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# The Body and Mind in Motion: Topic Notes

02

NSW HEALTH AND MOVEMENT SCIENCE 11-12 SYLLABUS 2023 FOR HSC 2028 AND LATER

**In this focus area:** the three energy systems · the interplay of the systems · nutrition · aerobic and anaerobic training · the FITT principle · physiological responses to training · fitness testing

## 1. The three energy systems

**All movement is powered by ATP (adenosine triphosphate).** The body has three systems for resupplying ATP. Which one dominates depends on the intensity and duration of the activity.

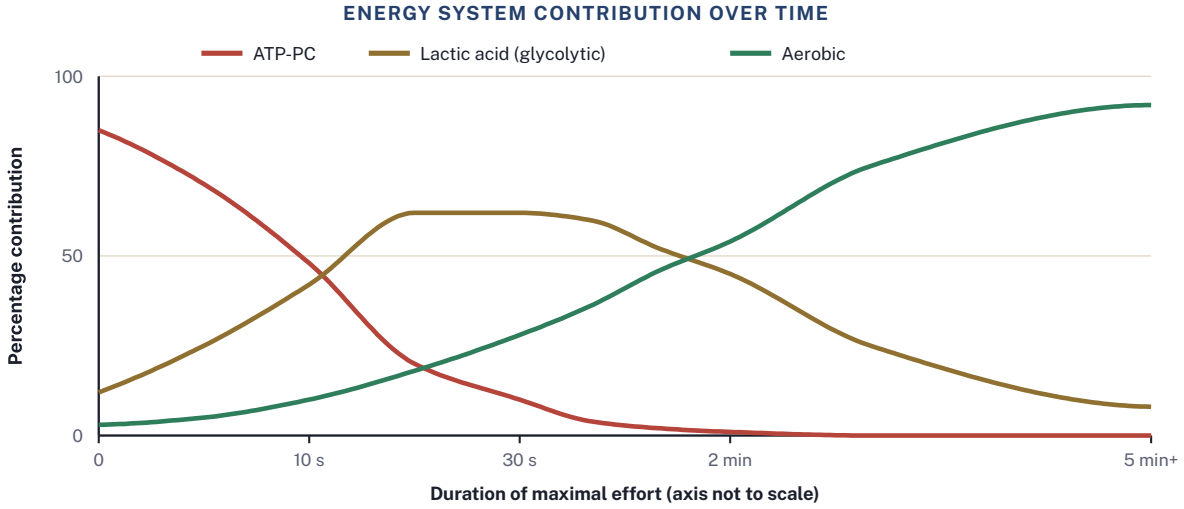



Figure 1 · As an activity lasts longer, the dominant energy system shifts from ATP-PC to lactic acid to aerobic.

| ENERGY SYSTEM | FUEL SOURCE | DURATION AND INTENSITY | BYPRODUCT |
|---|---|---|---|
| **ATP-PC (alactacid)** | Creatine phosphate | Very high intensity, up to about 10 seconds | None (no lactic acid) |
| **Lactic acid (glycolytic)** | Glucose without oxygen | High intensity, about 10 seconds to 2 minutes | Lactic acid |
| **Aerobic** | Carbohydrate and fat with oxygen | Low to moderate intensity, 2 minutes and beyond | Carbon dioxide and water |

The systems do not switch on and off; they overlap. At any moment all three contribute, but one predominates. The ATP-PC system recovers quickly (about 2 minutes), while the lactic acid system recovers more slowly because lactic acid must be removed. Fatigue is caused by the depletion of fuel and the build-up of by-products such as lactic acid.

## 2. Nutrition and the energy systems

**Nutrition fuels the energy systems.** Carbohydrate is the main fuel for high-intensity, predominantly anaerobic activity, while fat becomes a more important fuel for longer, predominantly aerobic activity. Micronutrients such as iron support the delivery of oxygen. Active people need enough energy and fluid to train and recover.

## 3. Aerobic and anaerobic training

**Training is matched to the demands of the sport.** Aerobic training builds the ability to sustain effort, while anaerobic training builds speed and power.

| TYPE | IMPROVES | METHODS |
|---|---|---|
| **Aerobic training** | Endurance and the aerobic system | Continuous training at a steady pace |
| **Anaerobic training** | Speed, power and tolerance of lactic acid | Interval training, and contemporary methods such as HIIT and SIT |

Contemporary methods include High Intensity Interval Training (HIIT) and Sprint Interval Training (SIT), which alternate hard efforts with recovery. Programs are differentiated to suit the individual or the group.

## 4. The FITT principle

**The FITT principle** guides the design of a training program:

- **Frequency:** how often you train.
- **Intensity:** how hard you train.
- **Time:** how long each session lasts.
- **Type:** the kind of training, matched to the goal.

## 5. Immediate physiological responses to training

**As soon as exercise begins,** the body responds to meet the greater demand for oxygen and energy. Heart rate, ventilation rate, stroke volume, cardiac output and lactate levels all rise.

Cardiac output (Q) is the volume of blood the heart pumps each minute. It is the product of stroke volume (SV), the blood pumped per beat, and heart rate (HR): Q = SV × HR.

#### WORKED EXAMPLE: CARDIAC OUTPUT

At rest an athlete has a stroke volume of 70 mL and a heart rate of 72 beats per minute. During hard exercise these rise to 120 mL and 180 beats per minute. Calculate the cardiac output in each case.

Working

Rest: Q = SV × HR = 70 × 72 = 5040 mL/min = 5.04 L/min

Exercise: Q = 120 × 180 = 21600 mL/min = 21.6 L/min

Cardiac output rises with exercise because both stroke volume and heart rate increase.

## 6. Testing physical fitness

**Fitness testing** measures components of fitness such as aerobic capacity, strength, speed and flexibility. Tests help set goals and track progress, but their purpose and value differ for different groups, from elite athletes to the general population, which is worth debating.

## Exam focus: focus area 2, energy and training

**Match the system to the activity:** name the dominant energy system and justify it using intensity and duration.

**Show working in calculations:** write Q = SV × HR, substitute with units, and give the answer in L/min.

**Link training to responses:** explain how a training method improves a named physiological response.

## Check your understanding

1. Name the dominant energy system for a 100 metre sprint and for a marathon.
2. State the by-product of the lactic acid system.
3. What do the letters FITT stand for?
4. Calculate the cardiac output for a stroke volume of 80 mL and a heart rate of 150 beats per minute.
5. Explain why cardiac output rises during exercise.

## About this resource

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### Scope

NSW Health and Movement Science, Year 11. Written to the NSW Health and Movement Science 11-12 Syllabus 2023, The Body and Mind in Motion, for students sitting the HSC in 2028 and later years. Worked examples use invented athletes and training programs, and every number was recomputed from its inputs before printing.

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