# Response

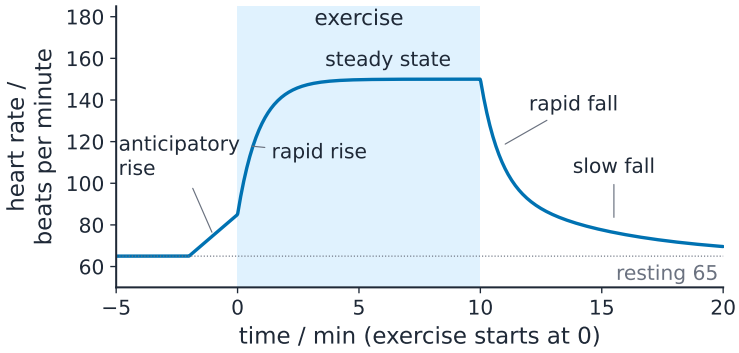
A.3 · SL and HL

# Two hours under two

Distinguish a bout-related response from a persistent **training adaptation**.

- Kipchoge's supported Vienna challenge: 42.195 km in 1:59:40.2, 12 October 2019.
- The result does not supply his moment-by-moment physiology.
- Graphs and calculations here use invented teaching values.

# Heart rate during exercise




Heart rate alone does not measure oxygen balance.

# Why stroke volume rises

A fuller, more stretched ventricle contracts more strongly (Frank–Starling).

- Muscle and respiratory pumps can raise **venous return**.
- Sympathetic input raises contractility; a plateau is not at one universal intensity.

# Blood pressure

## Running

Systolic up, about 120 $\rightarrow$ 180.

Diastolic about the same.

## Heavy lifting

Both rise sharply.

Worse when holding breath.

# The Fick equation

1. **Rest.** $5 \times 50 = 250$ mL/min
2. **Hard run.** $20 \times 150 = 3000$ mL/min
3. **Change.** Twelve times; delivery $\times 4$, extraction $\times 3$

**Decision**

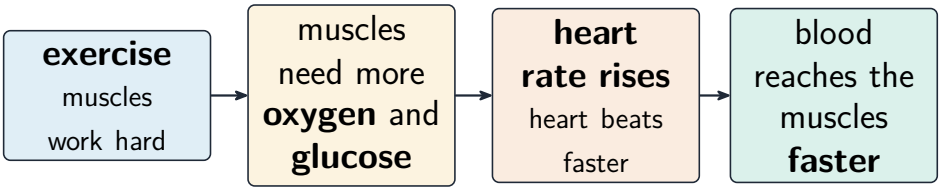
Oxygen uptake = cardiac output $\times$ a-v$O_2$ diff

# Ventilation and heat

A fixed workload can coexist with changing heart rate and temperature.

- Feedforward and feedback coordinate ventilation; arterial $CO_2$ need not rise in moderate work.
- Evaporated sweat removes heat; dripping sweat does not provide the same cooling.

# Why heart rate rises




check the heart's activity by feeling the **pulse**, listening to the valves, or with an **ECG**

> Blood reaches the muscles faster

# Types of fatigue

| **Interacting factor** | **Possible effect** |
| --- | --- |
| Reduced PCr availability | Limits rapid ATP resynthesis |
| $Na^+/K^+$ and phosphate changes | Excitability and contraction |
| Reduced glycogen availability | Prolonged exercise constraint |
| Reduced central drive | Can interact with peripheral factors |

# Lactic acid myths

> Soreness and restored task performance are different outcomes.

- Lactate can be transported and used as fuel; it is not the sole **fatigue** mechanism.
- Unfamiliar eccentric loading can lead to delayed soreness, not lactate retained for days.

# How long recovery takes

| Outcome | Interpretation |
| --- | --- |
| PCr restoration | Depends on rest and oxidative supply |
| Substrate availability | Depends on depletion and intake |
| Fluid balance | Includes continuing inputs and outputs |
| Tissue function/readiness | Symptoms and force can differ |

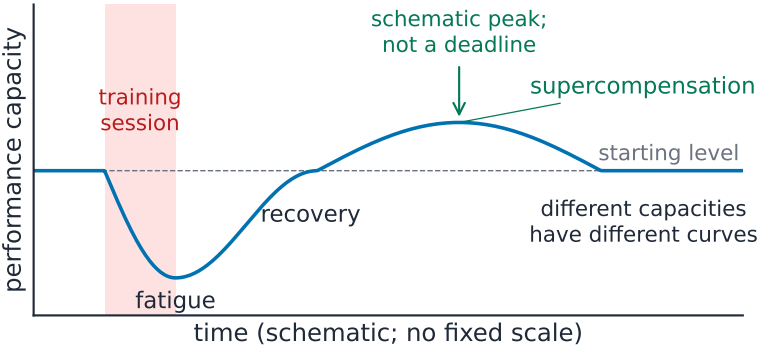
# Symptoms versus performance

1. **Given.** Invented soreness scores out of 10: comparison 5, intervention 3. Both groups remain 8% below baseline task performance.
2. **Symptoms** Difference $= 5 - 3 = 2$ scale points.
3. **Performance** Neither group has returned to its baseline.
4. **Evidence** Need allocation, sample size, controls and uncertainty.

## Decision

Reduced soreness is not proof of complete **recovery**.

# Supercompensation

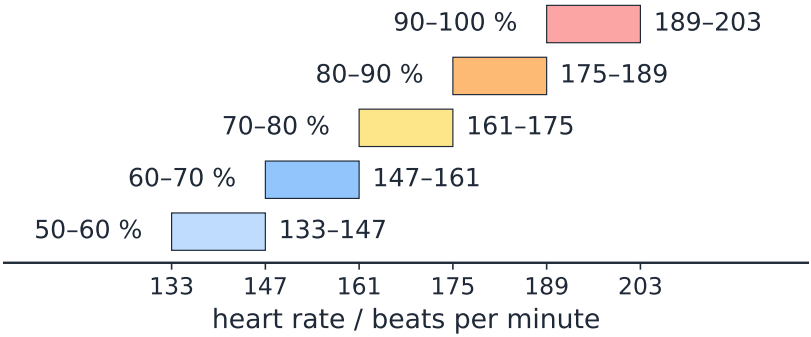



A model curve is not an individual training timetable.

# Principles of training

| Principle | Meaning |
| --- | --- |
| **Specificity** | Adaptations match the training |
| **Progressive overload** | Load rises gradually |
| **Reversibility** | Unused fitness is lost |
| Individual differences | People respond differently |

# Reserve-percentage arithmetic




Percentage bands are arithmetic, not measured thresholds.

# Target heart rate

1. **Reserve** $203 - 63 = 140$ beats/min
2. **Reserve model** $63 + 0.70 \times 140 = 161$ beats/min
3. **Maximum model** $0.70 \times 203 = 142.1$ beats/min

## Decision

Different definitions; no age estimate or personal prescription.

# Resistance training

| **Aim** | **Repetitions and load** |
|---|---|
| Strength | Heavier specific loading can develop maximal force |
| **Hypertrophy** | Sufficient challenging work; not one exclusive range |
| Local endurance | Repeated work with appropriate progression |

# Interval training

## Invented ratio

Work 40 s; **recovery** 160 s.

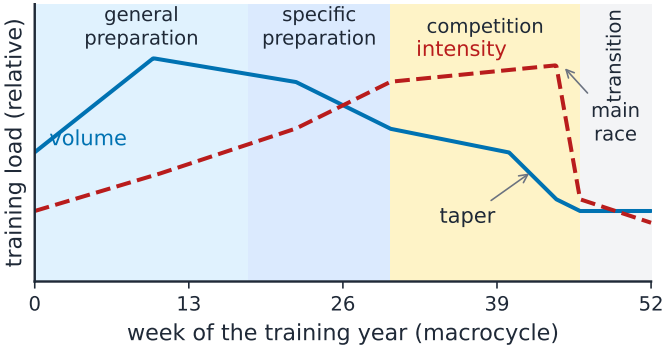
40:160 = 1:4.

## Interpretation

What intensity and movement?

What participant and next-task aim?

# A periodised year




Plan load around aims and monitor the response.

# The trained heart

1. **Untrained.** $70 \times 70$ mL $= 4.9$ L/min
2. **Trained.** $45 \times 110$ mL $= 4.95$ L/min
3. **Difference.** Fewer beats, bigger **stroke volume**

**Decision**

A larger stroke volume can maintain output at a lower rate.

# Muscle adaptations

## Endurance

More **mitochondria**, **myoglobin**, enzymes.

More fat used; glycogen spared.

## Resistance

Larger type II fibres.

More PCr; better buffering.

# The lactate threshold

1. **Given.** Invented oxygen-uptake maximum 45→52 mL/(kg min); threshold fraction 60%→75% of the maximum.
2. **Before.** $0.60 \times 45 = 27$ mL/(kg min)
3. **After.** $0.75 \times 52 = 39$ mL/(kg min)
4. **Change.** $(39-27)/27 \times 100 \approx 44.4\%$ in threshold uptake; maximum uptake rises about 15.6%.

## Decision

+44.44% in this metric does not determine running speed.

# Endurance or resistance adaptations

**endurance (aerobic) training**

more and larger mitochondria
more myoglobin
more capillaries
greater fat use at a given load

**resistance and sprint training**

fibre hypertrophy, mainly type II
more PCr and glycolytic capacity
greater strength and power
neural recruitment improves

the stimulus decides the adaptation (specificity)

Adaptations match the training

# Overtraining

| Concept | Interpretation |
| --- | --- |
| **Functional overreaching** | Short-term reduction with **recovery** |
| Maladaptive underperformance | Review load, health and recovery context |
| Session RPE | A monitoring proxy, not an injury threshold |

# Altitude

> Live high, train low is a conditional strategy, not a guarantee.

- Lower total pressure reduces oxygen partial pressure; the fraction remains near 21%.
- Response and benefit depend on exposure, individual, sleep and training quality.

# Check: heat acclimatisation

## Your turn

Which change happens with heat acclimatisation?

A. Sweat becomes saltier
B. Plasma volume rises
C. Heart rate rises at the same workload
D. Sweating starts later

# Apply FITT to a defined purpose

> Progress a suitable variable after evaluating response.

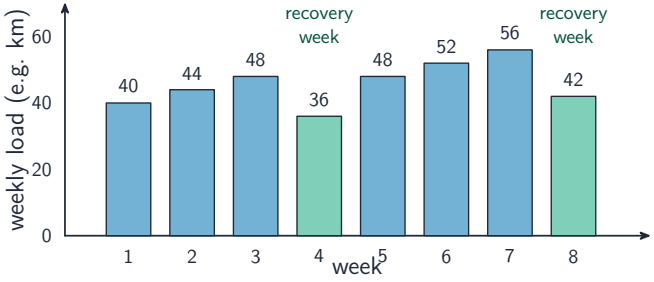
- Frequency counts sessions; intensity states the effort metric.
- Time records duration; type identifies the activity and loading.

# Individual response and interpretation

> A difference between two change scores does not isolate genetics.

- Baseline, history, adherence, sleep and stress can affect change.
- Measurement noise can also make observed responses differ.

# Progressive overload with recovery weeks




Raise one variable (here distance, about 10% a week), check the response, then build again

Load rises in steps, with planned **recovery**

# Taper arithmetic

1. **Difference** $600 - 360 = 240$ minutes
2. **Reference** Use the initial 600 minutes.
3. **Percentage** $240/600 \times 100 = 40\%$ reduction.

## Decision

A volume cut does not guarantee a particular race improvement.

# Weekly monitoring load

1. **Given.** Invented week: four 75-minute sessions at session RPE 6 and one 20-minute race at 9, all on the CR-10 scale.
2. **Sessions** $4 \times 75 \times 6 = 1800$
3. **Race** $20 \times 9 = 180$
4. **Total** $1800 + 180 = 1980$ arbitrary units

## Decision

Equal totals can hide different loading; AU are not kilojoules.

# Activity and long-term health

> A health benefit need not require elite performance.

- Appropriate loading supports muscle, bone and functional capacity.
- Activity can reduce cardiometabolic disease risk; it does not eliminate it.

# Energy balance needs the whole interval

> More exercise is not automatically better for every outcome.

- Daily balance depends on intake and all expenditure, not one workout.
- Immune health also depends on sleep, nutrition, exposure and **recovery**.

# Session load from RPE

session load $=$ RPE (CR-10) $\times$ minutes




Total 1140 arbitrary units

# Nutrition and recovery evidence

A mechanism or product label is not a guarantee of complete **recovery**.

- Water/electrolytes, energy and macronutrients support different restoration tasks.
- Creatine and polyphenol products require context-specific evidence and quality checks.

# Physical strategies and readiness

> Subjective comfort is relevant but not equivalent to tissue repair.

- Myofascial release, compression and thermal approaches may target different outcomes.
- Compare symptoms, force and next-task performance with controls and uncertainty.

# Sleep, travel and load

> A gadget cannot substitute for an appropriate training and **recovery** plan.

- Protect sleep opportunity; consider school stress and travel **fatigue**.
- Crossing time zones can add circadian disruption.

# Recovery is not one clock




Each recovers on its own timescale

# Plan for the participant

> An elite adult template is not universal.

- Adolescents: development, varied skills, enjoyment and supervision.
- Older adults: baseline function, strength, balance, access and suitable progression.

# Pregnancy and individual circumstances

> Use the context and appropriate advice, not one fixed worksheet target.

- Consider stage, prior activity, comfort and relevant individual health guidance.
- Avoid assumptions that all activity must stop or all prior intensity should continue.

# Planning for different groups

**children, adolescents**
growth, readiness, enjoyment, varied skills, supervision; not a scaled-down adult load

**older adults**
strength, balance, independence; baseline and health over an age stereotype

**pregnant participants**
stage, prior activity, comfort and individual health advice; no generic prescription

adapt to enable participation; protect privacy of health information

> Each group has its own considerations

# Exam tips

> Say whether a change is an **acute response** or a **training adaptation**.

- Describe evidence, mechanism and timescale.
- State the heart-rate definition and show units.
- Distinguish a symptom, a physiological measure and a performance outcome.

# Check yourself

## Try these

Given maximum 200 and rest 68 beats/min, calculate the model value at 75% reserve.

Calculate weekly load for four 75-minute sessions at CR-10 RPE 6 and a 20-minute race at 9.

Explain why the same programme can produce different observed changes.