out to be a useful test of mobility, strength, and balance at once, as the next section shows.

5e. A Functional Check

Four tests that take ten minutes and need only a chair, a tape measure, and a watch each predict health and survival in later life. The 30-second chair stand counts full rises from a chair with a seat about 17 inches (43 centimeters) high, arms crossed at the chest; the table gives the scores the CDC's falls program counts as below average. Gait speed is a 4-meter walk at usual pace, timed from a moving start. The one-leg stand asks a person to stand 10 seconds on either leg, with the free foot resting against the back of the standing leg, arms by the sides, and up to three attempts.

The sit-to-rise test asks a person to sit down on the floor and get up again without support. It is scored out of 10, five points for sitting and five for rising, with a point lost for each hand, forearm, knee, or side of a leg used for support and half a point for a loss of balance.

Age	Men: below average	Women: below average
60-64	Fewer than 14	Fewer than 12
65-69	Fewer than 12	Fewer than 11
70-74	Fewer than 12	Fewer than 10
75-79	Fewer than 11	Fewer than 10
80-84	Fewer than 10	Fewer than 9
85-89	Fewer than 8	Fewer than 8
90-94	Fewer than 7	Fewer than 4

Full stands in 30 seconds. Source: CDC, STEADI (Stopping Elderly Accidents, Deaths and Injuries) 30-Second Chair Stand assessment, from Rikli and Jones's norms for older adults.

What the other three predict comes from large cohorts. In a 2011 pooled analysis of nine cohorts and 34,485 adults over 65, each 0.1 meter per second of extra gait speed went with a 12% lower risk of death; about 0.8 meters per second matched the median life expectancy for age and sex, and 1.0 or faster predicted longer than expected survival. In a 2022 Brazilian study of 1,702 adults aged 51 to 75, one in five could not stand on one leg for 10 seconds, a share that rose from about 5% at 51-55 to about 54% at 71-75, and failing went with an 84% higher risk of death over about seven years after allowing for age, sex, and illness.

In a 2025 report from the same Brazilian clinic, 4,282 adults with an average age of 59 were followed for 12.3 years. Those who scored 0 to 4 on the sit-to-rise test had 3.8 times the risk of death from natural causes and six times the risk of cardiovascular death of those who scored a perfect 10, and scores below 8 marked the higher-risk group. All four are associations: the tests capture strength, power, balance, and general health together, and they are screening tools rather than targets.

Worked example — A 68-year-old checks himself

He manages 11 chair stands in 30 seconds, which is below average for men of 65 to 69 (fewer than 12). He walks 4 meters in 3.6 seconds, a speed of 4 ÷ 3.6 = 1.11 meters per second, above the 1.0 that predicts longer than expected survival. He stands 10 seconds on his right leg but only 6 on his left; the test counts either leg, so he passes, but the difference marks the left side for single-leg work. To sit on the floor he puts down one hand, and to rise he uses a hand and a knee, so his sit-to-rise score is 10 − 1 − 2 = 7, just under the threshold of 8. The pattern points to leg strength and power, not walking or balance, as his weak link. His plan: two strength sessions a week built on squats and step-ups, adding fast chair rises after the first two months; the daily ten-minute sequence at the back, including getting down to the floor and up again; and a minute of one-leg standing on each side, left first, every day. He retests every three months (Module 11), aiming first for 12 chair stands and a sit-to-rise score of 8.

Module 5 Key Points

Power, Balance, and Mobility

• Power, force times speed, fades faster than strength with age; fast lifting improved function slightly more than slow lifting in trials.

• Exercise cut falls by 23% in a 2019 Cochrane review; balance and functional training, especially combined with strength work, did best.

• Stretching raises range of motion but did not prevent sports injuries; strength training cut them to about a third.

• Short static stretches followed by dynamic movement cost little before exercise; holds of a minute or more lowered performance about 5%.

• Chair stands, gait speed, a 10-second one-leg stand, and rising from the floor each predict survival and take ten minutes to test.

Module 5 Quiz

Check Your Understanding

1. In the 2019 Cochrane review, which programs cut the rate of falls the most?

A) Several types combined, mainly balance and functional exercise with strength work
B) Walking programs
C) Stretching classes
D) Resistance training alone, done on machines two or three times a week under supervision

2. What did the 2014 meta-analysis of 25 trials find about stretching and sports injuries?

A) Stretching halved overuse injuries
B) Stretching did not prevent injuries, while strength training cut them to about a third
C) Stretching before sport doubled injuries
D) Only dynamic stretching prevented injuries

3. In the 2022 study of 1,702 adults aged 51 to 75, what went with an 84% higher risk of death?

A) Walking more slowly than one meter per second
B) Being unable to touch the toes with straight knees
C) Failing a 10-second one-leg stand
D) Doing fewer than twelve chair stands in thirty seconds

4. Where does most of the extra range of motion from a few weeks of stretching come from?

A) Longer muscles
B) Permanent lengthening of the tendons around the joint
C) New muscle fibers added along the length of the stretched muscle
D) Greater tolerance of the stretch

5. In Behm and colleagues' 2016 review, how did stretching just before exercise affect performance?

A) It improved strength by about 10%
B) It had no effect at any duration
C) Static holds lowered it slightly, more for holds of a minute or longer, and dynamic stretching raised it
D) It lowered performance only in older adults

Module 6 — Recovery

Getting the Adaptation the Training Paid For

Recommended Reading / Reference

Book: Christie Aschwanden, *Good to Go: What the Athlete in All of Us Can Learn from the Strange Science of Recovery* (2019)

Reference: Romain Meeusen and colleagues, "Prevention, Diagnosis, and Treatment of the Overtraining Syndrome," joint consensus statement of the European College of Sport Science and the American College of Sports Medicine, *Medicine & Science in Sports & Exercise* (2013)

6a. Adaptation Happens Between Sessions

A training session does not make a person fitter; it makes them temporarily less fit. The work depletes fuel, damages some muscle fibers, and leaves the nervous system tired, and performance dips for hours or days. The body then rebuilds, and if it has the time, food, and sleep to do so, it rebuilds to a level slightly above where it started. The next session should land after that rebuilding, not before it, which is why the gap between hard sessions matters as much as the sessions.

The parts of the body recover at different speeds. Muscle fuel stores refill within about a day when enough carbohydrate is eaten, while the soreness that follows unfamiliar or heavy work, called delayed-onset muscle soreness, peaks one to three days later. Soreness is not a measure of a good session: it falls sharply once an exercise becomes familiar, even as the training keeps working. Most programs therefore space hard sessions for the same muscles about two days apart and fill the days between with easy aerobic work or other muscle groups.

6b. Overreaching and Overtraining

The consensus statement of the European College of Sport Science and the ACSM, published in 2013, separates three states. Functional overreaching is a short dip in performance from a hard block of training, which recovers within about two weeks and is often followed by improvement; many programs use it deliberately. Non-functional overreaching is a deeper hole, from which recovery takes weeks or months. Overtraining syndrome is underperformance with disturbed mood that persists despite weeks or months of rest, and full recovery may take months or years.

True overtraining is uncommon: the statement's best estimate is that about 10% of endurance athletes such as college swimmers reach non-functional overreaching or overtraining, within a range of 7-21%; the much higher figures in athletes' own reports lump the states together. There is no diagnostic test, so the diagnosis is made by excluding other causes, such as hormonal disorders, iron-deficiency anemia, or infection, and none of the blood markers proposed meets the criteria for routine use.

For people who exercise for health, the common problem is not overtraining but under-recovery: hard training stacked on short sleep, work stress, and too little food. The warning signs are performance that falls for two weeks or more despite effort, persistent fatigue, a resting heart rate above its usual level, poor sleep, low mood, and frequent minor illness. The remedy is to cut the training back, and anyone whose signs persist after a few lighter weeks should see a doctor rather than train harder.

6c. Lighter Weeks

A deload is a planned period of lighter training, fewer sets or lower loads, meant to let fatigue clear so that training can resume at a higher level. Many coaches schedule one every month or two, but the evidence for doing so by the calendar is thin. In a 2024 trial from Brad Schoenfeld's laboratory, 39 trained adults followed a nine-week high-volume program, and half of them stopped training entirely for a week at the midpoint. Gains in muscle size, local endurance, and power did not differ, but the group that took the week off gained less lower-body strength.

That trial tested a full week off, not a lighter week, so it does not show that deloads cost strength, only that a layoff costs a little. For recreational lifters the practical rule is to take a lighter week when fatigue builds, after an illness, or when life gets busy, keeping the loads but halving the sets, which preserves the skill and strength of each lift. The maintenance doses in Module 3 show how little it takes to hold on to gains.

6d. Sleep

Sleep is the recovery method with the strongest evidence, and it costs nothing. In a 2021 crossover study by Séverine Lamon and colleagues in Australia, 13 healthy young adults spent one night without sleep in a laboratory and one night sleeping normally at home. After the sleepless night, the rate at which their muscles built new protein was 18% lower, cortisol, a hormone that breaks tissue down, was 21% higher, and testosterone was 24% lower. The drop in protein building appeared in every man and in none of the women, though the study was too small to test that difference.

Sleep loss also raises the effort that any given pace or load feels like, slows reaction time, and impairs mood and appetite control, all of which make the next session harder to do well. Adults need seven or more hours a night on a regular schedule, and exercise itself tends to improve sleep. For people who train hard, guarding sleep does more for recovery than any product.

6e. Heart-Rate Variability and Readiness Scores

Heart-rate variability (HRV) is the variation in the time between heartbeats. At rest the interval changes slightly with each breath, under the influence of the parasympathetic nervous system, the branch that slows the heart; when the body is stressed, by hard training, illness, alcohol, heat, or poor sleep, the variation shrinks. Wearables measure it overnight or on waking, usually as a statistic called rMSSD (the root mean square of successive differences between beats), in milliseconds.

A single morning's HRV is noisy, varying considerably from day to day for no clear reason, and the normal level differs widely between people. The useful signal is a rolling seven-day average compared with a person's own baseline, alongside the resting heart rate, which rises when HRV falls. Trials that let HRV decide when to train hard have found small advantages over fixed plans at best, according to reviews published in 2021, so it is a guide rather than a rule.

Readiness or recovery scores combine HRV, resting heart rate, sleep, and recent activity into one number by formulas the manufacturers do not publish, and none has been validated as a way to decide training. They are best read as a prompt to ask how one feels, not as a verdict; Module 11 covers what wearables measure well and badly.

6f. The Recovery Industry, Graded

A large industry sells recovery, from massage guns to supplements. A 2018 meta-analysis of 99 studies by Olivier Dupuy and colleagues gives the best overview of the methods aimed at soreness and fatigue: massage was the most effective for both, and the table grades the rest. None of these has been shown to speed the adaptations that training is for.

Method	What the evidence shows	Grade
Sleep and enough food	The foundation: sleep loss cuts muscle building, and eating too little impairs every adaptation (Module 7)	Settled
Massage	Reduced soreness and perceived fatigue the most among passive methods; no evidence that it speeds adaptation	Probable, for soreness
Compression garments, easy active recovery	Smaller reductions in soreness	Probable, for soreness
Foam rolling	Small, short-lived effects on soreness and range of motion	Probable, small
Stretching after exercise, electrical stimulation	No significant effect on soreness or fatigue	No effect shown
High-dose antioxidant vitamins (C and E)	Can blunt adaptation: in a 2009 trial they blocked the gain in insulin sensitivity from four weeks of training	Avoid during training
Anti-inflammatory painkillers such as ibuprofen	Occasional use is reasonable; regular high doses reduced muscle gains in young adults in one trial, though a trial in older adults found no such cost	Avoid regular high doses
Cold plunges and saunas	Section 6g	Contested

6g. Cold Plunges and Saunas

The case for them, as their advocates make it. Cold-water immersion reduces muscle soreness and the feeling of fatigue after hard exercise, which is why athletes use it between competitions. A 2025 meta-analysis in *PLOS ONE*, covering 11 trials with 3,177 healthy adults who used cold baths or showers at 15 °C or below, found improved sleep quality and quality of life, and in one large trial cold-shower users took 29% fewer sick days. Saunas have an even stronger claim. In a Finnish cohort of 2,315 middle-aged men followed for about 20 years, men who used a sauna two or three times a week had a 22% lower risk of sudden cardiac death than those who went once, a difference that could have been chance. Those who went four to seven times had a 63% lower risk, and lower death rates from heart disease and from all causes too.

The case against, as their skeptics make it. Cold immersion after lifting appears to blunt the training it is meant to support. A 2024 meta-analysis pooled eight studies and found a 96% probability that cold-water immersion after resistance training reduces muscle growth, and its authors advised against it for anyone seeking to build muscle. The 2025 cold-water review found no effect on mood or immune markers, a rise in inflammation immediately after exposure, and few, small trials. The sauna findings come from one observational cohort of Finnish men in which nearly all used saunas, only 12 did not, so sauna use could not be compared with none, and men well enough to take frequent saunas may simply have been healthier.

The evidence between them. Cold eases soreness, but its cost to muscle growth is the more consistent finding, and the studies of both are small. Its broader benefits for well-being rest on weak trials. Sauna's link with lower cardiovascular death is large and consistent within the cohort, and a 2022 Finnish trial found that adding sauna sessions to exercise improved cardiovascular risk factors more than exercise alone, but no trial has tested it against hard outcomes such as heart attacks or deaths.

The course's reading. Cold plunges are contested: fine for soreness or enjoyment, but not straight after strength training when muscle is the aim. Sauna bathing may benefit the heart, though the evidence is one cohort and one short trial of risk factors, and it is safe for most healthy people who avoid alcohol, drink enough, and leave if they feel dizzy. Anyone with unstable heart disease, very low blood pressure, or pregnancy should ask a doctor first. Neither substitutes for training or sleep.

6h. Reading a Week of Heart-Rate Data

Worked example — A week of morning readings

A 45-year-old has a resting heart rate that averages 52 beats a minute and an HRV that averages 60 milliseconds over the past two months, and readings between 55 and 65 milliseconds are normal for him. His week, as resting heart rate and HRV: Monday 52 and 62, after a rest day. Tuesday 53 and 58, after a hard interval session on Monday evening. Wednesday 55 and 49, after five and a half hours of sleep and a late work deadline. Thursday 58 and 42, with a scratchy throat. Friday 56 and 47. Saturday 53 and 57. Sunday 52 and 61. Tuesday's dip after a hard session is expected and needs no change. By Thursday, HRV has been below his normal band for two days running and his resting heart rate is 6 beats above its average, so the strength session planned for Thursday becomes a 30-minute walk, and Friday's intervals become easy cycling. By Saturday both numbers are back in range, so he resumes the plan, moving the missed interval session to Sunday. His seven-day average HRV for the week is (62 + 58 + 49 + 42 + 47 + 57 + 61) ÷ 7 = 53.7 milliseconds, below his band, which matches a week that included poor sleep and a cold. The rule he follows is simple: one low day changes nothing, two low days with a raised resting heart rate mean easy training, and symptoms of illness below the neck, such as a fever or chest symptoms, mean rest.

Module 6 Key Points

Recovery

• Adaptation happens between sessions; about 10% of endurance athletes reach non-functional overreaching or overtraining, which no test can diagnose.

• One night without sleep cut muscle protein synthesis by 18%; sleep is the recovery method with the strongest evidence.

• A week off midway through a program cost some strength but no muscle; take lighter weeks when fatigue builds.

• Massage, compression, and easy movement ease soreness, while stretching and electrical stimulation did not; none is shown to speed adaptation.

• Cold plunges right after lifting probably blunt muscle growth; sauna's link with longer life comes from one observational cohort.

• Read heart-rate variability as a seven-day trend against a personal baseline, not as a single day's verdict.

Module 6 Quiz

Check Your Understanding

1. What did the 2013 consensus statement say about diagnosing overtraining syndrome?

A) No single test exists; other diseases must be ruled out
B) A blood cortisol test confirms it
C) A drop in heart-rate variability confirms it
D) It can be diagnosed after one bad week of training if mood and appetite also fall

2. In the 2021 crossover study, what did one night without sleep do to muscle protein synthesis the next day?

A) Raised it, as the body compensated
B) Cut it by 18%
C) Left it unchanged in both men and women
D) Cut it by half for the following three days

3. What did the 2024 meta-analysis of cold-water immersion after resistance training conclude?

A) It doubles growth
B) It has no effect on muscle when the water is above 10 °C
C) It improves muscle growth but slows the gains in maximal strength
D) It probably blunts muscle growth

4. What did the 2024 trial of a week off halfway through a nine-week program find?

A) Strength rose more after the break
B) Muscle size fell sharply
C) Muscle size gains were similar, but strength gains were smaller
D) Everyone who took the break lost all the muscle gained in the first half of the program

5. In the 2018 meta-analysis of 99 studies, which recovery technique reduced soreness and perceived fatigue the most?

A) Static stretching after the session
B) Massage
C) Electrical muscle stimulation
D) Anti-inflammatory painkillers such as ibuprofen

Module 7 — Fuel

Eating to Support the Training

Recommended Reading / Reference

Book: Herman Pontzer, *Burn: New Research Blows the Lid Off How We Really Burn Calories, Lose Weight, and Stay Healthy* (2021)

Reference: US Department of Agriculture and Department of Health and Human Services, *Dietary Guidelines for Americans, 2025-2030* (2026)

7a. Energy, and the Cost of Eating Too Little

Exercise burns fewer extra calories than most people expect, and the body partly makes up for what it does burn. In a 2016 study of 332 adults in five countries, the anthropologist Herman Pontzer and colleagues measured total daily energy use with a precise tracer method and found that it rose with physical activity at low levels but leveled off at higher ones, as if the body trimmed other spending to stay within a budget. Trials of exercise without dieting accordingly produce modest weight loss, and weight is lost mainly by eating less.

None of that makes exercise less valuable: its health effects, from fitness to blood sugar, do not depend on weight loss, and it helps people keep weight off once they have lost it. For anyone combining training with a diet, the aim is to lose fat while keeping muscle, which calls for the strength training of Modules 3 and 4, a moderate rather than a severe deficit, and enough protein.

The opposite error, eating too little for the training done, has its own name. The International Olympic Committee's 2023 consensus calls it Relative Energy Deficiency in Sport (REDs): a syndrome caused by large, prolonged, or frequent shortfalls in the energy left over for the body's own needs after training. Its estimated prevalence ranges from 15% to 80% depending on the sport. It disturbs hormones and menstrual cycles, weakens bones and raises the risk of stress fractures, impairs immunity, mood, and the response to training, and in men can lower libido.

REDs is not confined to elite athletes: it can affect anyone who trains hard while dieting, including recreational runners and older adults trying to lose weight. Missed or stopped periods, frequent injuries or illness, persistent fatigue, and falling performance despite training are signs to take to a doctor, and a lost period is a warning, not a sign of fitness.

7b. Protein: What It Does and How to Spread It

Protein supplies the amino acids from which muscle is built and repaired, and training raises the body's use of them. The official recommended dietary allowance (RDA), 0.8 grams per kilogram of body weight a day, was set from studies of the minimum needed to stay in nitrogen balance, and it is meant to cover the needs of nearly all healthy adults, not to maximize the response to training. How far above it to go is argued in Section 7e.

Older muscles respond less to a given dose of protein, a phenomenon called anabolic resistance. A 2015 pooled analysis of laboratory studies by Daniel Moore and colleagues estimated that older men needed about 0.4 grams per kilogram in a meal to get the maximal muscle-building response that younger men got from about 0.24. Many older adults eat most of their protein at dinner and little at breakfast, so the practical rule is to spread protein across three or four meals with a substantial dose in each.

Timing within the day matters less than the total. Eating a protein-rich meal within a few hours of training is sensible, but the window is far wider than the half hour once claimed. Protein powders are a convenient form of the same nutrient and no better than food.

Plant protein works, with some adjustment: in a 2021 Brazilian trial, 19 vegan and 19 omnivorous young men trained for 12 weeks on 1.6 grams of protein per kilogram a day, with soy or whey to top up, and gained similar muscle and strength. A 2021 meta-analysis of trials found a small advantage for animal protein in lean mass among adults under 50. Plant proteins are lower in some amino acids, especially leucine, so vegans who train do well to eat a little more protein from a mix of sources such as soy, legumes, and grains.

For people with healthy kidneys, higher protein intakes have not been found to harm kidney function: a 2018 meta-analysis found that changes in kidney function did not differ between higher- and lower-protein diets. People with kidney disease are a different case and should follow their doctor's advice on protein.

7c. Carbohydrate, Fluids, and Heat

Carbohydrate is the main fuel for hard exercise: fat supplies most of the energy at easy intensities, but as effort rises the muscles rely increasingly on glucose and their stored glycogen. Low-carbohydrate and ketogenic diets teach the body to burn more fat, but in a 2017 study of elite race walkers led by Louise Burke, a ketogenic diet made walking at race pace less economical, and only the walkers on carbohydrate-rich diets improved their race times after three weeks of hard training.

For most sessions under an hour, nothing is needed beyond water and a normal diet. For efforts of one to two and a half hours, the joint position of the ACSM and North American dietitians' associations advises 30 to 60 grams of carbohydrate an hour, and for longer events up to 90 grams an hour from drinks or gels that mix glucose and fructose. People who train for health rather than competition rarely need these, but a long ride or hike is an exception.

Drinking too much is a greater danger in long events than drinking too little. In a study of the 2002 Boston Marathon, 13% of the 488 runners who gave blood at the finish had low blood sodium, called hyponatremia, and 0.6% had critically low levels. The strongest predictor was gaining weight during the race, which can happen only by drinking more than is sweated out; runners slower than four hours were at much higher risk than those under three and a half. The safe rule is to drink to thirst, and to weigh before and after long sessions: a gain means too much fluid, and a loss of more than about 2% of body weight means too little.

Heat raises the cost of exercise: the heart beats faster at any pace, and the same effort feels harder. The body adapts to heat over about one to two weeks of exposure, sweating sooner and more, so the first hot days of the year call for slower paces and shorter sessions. Long sessions in heavy sweat need salt as well as water, from food or a sports drink.

7d. Supplements, Graded

Most supplements sold for exercise have little evidence behind them, and a few have a great deal. The table grades the ones people ask about most.

Supplement	What the evidence shows	Grade
Creatine monohydrate	The best-studied supplement: with training, it adds to gains in strength, power in short efforts, and lean mass, at 3-5 grams a day, with no evidence of harm in healthy people. A 2025 randomized trial of 5 grams a day for 12 weeks found no effect on hair or on dihydrotestosterone (DHT), the hormone involved in male-pattern hair loss; claims for memory and thinking are not established	Settled, for strength and lean mass
Caffeine	About 3-6 milligrams per kilogram an hour before exercise improves endurance, strength, and sprint performance; responses vary, and late doses cost sleep	Settled
Dietary nitrate (beetroot juice)	Small improvements in endurance, clearer in recreational exercisers than in trained athletes	Probable, small
Beta-alanine	Helps hard efforts lasting about one to four minutes; causes harmless tingling	Probable, narrow
Protein powder	Works as well as food protein; a convenience, not a necessity	Settled, as food
Vitamin D	Corrects deficiency; in a large 2022 trial in healthy adults not chosen for low levels, it did not reduce fractures	No benefit unless deficient
Branched-chain amino acids	Add nothing when total protein intake is adequate	Marketing
"Testosterone boosters," fat burners, and blends with undisclosed doses	No good evidence, and the highest risk of contamination	Marketing

Doses are for healthy adults; anyone taking medication or with a medical condition should check with a doctor or pharmacist.

Contamination is a real risk: a 2023 review found that, across studies, 14% to 50% of supplement samples analyzed contained anabolic agents or other substances banned in sport, often undeclared on the label. Products certified by an independent testing program that screens each batch, such as NSF Certified for Sport or Informed Sport, lower the risk without removing it, and they matter most for people subject to drug testing and for anyone buying products sold for muscle building or weight loss.

7e. How Much Protein?

The case for more, as sports nutrition researchers make it. The largest meta-analysis of protein and training, published in 2018 by Robert Morton, Stuart Phillips, and colleagues, pooled 49 randomized trials with 1,863 people. Protein supplements added 2.49 kilograms to the gain in the one-repetition maximum and 0.30 kilograms to the gain in lean mass, and the extra lean mass leveled off at a total intake of about 1.6 grams per kilogram a day. The American dietary guidelines for 2025-2030 now advise 1.2 to 1.6 grams per kilogram a day for adults, with protein at every meal. Older adults' anabolic resistance, weight loss on diets or drugs, and protein's ability to curb hunger all strengthen the case.

The case for the established allowance, as many nutrition scientists make it. The RDA already covers the needs of nearly all healthy adults, and most people in rich countries eat more than it. The gains in the 2018 meta-analysis were small, a few hundred grams of lean mass, and its breakpoint was uncertain: the authors found it statistically non-significant, with a confidence interval running from 1.03 to 2.20 grams per kilogram. Some cohort studies have linked high intakes of animal protein in middle age with higher mortality, and while such studies cannot separate protein from the rest of the diet, they are a reason not to push intakes far above need.

The evidence between them. For people who train, intakes up to about 1.6 grams per kilogram are safe for healthy kidneys and probably help a little, and the help is likely largest in older adults and in people losing weight. Above that level the benefit is unclear, and very high intakes crowd out other foods.

The course's reading. Probable: people who train, especially after 50, should aim for 1.2 to 1.6 grams of protein per kilogram a day, spread across three or four meals. More than that adds little, and plant sources serve as well as animal ones when the total is adequate.

7f. One Day's Protein for a Lifter of 60

Worked example — Hitting the target in ordinary meals

A 60-year-old man who weighs 80 kilograms and lifts three times a week aims for 1.2 to 1.6 grams per kilogram, which is 96 to 128 grams a day, with about 0.4 grams per kilogram, or 32 grams, at each main meal. Breakfast: three eggs (about 18 grams of protein), two slices of wholegrain toast (8), and a glass of milk (8), for 34 grams. Lunch: a sandwich made with a drained can of tuna (about 25 grams) and two slices of bread (8), for 33. Afternoon: 200 grams of plain Greek yogurt (20). Dinner: 150 grams of cooked salmon (about 33) with potatoes and vegetables (5), for 38. The day's total is 34 + 33 + 20 + 38 = 125 grams, near the top of the range, and each main meal clears 32 grams. His old pattern, toast and coffee for breakfast, a light lunch, and a large steak at dinner, came to about the same total but put more than half of it into one meal, below the per-meal threshold twice a day. A vegetarian version replaces the tuna with 200 grams of firm tofu and the salmon with a bowl of lentils and a glass of soy milk, which gets within a few grams of the same totals. The values are approximate, from standard food tables.

Module 7 Key Points

Fuel

• Exercise burns fewer extra calories than expected; eating too little while training hard harms hormones, bone, immunity, and performance.

• Protein supplements added modestly to strength and lean-mass gains in 49 trials, with lean-mass gains leveling off near 1.6 g/kg.

• Older muscle needs about 0.4 g/kg of protein per meal, so spread protein across three or four meals.

• Drink to thirst: 13% of sampled Boston Marathon finishers had low blood sodium, mainly from drinking too much.

• Creatine and caffeine have strong evidence; most other supplements have little, and 14-50% of tested samples were contaminated.

Module 7 Quiz

Check Your Understanding

1. In the 2018 meta-analysis of 49 trials, at about what total daily protein intake did the extra gain in lean mass level off?

A) 0.8 g/kg
B) About 2.5 g per kilogram, double the usual target
C) Only above 3 g per kilogram, and only in men under 30
D) About 1.6 g per kilogram

2. Why do older adults need more protein in each meal than younger adults?

A) Their muscles respond less to a given dose, so it takes about 0.4 g per kilogram in a meal to get the response younger muscles get from less
B) Their kidneys clear protein faster
C) They burn protein for fuel instead of fat
D) Older stomachs cannot digest plant protein

3. What did the study of the 2002 Boston Marathon find about low blood sodium?

A) It affected only elite runners
B) Sports drinks prevented it
C) About 13% of sampled runners had it, mostly from drinking too much
D) It was caused mainly by sweating out salt in runners who drank too little during the race

4. What did the 2025 randomized trial of creatine and hair loss find?

A) DHT rose by 56% in the creatine group
B) Hair thinned only in men over 30
C) Hair loss doubled in 12 weeks
D) No differences from placebo in hair density, hair thickness, or the hormone DHT after 12 weeks of 5 grams a day

5. According to a 2023 review, what share of tested supplement samples contained anabolic agents or other banned substances?

A) Anywhere from 14% to 50%
B) Under 1%
C) About 2%, almost all of it from overseas sellers
D) Every product sold online without a certification seal

Module 8 — Exercise as Medicine

What It Treats, and How Well

Recommended Reading / Reference

Book: Kelly McGonigal, *The Joy of Movement: How Exercise Helps Us Find Happiness, Hope, Connection, and Courage* (2019)

Paper: Bente Klarlund Pedersen and Bengt Saltin, "Exercise as Medicine: Evidence for Prescribing Exercise as Therapy in 26 Different Chronic Diseases," *Scandinavian Journal of Medicine & Science in Sports* (2015)

8a. Blood Pressure

High blood pressure is the most common treatable risk for heart attack and stroke, and exercise lowers it reliably. A 2023 network meta-analysis in the *British Journal of Sports Medicine* pooled 270 randomized trials with 15,827 participants and compared the kinds of training directly. Every kind lowered resting pressure, but isometric training, in which a muscle holds a position without moving, ranked first for both the systolic (upper) and diastolic (lower) readings, measured in millimeters of mercury (mmHg).

Kind of training	Systolic reduction (mmHg)	Diastolic reduction (mmHg)
Isometric (wall squat, handgrip, leg extension held)	8.2	4.0
Aerobic and resistance combined	6.0	2.5
Dynamic resistance	4.6	3.0
Aerobic	4.5	2.5
High-intensity intervals	4.1	2.5

Average reductions against control groups. Source: Edwards et al., British Journal of Sports Medicine, 2023; 270 trials. Among single exercises, the isometric wall squat lowered systolic pressure the most and running lowered diastolic pressure the most.

The isometric protocols are short: typically four holds of about two minutes each, with a rest between, three times a week, at an effort that becomes hard by the end of each hold. A wall squat, with the back against a wall and the knees bent, needs no equipment. Isometric work is a supplement to aerobic and strength training, not a replacement, because it does little for fitness, muscle, or blood sugar. Large trials of blood-pressure drugs suggest that each 5 mmHg fall in systolic pressure cuts the risk of major cardiovascular events by about a tenth, so these effects matter. **Grade: settled.**

8b. Blood Sugar and Diabetes

Exercise prevents type 2 diabetes in people at high risk. In the Diabetes Prevention Program, an American trial published in 2002, 3,234 adults with raised blood sugar were assigned to a lifestyle program aiming for 7% weight loss and 150 minutes a week of activity such as brisk walking, to the drug metformin, or to a placebo. Over an average of 2.8 years, the lifestyle program cut new cases of diabetes by 58% and metformin by 31%.

Exercise also treats diabetes once it has developed: the standard measure of control is HbA1c, the share of hemoglobin carrying glucose, which reflects average blood sugar over about three months. A 2011 meta-analysis in *JAMA* by Daniel Umpierre and colleagues pooled 47 trials with 8,538 patients and found that structured exercise lowered HbA1c by 0.67 percentage points, by 0.89 points with more than 150

minutes a week and by 0.36 with less. Advice to be more active, without supervised training, helped only when it came with dietary advice. Aerobic, resistance, and combined training all worked. **Grade: settled.**

8c. The Heart After a Heart Attack

Cardiac rehabilitation, a supervised program of exercise with education and support after a heart attack, a stent, or bypass surgery, is the oldest established use of exercise as treatment. A 2021 Cochrane review of 85 randomized trials with 23,430 people with coronary heart disease found that, over about a year of follow-up, exercise-based rehabilitation cut heart attacks by 28% and hospital admissions by 42%. It did not significantly change deaths within that period, and it improved quality of life slightly.

The case for rehabilitation therefore rests on fewer heart attacks and admissions, better fitness, and better daily life, rather than on clear evidence of longer survival in the short run. Many people who qualify never attend, and those who do usually train for only a few months, so the program's biggest lesson is to keep exercising afterward. **Grade: settled for fewer heart attacks and admissions.**

8d. Cancer

Active people get some cancers less often: a 2016 pooled analysis of 12 cohorts and 1.44 million adults by Steven Moore and colleagues at the National Cancer Institute compared people at the 90th and 10th percentiles of leisure activity. The more active had lower risks of 13 of the 26 cancers studied: 42% lower for adenocarcinoma of the esophagus, 20-27% lower for cancers of the liver, lung, kidney, upper stomach, and endometrium and for myeloid leukemia, and 10-17% lower for myeloma and for cancers of the colon, head and neck, rectum, bladder, and breast. Adjusting for body weight weakened most of these links only slightly.

Two cancers went the other way: melanoma was 27% more common in the more active, probably from time in the sun, and prostate cancer 5% more common, possibly because health-conscious men are screened more. These are observational findings, so the probable reading is that activity lowers the risk of several cancers, not that it prevents cancer in general. **Grade: probable.**

Exercise also helps people who have cancer: during and after treatment it reduces fatigue and improves fitness and quality of life, which is why cancer guidelines recommend it. The strongest test of whether it changes survival is the CHALLENGE trial, published in the *New England Journal of Medicine* in June 2025, which assigned 889 people who had finished chemotherapy for colon cancer at 55 centers to a three-year structured exercise program or to health-education materials. Over a median of 7.9 years, the exercise group had a 28% lower risk of the cancer returning or of death and a 37% lower risk of death. Section 8h turns these figures into absolute numbers.

A wider look appeared in September 2026. A meta-analysis of 21 randomized trials with 8,449 people with cancer, mostly breast cancer and 88% of them women, published in the *British Journal of Sports Medicine*, found that people assigned to structured exercise were about 23% less likely to die over an average of about five years and 17% less likely to have the cancer return. The benefit was clearest in early-stage disease and among those who completed most of their program, and the authors called the effects "context dependent." **Grade: settled that exercise helps people through treatment; probable that it extends survival after colon cancer and other early-stage cancers.**

8e. Depression and the Ageing Brain

Exercise treats depression: a 2024 network meta-analysis in *The BMJ* by Michael Noetel and colleagues pooled 218 randomized trials and found clear reductions in depressive symptoms against control conditions, with walking or jogging, yoga, and strength training among the most effective, and large effects for dance in a few small trials. More intense exercise produced larger effects, and strength training and yoga had the fewest dropouts. The trials were mostly small, short, and at risk of bias, so the authors rated confidence in the estimates low or very low.

The network also included cognitive behavioral therapy, whose effect was similar to that of the leading exercises, and the most widely used antidepressants taken alone, whose effect was smaller, though the evidence for exercise was less certain than for therapy. Exercise is best seen as one effective treatment among several. For mild to moderate depression it is a reasonable first choice or addition, and for severe depression it is an addition to standard care, not a substitute. **Grade: probable.**

For the ageing brain, the evidence is more modest. The US POINTER trial, published in *JAMA* in 2025, assigned 2,111 sedentary adults aged 60 to 79 at raised risk of dementia to two years of a structured program of exercise, diet, mental and social activity, and health checks, or to a self-guided version of the same advice. Thinking improved in both groups, and only very slightly more with the structured program. Reviews of exercise trials in healthy older adults find small effects on memory and thinking at best, while step-count cohorts link activity with much less dementia (Module 1). **Grade: contested for preventing dementia; small benefits to thinking are probable.**

8f. Joints, Back, Lungs, and Nerves

Exercise is a core treatment for osteoarthritis of the knee and hip in every major guideline: strengthening, aerobic, balance, and mind-body exercise all reduce pain and improve function, and trials have found no sign that exercise speeds the damage to the joint. Running is a common worry, but a 2017 meta-analysis of 25 studies with 125,810 people found hip or knee osteoarthritis in 3.5% of recreational runners, against 10.2% of sedentary people and 13.3% of elite competitive runners. The studies were observational, but they give no support to the idea that ordinary running ruins knees. **Grade: settled as treatment.**

For chronic low back pain, a 2021 Cochrane review of 249 trials with 24,486 people found that exercise reduced pain by about 15 points on a 100-point scale against no treatment, usual care, or placebo, an amount patients notice, and improved function by about 7 points, less than the 10 regarded as meaningful. Against other conservative treatments the advantage was smaller and not clinically important: exercise probably beat education alone and electrical therapies, and it matched manual therapy. **Grade: settled, with modest effects.**

For chronic obstructive pulmonary disease, pulmonary rehabilitation built on exercise improves breathlessness, quality of life, and walking distance by amounts patients notice, and a 2015 Cochrane review judged that further trials against usual care were not needed. For Parkinson's disease, a 2018 phase 2 trial, SPARX (Study in Parkinson Disease of Exercise), found that high-intensity treadmill training may slow the worsening of motor symptoms in the early stage; the phase 3 trial, SPARX3, is on the watch list in Module 13. **Grade: settled for lung disease; probable for Parkinson's symptoms.**

8g. Graded Exercise for Chronic Fatigue?

Myalgic encephalomyelitis, also called chronic fatigue syndrome (ME/CFS), causes disabling fatigue and post-exertional malaise: a worsening of symptoms after physical or mental effort, often delayed by a day or more and lasting days or weeks. Graded exercise therapy (GET) raises activity by fixed steps over weeks, on the theory that deconditioning maintains the illness. Whether it helps or harms is among the most bitter disputes in medicine, and it now extends to long COVID.

The case for graded exercise, as the PACE investigators and their supporters make it. The PACE trial, published in *The Lancet* in 2011, randomized 641 people to specialist medical care alone or with cognitive behavioral therapy (CBT), graded exercise, or adaptive pacing. On the trial's published measures, 61% improved with graded exercise and 59% with CBT, against 45% with specialist care alone, and a 2013 follow-up paper reported that 22% recovered with either treatment against 7%. Even on the measure of improvement in the original protocol, graded exercise roughly doubled the rate, 21% against 10%. Serious adverse reactions were rare, and a Cochrane review concluded that exercise therapy probably reduces fatigue at the end of treatment.

The case against, as patients' groups and the trial's critics make it. The PACE team changed its main outcomes in 2010, after the trial had begun, and a 2018 reanalysis of data released under freedom-of-information law, by Carolyn Wilshire and colleagues, applied the original definitions. Recovery never exceeded 8% in any group, with no significant effect of treatment, and after correcting for multiple comparisons neither CBT nor graded exercise significantly beat specialist care alone. There were no reliable differences at two years. The outcomes were patients' own ratings in a trial that could not be blinded, while objective measures did not improve, and surveys of patients report frequent harm from graded exercise. Britain's National Institute for Health and Care Excellence (NICE) advised in 2021 against offering graded exercise therapy or any fixed-increment exercise program to people with ME/CFS.

The evidence between them. The benefits in PACE were modest, self-reported, and fragile to the choice of outcome, and the trials excluded the most severely ill, so they cannot show safety for them. Post-exertional malaise is a real and distinctive feature that a fixed schedule ignores. On the other side, inactivity has its own costs, and in long COVID without post-exertional malaise, supervised rehabilitation trials have reported modest gains.

The course's reading. Contested, with the weight of current guidance against fixed-increment graded exercise for anyone with post-exertional malaise. For those people, activity should be paced to stay within their limits, under specialist guidance. For people with long COVID or fatigue without post-exertional malaise, gradual, symptom-guided rehabilitation is reasonable.

8h. The Colon-Cancer Trial in Absolute Numbers

Worked example — What a 28% lower risk means for 100 patients

In the CHALLENGE trial, 80.3% of the exercise group were alive without recurrence at five years, against 73.9% of the health-education group, a difference of 6.4 percentage points. Dividing 100 by 6.4 gives about 16: for every 16 patients who take up the program, one more is alive and free of cancer at five years. At eight years, 90.3% of the exercise group were alive against 83.2%, a difference of 7.1 points, so about 14 patients needed to exercise for one more to be alive. The cost was a rise in muscle and joint problems, mostly minor, from 11.5% to 18.5% of patients, or about one extra problem for every 14 patients. A relative reduction of 28% sounds larger than six points, and a reduction of six points sounds smaller than one life in 16; both describe the same result, and patients deciding whether to commit three years to a program deserve both. The numbers apply to people who had finished chemotherapy for colon cancer and were willing to join an exercise trial, not to every patient.

Module 8 Key Points

Exercise as Medicine

• Isometric training such as the wall squat lowered systolic blood pressure about 8 mmHg, the most of any kind of exercise.

• Structured exercise lowered HbA1c by 0.67 points in type 2 diabetes; lifestyle change cut new diabetes by 58% in people at risk.

• After colon-cancer chemotherapy, three years of structured exercise cut recurrence or death by 28%: one more survivor free of cancer per 16 patients.

• Exercise treats depression, with walking, yoga, and strength training among the most effective, though the trials are small and short.

• Graded exercise for ME/CFS is contested; current guidance advises pacing, not fixed increases, for people with post-exertional malaise.

Module 8 Quiz

Check Your Understanding

1. In the 2023 network meta-analysis of 270 trials, which kind of training lowered resting blood pressure the most?

A) High-intensity interval training
B) Isometric
C) Aerobic training such as brisk walking
D) Heavy dynamic resistance training

2. What did the 2021 Cochrane review find about cardiac rehabilitation over about a year of follow-up?

A) Deaths fell by half
B) It raised the risk of a second heart attack
C) Fewer heart attacks and hospital admissions, but no clear change in deaths
D) It reduced deaths and heart attacks only in men under 60 who trained for at least two years

3. How did the 2016 pooled analysis of 1.44 million adults find leisure activity related to cancer?

A) Lower risk of 13 of 26 cancers
B) Lower risk of all cancers
C) No link once body weight was counted
D) Higher risk of most cancers, because active people are screened more often

4. What did the 2018 reanalysis of the PACE trial, using the original protocol's definitions, find?

A) Graded exercise cured most patients
B) Recovery never exceeded 8% in any group, and after correcting for multiple comparisons graded exercise did not significantly beat specialist care
C) Graded exercise doubled recovery rates
D) Pacing worked better than all other treatments

5. In the CHALLENGE trial, about how many patients needed to take up the exercise program for one more to be alive and cancer-free at five years?

A) About 2, since exercise halved the risk
B) About 100, because the effect was tiny
C) About 50, the same as for most cancer drugs
D) About 16

Module 9 — Through the Lifespan

Fitting the Dose to the Stage of Life

Recommended Reading / Reference

Book: Peter Attia with Bill Gifford, *Outlive: The Science and Art of Longevity* (2023)

Reference: American College of Obstetricians and Gynecologists, Committee Opinion No. 804, "Physical Activity and Exercise During Pregnancy and the Postpartum Period" (2020)

9a. Children and Teenagers

Children's guidelines ask for more activity than adults' (Module 1), and only a minority of American teenagers meet them. Activity in childhood builds the bone mass, motor skills, and habits that later life draws on, and the gains in bone are largest before and during puberty. The aim is plenty of varied, playful, vigorous activity rather than adult-style training.

Strength training is safe for children and teenagers when it is supervised and properly designed. The American Academy of Pediatrics' 2020 clinical report concluded that it improves strength, bone health, motor skills, and confidence, may reduce sports injuries, and has not been shown to damage growth plates or stunt growth, a long-standing fear. Children can start whenever they can follow instructions, usually around seven or eight, with body weight and light loads and an emphasis on technique.

The greater risk for young athletes is too much of one thing. The academy's reports on intensive training, the latest published in 2024, warn that early specialization in a single sport raises the risk of overuse injuries and burnout, and they advise playing several sports, delaying specialization until mid-adolescence for most sports, and taking regular days and months away from organized training.

American schools are also bringing back a fitness test. An executive order signed on July 31, 2025 reestablished the Presidential Fitness Test, to be administered by the Department of Health and Human Services (HHS), and revived a presidential council to recommend how to restore it as the main assessment for a Presidential Fitness Award. The original test, given from the 1960s until 2012, scored events such as the mile run, sit-ups, pull-ups, and a shuttle run against national percentiles and rewarded the top 15%; it was replaced in 2012 by a program that judged children against health standards rather than against each other. As of October 2026, states including Mississippi and Virginia had moved to adopt the revived test, with Virginia aiming to do so by the 2026-27 school year, and the Defense Department had announced that its schools would require it.

Supporters see the test as a spur to fitness at a time of rising childhood obesity, while critics argue that ranking children against one another discourages the least fit, who need activity most. Either way, a test measures fitness rather than building it, and what moves children's health is daily activity in school and out of it.

9b. Pregnancy

Exercise in an uncomplicated pregnancy is safe and beneficial. The American College of Obstetricians and Gynecologists advises at least 150 minutes a week of moderate aerobic activity, and women who were vigorously active before pregnancy can generally continue, adjusting as the pregnancy advances. A 2018 meta-analysis in the *British Journal of Sports Medicine* by Margie Davenport and colleagues, covering 106

studies and 273,182 women, found that programs of exercise alone cut the odds of gestational diabetes by 38%, gestational hypertension by 39%, and preeclampsia by 41%. Reductions of at least a quarter required about 600 MET-minutes a week (METs multiplied by minutes), roughly 140 to 150 minutes of brisk walking.

Heavy lifting in pregnancy is less studied. A 2023 survey by Davenport's group of 679 women who had lifted at least 80% of their maximum while pregnant found that 66% reported no complications in pregnancy or delivery, that those who kept training until delivery reported fewer complications, and that Olympic lifts, lifting while lying on the back, and breath-holding were not linked to worse outcomes. The women chose themselves for the survey and there was no comparison group, so the finding reassures experienced lifters without proving safety for everyone.

Some complications make exercise unsafe, and any woman who is pregnant should agree her plan with her maternity care provider. Warning signs to stop and seek care include vaginal bleeding, regular painful contractions, leaking fluid, dizziness or fainting, chest pain, and pain or swelling in a calf. Pelvic-floor exercises during and after pregnancy reduce the urinary leakage that is common afterward, and a gradual return to training after birth starts with walking and those exercises.

9c. Menopause

Menopause speeds several of the changes that exercise opposes. Long-term studies of women through the transition, notably the American Study of Women's Health Across the Nation, show bone loss accelerating from about a year before the final menstrual period to about two years after it, then slowing. Muscle and strength decline, fat shifts toward the abdomen, and the risk of heart disease begins to catch up with men's.

The response is the program in the rest of this course, with two priorities. Strength training on at least two days a week, progressing to heavy loads, and impact work are the main defenses for bone and muscle (Module 3 sets out the evidence and the cautions for thin bones), and enough protein supports them (Module 7). Aerobic training protects the heart as it does at any age. The menopause transition is an especially good time to start lifting, because the losses it accelerates are easier to prevent than to reverse.

9d. Old Age and Frailty

Frailty is a state of low reserve in which a minor illness or fall can tip a person into disability. Its most used definition, from Linda Fried and colleagues in 2001, requires three or more of five features: unintended weight loss, exhaustion, weak grip, slow walking, and low activity. Surveys put it at roughly one in ten people over 65 living at home, rising steeply with age, with many more in an intermediate pre-frail state.

Exercise is the main treatment: international guidelines on frailty recommend multicomponent programs built on progressive resistance training, with balance and aerobic work, and the trials discussed earlier show what they can do for strength in frail 90-year-olds (Module 3), for falls (Module 5), and for mobility disability (Module 1). The common errors in old age are starting too gently and never progressing, so that the exercise never becomes hard enough to change anything, and stopping during illness without restarting afterward.

9e. Starting from Zero

Most people can start without seeing a doctor first. The ACSM's 2015 screening advice dropped the old practice of counting risk factors and asks three questions instead: does the person exercise now, do they have known heart, metabolic, or kidney disease, and do they have symptoms that suggest it? The table gives its answers.

Situation	Advice
Not exercising now; no known disease; no symptoms	No medical clearance needed. Start at light to moderate intensity and progress gradually
Not exercising now; known heart, metabolic, or kidney disease; no symptoms	Medical clearance recommended before starting
Exercising now; known disease; no symptoms	Continue at moderate intensity; get clearance before moving to vigorous exercise
Anyone with symptoms such as chest pain, unusual breathlessness, fainting, or palpitations	Medical clearance recommended; people already exercising should stop until cleared

Source: Riebe et al., "Updating ACSM's Recommendations for Exercise Preparticipation Health Screening," Medicine & Science in Sports & Exercise, 2015.

For a beginner, the first goal is the habit, not the dose. Sessions of 10 to 20 minutes, done often, build it more surely than long sessions done rarely, and the first strength sessions use light loads to learn the movements. The hard sessions of Module 2 and the heavy loads of Module 3 come after a month or two, when the body and the habit can take them, and Module 12 deals with keeping going.

9f. A 70-Year-Old's First Six Months

Worked example — From sedentary to strong

A 70-year-old woman who has not exercised in years has no known heart, metabolic, or kidney disease and no symptoms, so she can start without clearance. Her baseline, using the tests in Module 5: 8 chair stands in 30 seconds, below average for women of 70 to 74 (fewer than 10); a gait speed of 0.9 meters per second; she cannot stand 10 seconds on one leg; and she scores 4 on the sit-to-rise test, using both hands and a knee. Months one and two: a 10-minute walk every day, building to 20 minutes; two strength sessions a week of sit-to-stands from a chair, push-ups against a wall, band rows, step-ups onto a low step, and carrying light shopping bags, two sets of 10 to 12 each; and five minutes of balance practice daily, holding the back of a chair. Months three and four: brisk walking reaches 150 minutes a week; strength sessions rise to three sets, adding a goblet squat with a light dumbbell, a hinge with a kettlebell, and fast chair rises for power; balance progresses to heel-to-toe standing without support; and she joins a weekly tai chi class. Months five and six: loads rise until 8 to 12 repetitions are hard; one walk a week becomes a longer route with a hill; and she practises getting down to the floor and up again. At six months she retests: 13 chair stands, a gait speed of 1.05 meters per second, 10 seconds on each leg, and a sit-to-rise score of 8. Each result has moved from a higher-risk band to a lower one, which is the practical meaning of the trials, and her plan for the next six months is to keep progressing the loads.

Module 9 Key Points

Through the Lifespan

• Strength training is safe for supervised children; the greater risk for young athletes is early specialization in one sport.

• In pregnancy, exercise alone cut the odds of gestational diabetes, gestational hypertension, and preeclampsia by roughly 40% in a 2018 meta-analysis.

• Bone loss speeds up around the final menstrual period, making the menopause transition an especially good time to start lifting.

• Frailty, affecting about one in ten people over 65, responds to multicomponent programs built on progressive strength training.

• Inactive adults with no known disease or symptoms can start light-to-moderate exercise without medical clearance, then build gradually.

Module 9 Quiz

Check Your Understanding

1. What did the 2018 meta-analysis of 106 studies find about exercise in pregnancy?

A) It raised the risk of preterm birth
B) It helped only women who were already athletes
C) It mattered only in the third trimester
D) Exercise-only programs cut the odds of gestational diabetes, gestational hypertension, and preeclampsia by roughly 40%

2. Under the July 2025 executive order, who administers the revived Presidential Fitness Test?

A) Health and Human Services
B) The Secretary of Education
C) Each state's education department
D) The Department of Defense, through its schools

3. What did the 2023 survey of 679 women who lifted heavy weights while pregnant find?

A) Most had complications
B) Lifting heavy weights led to premature labor in most of the women who kept deadlifting
C) Two-thirds reported no complications in pregnancy or delivery
D) Women who stopped lifting early in pregnancy had the fewest complications at delivery

4. Under the ACSM's 2015 screening advice, who should get medical clearance before starting to exercise?

A) Everyone over 40
B) Inactive people with known heart, metabolic, or kidney disease
C) Anyone with two or more risk factors
D) Only people who plan to run marathons or lift heavy weights, whatever their health

5. What happens to bone loss around the menopause transition, according to long-term studies of women?

A) It stops entirely for five years
B) It speeds up
C) It slows, as activity tends to rise
D) It affects only the wrist and forearm

Module 10 — Risk: Injury, the Heart, and Enhancement

What Can Go Wrong, and What Is Sold to Speed Things Up

Recommended Reading / Reference

Book: John Mandrola, Lennard Zinn, and Chris Case, *The Haywire Heart: How Too Much Exercise Can Kill You, and What You Can Do to Protect Your Heart* (2017)

Paper: A. Michael Lincoff and colleagues, "Cardiovascular Safety of Testosterone-Replacement Therapy" (the TRAVERSE trial), *New England Journal of Medicine* (2023)

10a. How People Get Hurt

Most exercise injuries are overuse injuries, built up over weeks when tissues are loaded faster than they can adapt, rather than sudden accidents. Running shows the pattern most clearly. A 2015 meta-analysis of 13 studies by Solvej Videbæk and colleagues found 17.8 injuries per 1,000 hours of running among novices, against 7.7 among established recreational runners: the newcomer, whose heart and lungs adapt in weeks but whose tendons and bones take months, is hurt more than twice as often per hour.

Lifting weights, often thought dangerous, is among the safer ways to train. Reviews report about two to three injuries per 1,000 hours of training in weightlifting, one to four in powerlifting, and fewer than one in bodybuilding, mostly to the shoulder, lower back, and knee, which is lower than the rate for running. The common causes across activities are the same: a sudden jump in training, a return after a break at the old level, poor sleep, and a previous injury that has not fully recovered.

The familiar "10% rule", never increasing weekly running by more than a tenth, has been tested once and failed. In a 2008 Dutch trial of 532 novice runners preparing for a four-mile race, a 13-week graded program that kept increases to 10% a week injured 20.8% of runners, against 20.3% on a standard 8-week program. A more elaborate idea, the acute-to-chronic workload ratio, compares the past week's load with the past month's and was proposed in 2016 as a guide to a "sweet spot" of low injury risk. Statisticians have since shown that the ratio is partly an artifact of how it is calculated, and its leading critics have argued that it should be dismissed as a basis for setting thresholds.

What the evidence supports is plainer: avoid spikes. A 2025 study of about 5,200 runners whose runs were recorded by GPS watches found that a single run more than 10% longer than the longest of the previous 30 days raised the injury rate by half or more, while week-to-week ratios of load did not predict injury. The practical rules follow: change one thing at a time, distance, speed, or load; keep the longest session within about a tenth of the longest of the past month; and after a break, return at a fraction of the old level and build back. Strength training itself prevents injuries in other sports (Module 5).

10b. The Heart During Exercise and at Races

Exercise protects the heart over years, but vigorous exertion briefly raises the risk of a cardiac event. The American Heart Association's 2020 scientific statement puts the rise at 3 to 17 times for sudden cardiac death during and for 30 minutes after vigorous exercise, and 2 to 10 times for a heart attack within an hour. The absolute risk is small, and it is lowest in people who exercise regularly: in a classic study of American male physicians, the transient risk was far smaller in men who exercised vigorously five or more times a

week than in those who rarely did. In middle-aged adults, most exercise-related sudden deaths come from existing coronary disease.

Races provide the best counts. The Race Associated Cardiac Event Registry (RACER), published in *JAMA* in 2025, found 176 cardiac arrests among 29.3 million finishers of American marathons and half marathons from 2010 to 2023, a rate of 0.60 per 100,000, higher in men (1.12) than in women (0.19) and in the marathon (1.04) than in the half (0.47). Only 34% of the arrests were fatal, against 71% in the decade before, and the cardiac death rate halved, from 0.39 to 0.20 per 100,000. The difference was resuscitation: bystander cardiopulmonary resuscitation (CPR) and defibrillators were used in nearly every case with full records, and experts aim for under three minutes from collapse to shock.

Screening athletes with an electrocardiogram (ECG) divides experts. Italy has required ECG screening for competitive athletes since 1982 and credits it with fewer sudden deaths, while the American Heart Association does not support routine ECG screening of young athletes, because of false positives, and relies on a history and examination. For adults starting to exercise, the screening questions and warning symptoms in Module 9 apply.

Heat is the other acute danger: exertional heat stroke, in which body temperature passes about 40 °C and the brain begins to fail, causing confusion or collapse, is treated by immediate whole-body immersion in cold water at the scene, "cool first, transport second"; with prompt cooling, nearly everyone survives.

10c. Can Endurance Exercise Be Too Much?

The case for harm, as some cardiologists and former athletes make it. Decades of very high endurance training may remodel the heart in ways that cause trouble. A 2021 meta-analysis in the *British Journal of Sports Medicine* pooled 13 studies with 70,478 people and found that athletes had 2.46 times the odds of atrial fibrillation, which raises the risk of stroke; in athletes under 55 the odds were 3.6 times. In a cohort of 52,755 Swedish long-distance cross-country skiers, those who completed the most races and finished fastest had more heart-rhythm disorders. The most active middle-aged men also have more calcium in their coronary arteries, and in the Dutch MARC-2 study of 289 male amateur athletes, published in 2023, very vigorous exercise was linked to faster progression of calcium over six years.

The case against, as most exercise cardiologists make it. The outcome that matters is survival, and fitness and activity predict longer life with no upper limit found in the largest studies (Module 2). The coronary calcium of athletes is mostly dense and calcified, a kind of plaque thought less likely to rupture, and in MARC-2 the total volume of exercise was not linked to its progression. Studies suggesting a U-shaped curve, in which the hardest joggers lose the benefit, have rested on tiny groups: the much-cited Copenhagen finding had only 40 strenuous joggers and 2 deaths. Riders in the Tour de France, among the most heavily trained people ever studied, have lived longer than the general population.

The evidence between them. The raised risk of atrial fibrillation is real but concentrated in long-term endurance athletes, especially those under 55, and the absolute increase is modest. The meaning of athletes' coronary calcium is unknown, because no study has followed enough of them to see whether it causes heart attacks. No study shows that high training volumes shorten life.

The course's reading. Probable: decades of very high endurance volumes raise the risk of atrial fibrillation somewhat, without evidence of shorter life. For people training within this course's targets the question does not arise, and endurance athletes who notice palpitations, an irregular pulse, or a drop in performance they cannot explain should have their heart checked.

10d. Testosterone, Steroids, and Peptides

Testosterone treats a real deficiency: the TRAVERSE trial, published in 2023, gave testosterone gel or a placebo to 5,246 men aged 45 to 80 with symptoms and low testosterone and with heart disease or a high risk of it. Major cardiovascular events were no more common with testosterone, 7.0% against 7.3%, though atrial fibrillation, acute kidney injury, and blood clots in the lung were slightly more frequent. In February 2025 the Food and Drug Administration (FDA) removed the cardiovascular-risk language from the boxed warning on testosterone products, added a warning that they raise blood pressure, and kept the limitation that they are not approved for low testosterone due to ageing alone.

Prescribing is rising again: an analysis of health records by Epic Research, published in July 2026, found that the share of American men with an active testosterone prescription fell from a peak of 0.83% in 2013 to 0.64% in 2021, then rose to 0.93% in 2025. The rise coincided with the growth of online men's-health clinics, though the analysis did not measure their share. The Endocrine Society advises diagnosing deficiency only when symptoms come with consistently low morning testosterone on repeated tests. Testosterone also suppresses sperm production and can raise the red-cell count, so it is not a training aid for men with normal levels. **Grade: settled for diagnosed deficiency; marketing as a performance or anti-ageing aid.**

Anabolic steroids, testosterone and related drugs taken in doses far above the body's own production to build muscle, work and carry heavy costs. An estimated three to four million Americans have used them, and studies of long-term users find weaker heart pumping, more coronary plaque, infertility, mood disturbance, and dependence. Selective androgen receptor modulators (SARMs), sold as safer alternatives, are not approved for any use, have been linked to liver injury, and are banned in sport. **Grade: settled, for harm.**

Peptides are the newest market: these short chains of amino acids, such as BPC-157 and TB-500, are sold through compounding pharmacies, which mix drugs to order, and online for healing and recovery. In February 2026 the HHS secretary announced that most of the peptides the FDA had listed as raising significant safety concerns would be moved to a category that allows compounding while they are reviewed. In July 2026 an FDA advisory committee voted to recommend six of them, including BPC-157 and TB-500, for the list of substances pharmacies may compound, against the advice of FDA staff, who cited an absence of human data. As of October 2026 the FDA had not acted on the recommendations, which do not bind it.

The staff had a point: a 2025 systematic review of BPC-157 found 36 studies, of which 35 were in animals or cells; the one human study was an uncontrolled series of 12 patients with knee pain, and the reviewers concluded that its safety in humans remains unknown. The World Anti-Doping Agency (WADA) bans it. **Grade: no human evidence; marketing.**

10e. A Marathon's Risk Beside a Sedentary Year's

Worked example — Race day against a year on the couch

Take 100,000 American men of 50. If they run a marathon, the marathon rate in Section 10b gives about 1.04 cardiac arrests among them on race day, and if about a third prove fatal, as across the registry, about 0.35 deaths. That rate mixes men and women, so men's is somewhat higher, though doubling it would not change the conclusion. Now suppose instead they spend a year inactive. National life tables put the yearly death risk for men of 50 at roughly 0.5%, or about 500 per 100,000. Module 1's pooled cohorts found a 31% lower risk of death in people doing one to two times the guideline minimum; applied to these men, being active would mean about 155 fewer deaths a year, and if only half of that association is causal, as Module 1 suggests may be, about 78 fewer. Race day's 0.35 deaths are therefore between about 220 and 440 times fewer than the deaths a sedentary year costs. Women's race risk is lower still, about a sixth of men's. The comparison flatters neither side unfairly: the marathoner's training year is itself an active year, and race-day risk falls further with a defibrillator nearby. What the numbers say is that the dangers of exercise are real enough to respect, through gradual training, attention to symptoms, and knowing CPR, and small beside the danger of not doing it.

Module 10 Key Points

Risk: Injury, the Heart, and Enhancement

• Novices were injured over twice as often per hour as established runners; avoid sudden spikes rather than relying on a 10% rule.

• Race cardiac arrests occur in about 0.6 per 100,000 finishers, and two-thirds now survive, thanks mainly to bystander CPR and defibrillators.

• Endurance athletes have about 2.5 times the odds of atrial fibrillation, but no study shows that high training volumes shorten life.

• Testosterone treats diagnosed deficiency, and its heart-risk warning was removed in 2025; it is not a training aid for men with normal levels.

• BPC-157 and similar peptides have almost no human evidence: one uncontrolled report of 12 patients among 36 studies.

Module 10 Quiz

Check Your Understanding

1. What did the 2008 trial of 532 novice runners find about the "10% rule"?

A) It halved injuries

B) It doubled injuries in women

C) A 13-week program that raised running by no more than 10% a week injured about as many runners as a standard 8-week program

D) It worked only for runners over 50

2. In the RACER registry of 2010 to 2023, what share of cardiac arrests at races were fatal?

A) About a third

B) Nearly all

C) About 71%, as in the 2000s

D) About 90%, the same as before 2010

3. What did the 2021 meta-analysis of 13 studies find about athletes and atrial fibrillation?

A) No higher risk

B) Ten times the odds

C) Higher odds only in women over 55 who ran more than five marathons a year

D) About 2.5 times the odds, and higher still under 55

4. What did the FDA change on testosterone labels in February 2025?

A) It banned testosterone gels

B) It removed the heart-risk language from the boxed warning and added a blood-pressure warning

C) It approved testosterone for healthy men

D) It approved testosterone to treat age-related low testosterone in men over 65 who have no symptoms of any kind

5. How much human clinical evidence did a 2025 systematic review find for BPC-157?

A) Several large trials showing faster tendon healing

B) A phase 3 trial that led to FDA approval in 2024

C) One small uncontrolled report

D) Dozens of placebo-controlled trials in athletes

Module 11 — Measuring

The Few Numbers That Predict

Recommended Reading / Reference

Paper: Cailbhe Doherty and colleagues, "Keeping Pace with Wearables: A Living Umbrella Review of Systematic Reviews Evaluating the Accuracy of Consumer Wearable Technologies in Health Measurement," *Sports Medicine* (2024)

Reference: American College of Sports Medicine, *ACSM's Guidelines for Exercise Testing and Prescription* (twelfth edition, 2025)

11a. The Tests That Matter

Measuring serves two purposes: to find the weak link worth training, and to see whether the training is working. A handful of tests, most of which predict health in large studies, cover the abilities this course trains, and the table gathers them with the module that gives the norms or the method.

Test	How	What it shows
Resting heart rate	Count for a full minute on waking on several mornings, or use a wearable's overnight figure	Aerobic fitness and recovery; in a 2016 meta-analysis of 46 cohorts, each 10 beats a minute higher went with about 9% higher mortality
Blood pressure	A validated upper-arm cuff at home, two readings morning and evening for a week	A major treatable risk (Module 8)
Estimated VO2 max	The 12-minute run (Module 2)	The strongest single predictor of survival (Module 2)
Grip strength	A hand dynamometer, best of three tries with each hand	Overall strength (Module 3)
Push-ups	As many as possible with good form, without stopping	Upper-body strength and endurance; in a study of 1,104 male firefighters, those who managed more than 40 had 96% fewer cardiovascular events over ten years than those who managed fewer than 10
Chair stands, gait speed, one-leg stand, sit-to-rise	As in Module 5	Strength, power, balance, and mobility, with norms (Module 5)
Waist-to-height ratio	Waist at the midpoint between the lowest rib and the top of the hip bone, divided by height	Abdominal fat; Britain's NICE advises keeping the waist below half of height, with 0.5-0.59 marking increased risk and 0.6 or more high risk
Estimated one-repetition maximum	The Epley estimate from a set near failure (Module 3)	Progress in strength on a given lift

The firefighter study had few events and only young, active men, so its figure is a striking association rather than a norm.

The slow-changing measures, fitness, strength, and the functional tests, are worth repeating every three months, which is long enough for training to show. Blood pressure and waist can be checked monthly or after any change in the program, and resting heart rate and heart-rate variability daily only if they are used to steer training (Module 6). The point of a baseline is comparison with oneself, so the same test, done the same way at the same time of day, matters more than any norm.

11b. What Wearables Measure Well and Badly

Watches, rings, and chest straps now measure much of what used to need a laboratory, with very uneven accuracy. The best summary is a 2024 living umbrella review in *Sports Medicine* by Cailbhe Doherty and colleagues, which gathered 24 systematic reviews covering 249 studies and 430,465 participants and is updated as new studies appear. It found that only about 11% of the 310 consumer wearables it identified had been validated for even one measure.

Measure	Typical accuracy	Use it for
Heart rate	Within about 3% on average; worse during vigorous or jerky movement	Training zones and resting heart rate
Heart rhythm (atrial fibrillation)	Sensitivity 100% and specificity 95%, in studies mostly of people already diagnosed	A prompt to see a doctor, not a diagnosis
Heart-rate variability	Excellent agreement at rest; worse with movement	Morning or overnight trends (Module 6)
Steps	From about 9% too few to 12% too many	Daily trends
Energy expenditure	From about 21% too low to 15% too high	Little: calories burned are not worth eating back
Exercise intensity	Errors of 29-80%	Little
Sleep	Overestimates total sleep, usually by more than 10%, and underestimates time awake	Rough trends in timing and duration
VO2 max estimate	Overestimates by about 15% from resting data and about 10% from exercise data	Trends, if the device uses data from exercise
Blood oxygen	Within about 2% in the one watch studied	Little for healthy people

Source: Doherty et al., Sports Medicine, 2024. Sensitivity is the share of true cases a test catches; specificity is the share of people without the condition whom it correctly clears.

Wearables are also moving into medical territory: in September 2025 the FDA cleared an Apple Watch feature that analyzes 30 days of optical pulse data and notifies users who may have high blood pressure, advising a week of home readings with a cuff. In its validation, the feature flagged 41.2% of people whose blood pressure was 130/80 or higher and correctly left alone 92.3% of those below it. A notification is therefore a good reason to measure properly, but the absence of one says little, since it misses most people with high pressure.

Regulation has also loosened: guidance the FDA issued on January 6, 2026 lets wearables that estimate blood pressure count as general wellness products, outside the agency's review, provided they do not present clinical values, name diseases or thresholds, or prompt clinical action. More devices will therefore offer numbers that no regulator has checked, and they deserve the skepticism the table suggests.

11c. Body Composition

Weight alone cannot tell fat from muscle, which matters when training builds one while a diet removes the other. Dual-energy X-ray absorptiometry (DXA), the scan used for bone density, also measures fat, lean mass, and bone region by region, with good repeatability and a very small radiation dose, and it is the practical reference for tracking change. Bioelectrical impedance, used by bathroom scales and handheld devices, estimates body fat from how a weak current passes through the body; it is sensitive to hydration, recent meals, and exercise, and for an individual it can be off by several percentage points, so only its trend under the same conditions means much.

Cheaper measures do most of the work: waist circumference and the waist-to-height ratio track the abdominal fat that carries the most risk, and the loads lifted, the fit of clothes, and progress photographs show the direction of change. For someone losing weight, a scan every six months or so can confirm that most of the loss is fat, and Module 3 covers the special case of the GLP-1 drugs.

11d. Do Wearables Make People Healthier?

The case for, as device makers and digital-health researchers make it. A 2022 umbrella review in *The Lancet Digital Health*, by Ty Ferguson and colleagues, gathered 39 systematic reviews and found that activity trackers raised activity by about 1,800 steps a day, roughly 40 minutes of walking, and produced about a kilogram of weight loss. Watches detect atrial fibrillation that would otherwise go unnoticed until a stroke, and the new blood-pressure alerts will find some of the many people with undiagnosed hypertension. Feedback, goals, and the social features of apps help people keep going, and they cost little.

The case against, as skeptics make it. In the IDEA trial, published in *JAMA* in 2016, 471 young adults with overweight or obesity in a two-year weight-loss program were given either a wearable armband or standard self-monitoring. The armband group lost less weight, 3.5 kilograms against 5.9. The gains in steps in other trials are measured over weeks or months and fade, the people who buy trackers are already healthier and more motivated than those who do not, most devices have never been validated, and false alarms send healthy people to doctors.

The evidence between them. Trackers modestly raise activity in trials, mostly in the short term, and no trial shows an effect on disease or death. The IDEA result shows that within a structured program a device can distract rather than help. Accuracy is good for heart rate and steps and poor for calories and fitness estimates, so the same device can be useful for one purpose and misleading for another.

The course's reading. Probable that trackers help some people move more, at least for a while. Treat heart rate and steps as useful, calories and VO2 max estimates as rough, and any medical alert as a reason for a proper test, not a diagnosis; and if checking the numbers becomes a source of worry, put the device away.

11e. A Personal Baseline in an Hour

Worked example — A 52-year-old's first measurements

A 52-year-old woman, 165 centimeters tall and weighing 72 kilograms, sets aside an hour on a Saturday morning. Before getting up, she counts a resting heart rate of 64 beats a minute, close to the overnight figure on her watch. Her home cuff readings over the previous week averaged 128/82, above the 120/80 regarded as normal. Her waist measures 84 centimeters, so her waist-to-height ratio is 84 ÷ 165 = 0.51, just over the line NICE draws at half of height. After a 10-minute warm-up she covers 1,600 meters in the 12-minute run, which gives an estimated VO2 max of (1,600 − 504.9) ÷ 44.73 = 24.5, just above the median for her decade in Module 2's table. Her best grip is 27 kilograms; she manages 8 full push-ups; she stands 10 seconds on each leg; and she scores 9 on the sit-to-rise test, putting one hand down to rise. The whole session, with rests, takes about an hour, and she records every number with the date and time. Her weak links are blood pressure and upper-body strength, not aerobic fitness or balance, so her first three months add isometric wall squats three times a week (Module 8) and push-up progressions in two strength sessions to her walking and a weekly interval session. She will show the week of blood-pressure readings to her doctor and retest everything in three months, under the same conditions.

Module 11 Key Points

Measuring

• A baseline in an hour: resting heart rate, home blood pressure, waist-to-height ratio, a 12-minute run, grip, push-ups, and functional tests.

• Wearables measure heart rate within about 3% but energy burned only within about -21% to +15%; few devices have been validated.

• Watches overestimate VO2 max by roughly 10-15%, so treat the figure as a trend rather than a measurement.

• Apple's blood-pressure alert caught 41% of people with high pressure, so the absence of an alert does not mean normal pressure.

• Trackers raise daily steps modestly, but in a two-year trial adding one led to less weight loss than standard self-monitoring.

Module 11 Quiz

Check Your Understanding

1. According to the 2024 umbrella review, how accurately do wearables estimate energy expenditure?

A) Within 1%
B) Within 5% for all devices
C) Accurately for walking, but not at all for sleep
D) Poorly: errors ranged from about 21% too low to 15% too high, far wider than for heart rate

2. In its validation, what share of people with high blood pressure did Apple's hypertension notification flag?

A) About 41%
B) 100%
C) About 92%, so it catches nearly everyone
D) About 75%, similar to a cuff reading at home

3. What did the two-year IDEA trial find about wearable activity monitors in young adults trying to lose weight?

A) They doubled weight loss
B) They made no difference to weight
C) They helped only men who already exercised
D) Those given the armband lost less weight, 3.5 kg against 5.9 kg with standard self-monitoring

4. NICE advises keeping the waist below half of what?

A) Height
B) Hip circumference
C) Chest circumference
D) Shoulder width times two

5. By how much do wearables overestimate VO2 max when they base the estimate on resting data, according to the 2024 review?

A) Not at all
B) By about 50%, so the figure is useless
C) By about 15%
D) By about 2%, the same as a laboratory treadmill test

Module 12 — The Program: A Week, a Year, a Decade

Putting It Together and Keeping It Going

Recommended Reading / Reference

Book: Michelle Segar, *No Sweat: How the Simple Science of Motivation Can Bring You a Lifetime of Fitness* (2015)

Paper: Moritz Schumann and colleagues, "Compatibility of Concurrent Aerobic and Strength Training for Skeletal Muscle Size and Function: An Updated Systematic Review and Meta-Analysis," *Sports Medicine* (2022)

12a. Weekly Plans for 2, 4, 6, and 10 Hours

The modules so far give the parts; a week has to fit them into the time a person actually has. The table shows how the balance shifts as the hours grow. At two hours, strength training and one hard aerobic session carry most of the load, and daily walking supplies the rest of the aerobic minimum. From four hours, easy aerobic volume grows; at six hours a third strength session becomes possible, and at ten a second hard aerobic session. Section 12f sets out the four-hour week session by session. Counting strength sessions as moderate activity and hard minutes double, four hours a week comes to about 1.7 times the guideline minimum and six hours to about 2.4 times.

Hours a week	Strength	Hard aerobic	Easy aerobic	Balance and mobility
2	Two full-body sessions of 35 minutes, with supersets	One interval session of 25 minutes	One session of 25 minutes, plus daily walking	The daily ten-minute sequence, outside the two hours
4	Two full-body sessions of 50 minutes	One 4×4 session of 40 minutes	One session of 40 minutes and a long one of 60	As above
6	Three full-body sessions of 45 minutes	One interval session of 40 minutes	Two sessions of 45 minutes and a long one of 75	Two 10-minute blocks inside the six hours
10	Three sessions of 50 minutes	Two sessions of 45 minutes, one of intervals and one of tempo	Three sessions of 60 minutes and a long one of two hours	An hour a week, including a class such as yoga or tai chi

Each plan meets the guidelines' aerobic minimum, counting a minute of hard effort as two of moderate, and trains every major muscle group at least twice a week. The routines at the back give the strength sessions.

Two principles shape every version: hard days and easy days alternate where the week allows, so that the hard sessions are done fresh, and the order of priorities decides what survives a busy week: strength twice and one hard aerobic session first, then easy volume. Anything the plan cannot fit is better dropped than squeezed, because a plan that is kept beats a better one that is abandoned.

12b. Combining Strength and Endurance

For years lifters were warned that aerobic training would cost them muscle, an idea called the interference effect. The best current evidence says the fear is mostly misplaced. A 2022 meta-analysis in *Sports Medicine* by Moritz Schumann and colleagues pooled 43 studies with 1,090 participants and found that

combining aerobic and strength training did not compromise gains in muscle size or maximal strength compared with strength training alone. Gains in explosive strength were smaller, especially when both kinds of training were done in the same session, and not when the sessions were at least three hours apart. The order of exercise within a session, training status, and age made no difference.

The practical rules are light: where possible, put hard aerobic and heavy strength sessions on different days or at least three hours apart; where they must share a session, do first whichever matters more that day. People training for power, such as older adults working on fast chair rises or athletes who jump and sprint, gain most from the separation. Easy aerobic work interferes little with anything.

12c. Progression, Interruptions, and Detraining

A program progresses by asking for a little more once the current demand becomes easy, one variable at a time: repetitions and then load in strength work (Module 3's worked example), and duration and then intensity in aerobic work. Over a year it helps to shift emphasis every two or three months, toward strength in one block and aerobic fitness or a sporting goal in another, mainly to keep training interesting. Elaborate periodization schemes, which plan such blocks in detail, are optional: the ACSM's 2026 overview found that they did not consistently improve results for ordinary healthy adults.

Interruptions are certain, and what they cost depends on the quality. Aerobic fitness fades fastest: in a classic 1984 study of endurance-trained people who stopped training, VO2 max fell by about 7% in the first 12 days and leveled off after about eight weeks, roughly 16% below its trained level but still above that of sedentary people. Strength fades much more slowly (Module 3). A 2021 review of maintenance studies found that endurance could be held for up to 15 weeks on as few as two sessions a week, or on a third to two-thirds of the usual volume, provided the intensity stayed up.

So the response to a busy month is to cut volume, not intensity, and to keep at least two short sessions a week. After a week or two off, training can resume almost where it stopped. After a month or more, it should restart at about half the old volume and rebuild over a few weeks, because the heart and lungs return faster than the tendons that a full return would load (Module 10).

12d. Why People Quit and What Keeps Them

The hardest part of exercise is continuing: in a 2016 study of 5,240 members of a gym in Rio de Janeiro, about 63% had quit within three months, and fewer than 4% were still attending regularly after a year. Habits take time to form: in a 2010 study by Phillippa Lally and colleagues at University College London, a new daily behavior took a median of 66 days to become automatic, with a range from 18 to 254, and missing a single day did not derail it. The early weeks are the vulnerable ones, and they are when the most deliberate support is needed.

Intensity affects whether people come back: exercise below the first threshold of Module 2 feels pleasant to most people, while effort well above it feels unpleasant to most beginners, and how a session feels predicts whether it is repeated. Beginners therefore do better choosing their own intensity at first and adding hard sessions once the habit holds.

A few techniques have been tested: in a 2014 study by Katherine Milkman and colleagues, people given gripping audiobooks they could listen to only at the gym, a method called temptation bundling, went more often at first, though the effect faded after a holiday break. A 2021 "megastudy" in *Nature* tested 54 four-week programs on 61,293 members of an American gym chain and found that the most effective

offered small rewards for returning after a missed workout, though most effects faded once the programs ended and experts could not predict which would work.

The lessons are practical. Fix the times in the week and treat them as appointments; choose activities that are enjoyable or social, or pair them with something enjoyable; start easier than ambition suggests; and plan for lapses, since the habit that survives is the one that restarts after a missed week, not the one that is never broken.

12e. The Minimum or the Maximum?

The case for doing more, as performance-minded longevity advocates make it. The largest studies of fitness found no level above which survival stopped improving, and the fittest few percent had the lowest death rates of all (Module 2). Function in old age depends on reserve: a person who reaches 70 with high fitness and strength can lose some and still climb stairs, carry shopping, and rise from the floor, so training hard in midlife builds the margin that ageing spends. On this view the guidelines are a floor for populations, not a target for individuals who want the most from exercise.

The case for the minimum, as many public-health researchers make it. The dose-response curve in Module 1 flattens early, so most of the gain comes from moving out of inactivity, and running's benefit to lifespan appears to cap however much is run. Injury risk rises with volume (Module 10), very high endurance volumes raise the risk of atrial fibrillation, and hours spent training have other uses. Telling people they need ten hours a week may deter the many who would benefit from two.

The evidence between them. Both are partly right: for survival, returns diminish sharply after the first few hours a week, while fitness and strength keep rising with more training, and fitness predicts survival without a ceiling. Part of that predictive power reflects genes and health rather than training (Module 2), so the extra fitness that extra hours buy is worth less for lifespan than the correlations suggest, though it is worth something for function.

The course's reading. Settled that the minimum is worth doing; probable that four to six hours a week, including two strength sessions, captures nearly all the health benefit, which by the counting in Section 12a is about twice the minimum. Beyond that, training more buys fitness, function, and performance more than lifespan, and enjoyment and sport are good reasons for it.

12f. The Four-Hour Week

Worked example — Four hours, session by session

Monday, strength A, 50 minutes: an 8-minute warm-up; goblet or back squat, 3 sets of 6 to 8; bench press paired with chest-supported row, 3 sets of 6 to 10 and 8 to 12; Romanian deadlift, 3 sets of 8 to 10; side plank, 2 holds of 30 seconds a side. Tuesday, easy aerobic, 40 minutes: cycling, a jog, or brisk walking at a conversational pace. Wednesday, intervals, 40 minutes: a 10-minute warm-up, then four 4-minute efforts at 90-95% of maximum heart rate with 3 minutes easy between them, and a 5-minute cool-down. Thursday: rest, or the daily ten-minute sequence. Friday, strength B, 50 minutes: deadlift or trap-bar deadlift, 3 sets of 5; overhead press paired with lat pulldown or pull-ups, 3 sets of 6 to 10 each; split squat, 3 sets of 8 to 10 a side; farmer's carry, 3 trips of 30 meters. Saturday, long easy aerobic, 60 minutes: a hike, a ride, or a long walk with hills. Sunday: rest. The total is 50 + 40 + 40 + 50 + 60 = 240 minutes. The aerobic work comes to 100 easy minutes plus a 40-minute interval session whose 16 hard minutes count double, about 156 moderate-equivalent minutes, which clears the guideline's 150. Pushing and pulling are matched at three sets each in both planes, squats and hinges at six sets each, and every major muscle group gets three or more hard sets a week, counting indirect sets as half. When Wednesday must be dropped, Tuesday becomes the interval day; when a strength session must go, the other becomes full body with one set less per exercise; and in a week of travel, two 20-minute hotel-room sessions of push-ups, split squats, and band rows hold the gains.

Module 12 Key Points

The Program: A Week, a Year, a Decade

• Strength and endurance training combine without costing muscle or maximal strength; only explosive strength suffers, mainly when both share a session.

• Aerobic fitness fades within weeks of stopping, but two short sessions a week at full intensity can hold it for months.

• Most new gym members quit within three months; fixed times, enjoyable effort, and planning to restart after lapses keep people going.

• New habits took a median of 66 days to become automatic, and missing a single day did not derail them.

• Four to six hours a week, about twice the guideline minimum with strength sessions counted, captures nearly all of exercise's health benefit.

Module 12 Quiz

Check Your Understanding

1. What did the 2022 meta-analysis of 43 studies find about combining aerobic and strength training?

A) Strength gains halved

B) Muscle growth and maximal strength were not compromised, but explosive strength gains were smaller

C) Aerobic fitness fell

D) Muscle growth and maximal strength were cut by about a third, whatever the order or the gap between sessions

2. In the 2010 study of habit formation, how long did a new daily behavior take to become automatic?

A) Exactly 21 days for everyone

B) One week

C) A median of 66 days, with a wide range, and missing a single day did not derail the habit

D) A year, with no exceptions

3. When does combining aerobic and strength training most reduce the gains in explosive strength?

A) In older adults

B) When the sessions are more than three hours apart

C) When the aerobic work is done after the strength work

D) When both are done in the same session

4. According to the ACSM's 2026 overview, what did elaborate periodization schemes do for ordinary healthy adults?

A) No consistent gain

B) They doubled strength gains

C) They prevented all overuse injuries

D) They were essential for anyone over 40

5. What does the course conclude about training beyond the guidelines for health?

A) More is always healthier

B) About four to six hours a week captures nearly all the health benefit

C) Anything above two hours harms the heart

D) Health benefits keep rising steeply with every extra hour, so ten or more hours a week is the target for everyone

Module 13 — Where Things Stand, and What to Watch

The Argument, the Contradictions, and What Moves Next

Recommended Reading / Reference

Reference: The World Health Organization's global physical activity estimates and the US National Health Interview Survey, the two series that will show whether more people are meeting the guidelines, and ClinicalTrials.gov, where the trials on the watch list are registered

13a. The Argument

The course's argument fits on a page: the body adapts only to what it is asked to do, and the abilities that predict a long and independent life, aerobic fitness, strength, power, and balance, each answer to their own kind of training (Modules 1 to 5). That exercise improves those abilities, and with them blood pressure, blood sugar, mood, and the course of several diseases, is settled by trials (Modules 1 and 8). That it extends life is probable, by less than the cohorts suggest.

The dose that captures most of the benefit is modest: about four to six hours a week, two of them strength sessions that cover the movement patterns and keep pushing and pulling in balance, with one or two hard aerobic sessions among easy ones (Modules 4 and 12). Most of the gain comes from leaving inactivity, and more training buys fitness and performance more than lifespan.

Around that simple core has grown an industry that mostly sells what the evidence does not support: recovery devices and pills, most supplements, peptides, and the readings of unvalidated devices (Modules 6, 7, 10, and 11). The few aids with strong evidence, creatine and caffeine among them, are cheap, and so are the tests that predict best (Modules 2 and 5). The scarce ingredient is the habit (Module 12).

13b. The Contradictions

Read across the modules, the course's evidence leaves five tensions that cut across modules.

- **The strongest predictor is partly beyond reach.** Aerobic fitness predicts survival more strongly than any other measure (Module 2), yet much of trainability is inherited (Module 2), and part of what fitness predicts is health already present (Module 1). The number most worth celebrating is therefore partly a marker of luck, and the part people control is the dose, which is why the course grades the training more confidently than the number it produces.
- **Muscle matters more than its proof.** Strength predicts survival (Module 3) and keeps old people independent (Modules 5 and 9), yet the evidence that strength training extends life is observational and rated very low in certainty (Module 3). Trials count deaths more easily than they count independence, so the evidence understates what muscle is for.
- **What feels like recovery can block what recovery is for.** Cold plunges, high-dose antioxidants, and regular painkillers can make training feel easier while blunting the adaptations it is meant to produce (Module 6), and drinking more feels safe but caused the low blood sodium of Module 7. The method with the strongest evidence, sleep, is free and sells nothing (Module 6).
- **The exercise that feels risky is often the safer one.** Stretching feels protective and heavy lifting dangerous, yet stretching did not prevent injuries (Module 5), lifting injures fewer people per hour than

running (Module 10), and supervised heavy loading built bone in women with thin bones (Module 3). The acute danger that matters most, a cardiac event during exertion, is smallest in those who exercise hard and often (Module 10).

• **Measurement is everywhere and validation is scarce.** Wearables now report heart rhythm, sleep, and fitness, and can flag high blood pressure, but few have been validated for even one measure, and regulators loosened their oversight in 2026 (Module 11). Several tests that predict survival need only a chair, a stopwatch, and a floor (Module 5).

13c. What to Watch

What	When	Why it matters
The third edition of the Physical Activity Guidelines for Americans	Not before 2028; no advisory committee had been named as of mid-2026	Whether it settles the questions the second edition left open: a limit on sitting, targets in steps, and a dose for the balance and power training that older adults need (Modules 1 and 5)
The World Health Organization's 2030 target to cut physical inactivity	2030	On the current trend the world will miss it, with inactivity rising rather than falling (Module 1), which makes the habit problem of Module 12 a population problem
The FDA's response to its advisory committee's July 2026 vote on six peptides	No deadline; a proposed rule, if any, would come first	Approval for compounding would put substances that FDA staff said lack human data into pharmacies (Module 10), testing how far regulators will go without evidence
Trials of muscle-sparing drugs and of exercise alongside GLP-1 weight loss	2026-28	Whether muscle loss on the drugs proves to matter, and whether a drug or the cheaper answer of training and protein protects it (Modules 3 and 7)
Exercise trials in cancer and Parkinson's disease: INTERVAL-GAP4 in advanced prostate cancer, the breast-cancer weight-loss trial known as BWEL, and SPARX3	Main results not yet reported as of October 2026	Survival in advanced cancer and slower progression of Parkinson's would extend exercise from recovery and prevention into disease modification; failures would mark where its limits lie (Module 8)
The revived Presidential Fitness Test in schools	The 2026-27 school year	Whether testing raises children's activity or discourages the least fit (Module 9)
Testosterone prescribing after the 2025 label change	Annual record analyses	Whether the rise reflects better treatment of real deficiency or growing use by men with normal levels, for whom the drug is not indicated (Module 10)
Wearable blood-pressure estimates under the 2026 wellness guidance	Ongoing	Whether unvalidated readings help people find disease earlier or mainly multiply false alarms and false reassurance (Module 11)
The next national figure for adults meeting both the aerobic and the strength guideline	Annual surveys; the latest combined figure is from 2020	Strength is the half of the guidelines that is least met and least measured, so its trend is the best single test of whether the message of Module 3 is landing

13d. The Last Word

Most of this course's figures will move as trials report, and some grades will change. The shape of the evidence is less likely to. The largest gains come from moving out of inactivity, the abilities that fail first in old age are the ones that need specific training, and nearly everything sold as a shortcut either does nothing or costs some of the adaptation it promises to speed.

What remains is ordinary and demanding at once: a few hours a week, some of them hard, kept up for decades. The routines that follow are one way to begin, and the tests of Modules 5 and 11 are the way to know whether they are working.

Module 13 Key Points

Where Things Stand, and What to Watch

• Exercise's effects on fitness, function, and several diseases are settled; its effect on lifespan is probable but smaller than cohorts suggest.

• About four to six hours a week, with two strength sessions and one or two hard aerobic sessions, captures most of the health benefit.

• Fitness is the strongest predictor of survival, but genes shape much of it, so the controllable part is the dose of training.

• Much of the recovery and supplement industry sells comfort or hope; sleep, creatine, and caffeine are among the few aids with strong evidence.

• The trials to watch test whether exercise can slow advanced cancer and Parkinson's disease, beyond its proven roles in prevention and recovery.

Module 13 Quiz

Check Your Understanding

1. Why does the course call aerobic fitness the strongest predictor of survival but only partly within a person's control?

A) It cannot be measured
B) Genes shape both trainability and the health that fitness reflects
C) It falls only after 80
D) Training cannot raise it at all after the age of forty, whatever the dose or the intensity used

2. What tension does the course see in recovery products such as cold plunges and antioxidant pills?

A) They are banned in sport
B) They work only for elite athletes
C) They can feel restorative, but some blunt the adaptations training is meant to produce, while sleep, the best-supported method, is free
D) They speed up muscle growth

3. Why does the course watch the FDA's response to its advisory committee's July 2026 vote on six peptides?

A) It would show how far regulators will go without evidence
B) A ruling is due by the end of 2026
C) The peptides have passed large trials, so approval is certain
D) The vote banned all six peptides from pharmacies and online sales

4. Which kind of training does the course say injures fewer people per hour than running?

A) Ultra-marathon running
B) Track and field training
C) Team sports such as soccer and rugby
D) Weight training

5. Where does the course's argument say most of exercise's health benefit comes from?

A) Elite fitness levels
B) Moving out of inactivity into the first few hours a week
C) Supplements and recovery tools
D) Training beyond ten hours a week, where the benefits finally begin to accumulate for most people

The Routines

Complete Programs to Follow

These routines put the modules into practice. Choose by the days and minutes available, not by ambition: the starter routine suits anyone new to lifting, the three-day routine suits people with a few months of experience and the four-day routine people with a year or more, and the routines for older adults and for aerobic fitness can be combined with any of them. Every session starts with the warm-up in Routine 1. Routines 3, 7, and 8 leave out some of the patterns in Module 4 to stay short and simple; add them as the weeks allow.

Effort is given as reps in reserve, the repetitions left when a set ends; "2 in reserve" means stopping when two more good repetitions were possible. Rest is the time between sets, or between pairs when two exercises are done as a superset. Progress by double progression (Module 3): when every set reaches the top of the repetition range at the stated effort, add the smallest available step of weight. Any exercise can be swapped for another in the same pattern from the table in Module 4, and an exercise that hurts should be swapped, not pushed through.

Routine 1. The Warm-Up

Five to ten minutes before every session: the ramp-up sets prepare the first lift and count as rehearsal, not as work.

Step	What	Dose
1	Easy aerobic work: brisk walking, cycling, rowing, or skipping	3-5 minutes, until slightly warm
2	Movements through the session's ranges: arm circles, band pull-aparts, body-weight squats, lunges with a reach overhead, and hip hinges with a stick along the back	5-8 repetitions of each
3	Ramp-up sets of the first lift, at about 50%, 70%, and 85% of the working weight	5, 3, and 1-2 repetitions

Routine 2. The Daily Ten Minutes

A short daily sequence for mobility and balance, done at any time of day and on rest days too. People with osteoporosis should replace the cat-cow with gentle back extensions lying face down, in line with the advice in Module 3 against bending the spine forward.

Movement	Dose	Purpose
Cat-cow on hands and knees	8 slow repetitions	Spine mobility
Lunge with a twist toward the front knee	3 a side, holding 3 breaths each	Hips and upper back
Deep squat hold, holding a support if needed	30-60 seconds	Hips, knees, and ankles
Wall slides, back and arms against a wall	10 repetitions	Shoulders overhead
Ankle rocks, knee driven over the toes	10 a side	Ankles
One-leg stand, progressing from eyes open to eyes closed	30-60 seconds a side	Balance
Heel-to-toe walk along a hallway	2 lengths of 10 steps	Balance
Sit down on the floor and stand up, using as little support as possible	3 times	Mobility, strength, and balance together

Routine 3. Starter: Two Days, Full Body

For anyone new to lifting or returning after a long break. Do the same session twice a week, at least two days apart, for 8 to 12 weeks. For the first four weeks, stop every set with 3 in reserve and concentrate on technique; after that, stop with 2 in reserve. Pair the exercises as shown and rest 60-90 seconds after each pair. The session takes 35-45 minutes.

Exercise (gym)	Home version	Sets × reps	Effort
Leg press or goblet squat	Sit-to-stand from a chair, then goblet squat holding a loaded backpack	2-3 × 10-12	2-3 in reserve
Paired with: chest-press machine or push-up	Push-up against a wall, then a bench, then the floor	2-3 × 8-12	2-3 in reserve
Seated cable row	Band row, or inverted row under a sturdy table	2-3 × 10-12	2-3 in reserve
Paired with: Romanian deadlift with dumbbells	Hip bridge, then single-leg hip bridge	2-3 × 10-12	2-3 in reserve
Lat pulldown	Band pulldown	2 × 10-12	2-3 in reserve
Farmer's carry	Suitcase carry with a shopping bag in one hand	2 × 30 meters	Heavy but steady
Plank	Dead bug	2 × 20-40 seconds	Stop before the hips sag

Routine 4. Three Days, Full Body

For people with a few months of training: three different sessions a week, such as Monday, Wednesday, and Friday, each taking about 50 minutes. Rest 2-3 minutes after the first lift of each day and 90 seconds between pairs. Across the week, pulling exceeds pushing (11 sets to 9) and squats balance hinges (9 sets each).

Day	Exercise	Sets × reps	Effort
A	Back squat or goblet squat	3 × 6-8	2 in reserve
A	Bench press, paired with chest-supported row	3 × 6-10 and 3 × 8-12	1-2 in reserve
A	Romanian deadlift	3 × 8-10	2 in reserve
A	Side plank	2 × 30 seconds a side	Steady
B	Trap-bar or conventional deadlift	3 × 5	2 in reserve
B	Overhead press, paired with pull-up or lat pulldown	3 × 6-10 each	1-2 in reserve
B	Split squat	3 × 8-10 a side	2 in reserve
B	Farmer's carry	3 × 30 meters	Heavy
C	Leg press	3 × 10-15	1-2 in reserve
C	Incline dumbbell press, paired with one-arm dumbbell row	3 × 8-12 each	1-2 in reserve
C	Hip thrust or leg curl	3 × 10-12	1-2 in reserve
C	Face pull, paired with cable press-out	2 × 12-15 and 2 × 10 a side	2 in reserve

Routine 5. Four Days, Upper and Lower

For people with four days and a year or more of training. Upper and lower sessions alternate, such as Monday and Thursday for upper body and Tuesday and Friday for lower, at 50-60 minutes each. Each muscle group is trained twice a week, pulling sets exceed pushing sets (14 to 11), and squat and hinge sets are close to equal.

Session	Exercise	Sets × reps	Effort
Upper 1	Bench press	3 × 5-8	1-2 in reserve
Upper 1	Barbell or chest-supported row	3 × 6-10	1-2 in reserve
Upper 1	Overhead press, paired with lat pulldown	3 × 8-10 and 3 × 8-12	1-2 in reserve
Upper 1	Lateral raise to shoulder height; curl and triceps extension	2 × 12-15; 2 × 10-12 each	1-2 in reserve
Lower 1	Back squat	3 × 5-8	2 in reserve
Lower 1	Romanian deadlift	3 × 6-10	2 in reserve
Lower 1	Split squat, paired with leg curl	2 × 8-10 a side and 2 × 10-12	1-2 in reserve
Lower 1	Calf raise; plank	2 × 10-15; 2 × 40 seconds	1-2 in reserve
Upper 2	Incline dumbbell press, paired with pull-up	3 × 8-12 and 3 × 6-10	1-2 in reserve
Upper 2	Seated cable row	3 × 10-12	1-2 in reserve
Upper 2	Push-up, paired with face pull	2 × as many as possible less 2, and 2 × 15	2 in reserve
Lower 2	Deadlift	3 × 3-5	2 in reserve
Lower 2	Leg press, paired with hip thrust	3 × 10-12 and 3 × 8-12	1-2 in reserve
Lower 2	Step-up; suitcase carry; side plank	2 × 10 a side; 3 × 30 meters; 2 × 30 seconds a side	Steady

Routine 6. Push, Pull, Legs

For people who like focused sessions: run the three sessions twice through in six days, or once through in three days plus a fourth full-body session (Routine 3 at higher effort), so that each muscle is trained twice a week (Module 4). Sessions take 45-60 minutes.

Session	Exercise	Sets × reps	Effort
Push	Bench press	3 × 6-8	1-2 in reserve
Push	Overhead press	3 × 6-10	1-2 in reserve
Push	Incline dumbbell press	2 × 8-12	1-2 in reserve
Push	Lateral raise to shoulder height; triceps extension	2 × 12-15; 2 × 10-12	1-2 in reserve
Pull	Pull-up or lat pulldown	3 × 6-10	1-2 in reserve
Pull	Barbell or chest-supported row	3 × 8-10	1-2 in reserve
Pull	One-arm dumbbell row	2 × 10-12 a side	1-2 in reserve
Pull	Face pull; curl	2 × 15; 2 × 10-12	1-2 in reserve
Legs	Back squat	3 × 5-8	2 in reserve
Legs	Romanian deadlift	3 × 8-10	2 in reserve
Legs	Split squat, paired with leg curl	2 × 8-10 a side and 2 × 10-12	1-2 in reserve
Legs	Calf raise; farmer's carry; side plank	2 × 12-15; 3 × 30 meters; 2 × 30 seconds a side	1-2 in reserve

Routine 7. The 30-Minute Paired Session

For busy weeks, or as the strength half of the time-crunched week in Routine 11. Three pairs, each done for three rounds with 60-90 seconds' rest after each round, then a carry. Twice a week it meets the health minimum for strength in Module 3, and it needs only a pair of dumbbells and a band.

Pair	Exercises	Reps	Effort
1	Goblet squat, then push-up	8-12, then 8-15	1-2 in reserve
2	Romanian deadlift with dumbbells, then one-arm dumbbell row	8-12, then 8-12 a side	1-2 in reserve
3	Split squat, then band pull-apart or band pulldown	8-10 a side, then 15	1-2 in reserve
Finish	Farmer's carry with both dumbbells	2 × 30 meters	Heavy

Routine 8. Strength and Balance After 65

Two strength sessions a week on non-consecutive days, balance practice on most days, and walking. Start with 2 sets at 3 in reserve and build to 3 sets at 1-2 in reserve over two months; loads then rise until 8 to 12 repetitions are hard. People with osteoporosis can follow it with the cautions in Module 3, and the heavy-loading progression used in the trials there is best begun under supervision.

Exercise	Sets × reps	Notes
Sit-to-stand from a chair, progressing to a goblet squat	2-3 × 8-12	Lower the chair or add a dumbbell as it becomes easy
Fast chair rises	3 × 5	From the third month: rise as fast as possible, sit down slowly; the power exercise of Module 5
Push-up against a wall or bench, paired with band or cable row	2-3 × 8-12 each	Lower the push-up surface as strength grows
Romanian deadlift with a dumbbell or kettlebell	2-3 × 8-12	Hinge at the hips with a straight back
Step-up onto a low step	2 × 8-10 a side	Hold a rail at first; raise the step later
Heel raises	2 × 12	Holding a support
Carry with shopping bags or dumbbells	2 × 20-30 meters	Heavy enough to require effort

Balance practice progresses along a ladder: feet together, then one foot half in front of the other, then heel to toe, then one leg; first with a hand on a support and the eyes open, then without the hand, then with the eyes closed or on a cushion. Move up a step when the current one can be held for 30 seconds. Stepping over objects, turning, and walking heel to toe add movement, and a weekly tai chi class, which reduced falls in the trials of Module 5, adds variety and company.

Routine 9. Aerobic Base: From Zero to 150 Minutes

For anyone starting from little or no aerobic exercise. All of it is at a pace that allows full sentences. If a week feels hard, repeat it before moving on.

Weeks	Sessions	Each session	Weekly total	Notes
1-2	5	10-minute walk	50 minutes	Any pace that feels comfortable
3-4	5	15-minute walk	75 minutes	Brisk for the middle 5 minutes
5-6	5	20-minute walk	100 minutes	Brisk throughout
7-8	5	25-minute brisk walk	125 minutes	Add a hill or stairs

Weeks	Sessions	Each session	Weekly total	Notes
9-10	5	30-minute brisk walk	150 minutes	The guideline minimum
11-12	4 + 1	30 minutes, plus one longer session of 45-60 minutes	165-180 minutes	Optionally, swap one walk for 1-minute jogs alternating with 2-minute walks

Routine 10. The 4×4 Block

Eight weeks to raise VO2 max, for people with at least a month of regular aerobic exercise and no symptoms during exertion (Module 9). Do it on a bike, a rower, or uphill walking if running is not possible, once or twice a week with at least two days between sessions. Every session starts with a 10-minute warm-up and ends with a 5-minute cool-down, and the easy periods between efforts are active, not standing still.

Weeks	Efforts	Intensity	Easy between	Sessions a week
1-2	3 × 3 minutes	Hard: a few words at a time; about 85-90% of maximum heart rate	3 minutes	1
3-4	4 × 3 minutes	About 90% of maximum heart rate	3 minutes	1-2
5-8	4 × 4 minutes	90-95% of maximum heart rate: a word or two at a time	3 minutes	1-2
After week 8	Retest with the 12-minute run (Module 2)			Then keep one 4×4 a week

Routine 11. The Time-Crunched Week

About 80 minutes of sessions a week, plus the daily ten minutes, for people who have little more time. It meets the strength guideline, delivers hard aerobic work in very little time, and relies on daily walking and stair-climbing for the rest. When more time appears, add the easy sessions of Routine 9 or move to Routine 4.

Day	Session	Minutes
Monday	The 30-minute paired session (Routine 7)	30
Wednesday	Sprint intervals on a bike or uphill: three or four all-out efforts of 20 seconds with 2-3 minutes easy between, inside a 5-minute warm-up and a 5-minute cool-down	15-20
Friday	The 30-minute paired session (Routine 7)	30
Daily	The daily ten minutes (Routine 2); brisk walking where possible; stairs taken fast	10 or more

Answer Sheet

Answers to every module's Check Your Understanding quiz.

Module	Answers
Module 1 Quiz	1. A 2. D 3. B 4. C 5. B
Module 2 Quiz	1. A 2. D 3. C 4. B 5. D
Module 3 Quiz	1. A 2. C 3. B 4. C 5. D
Module 4 Quiz	1. A 2. D 3. C 4. A 5. B
Module 5 Quiz	1. A 2. B 3. C 4. D 5. C
Module 6 Quiz	1. A 2. B 3. D 4. C 5. B
Module 7 Quiz	1. D 2. A 3. C 4. D 5. A
Module 8 Quiz	1. B 2. C 3. A 4. B 5. D
Module 9 Quiz	1. D 2. A 3. C 4. B 5. B
Module 10 Quiz	1. C 2. A 3. D 4. B 5. C
Module 11 Quiz	1. D 2. A 3. D 4. A 5. C
Module 12 Quiz	1. B 2. C 3. D 4. A 5. B
Module 13 Quiz	1. B 2. C 3. A 4. D 5. B