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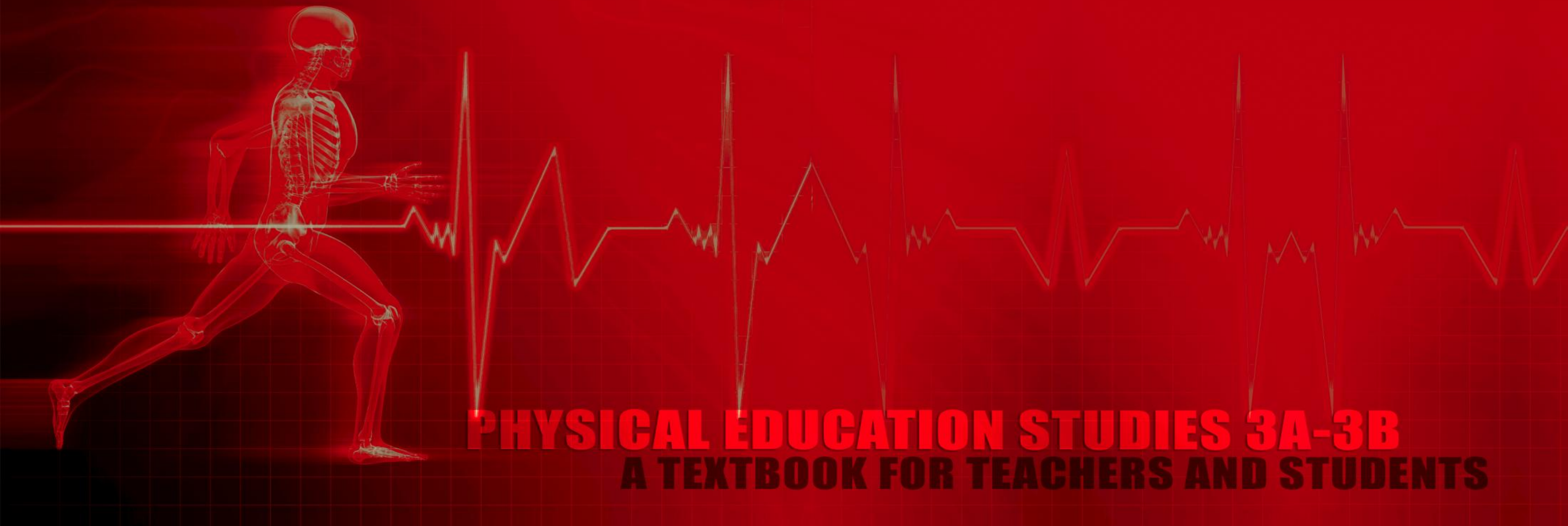
EXERCISE PHYSIOLOGY

Dr Kym Guelfi and Dr Peter Whipp



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Nutritional Considerations for Exercise

A ***balanced diet*** is important not only for everyday health, but also for optimal athletic performance.

A balanced diet includes healthy amounts and proportions of the three macronutrients - ***carbohydrate***, ***fat*** (lipid) and ***protein*** - as well as a variety of ***minerals*** and ***vitamins***.

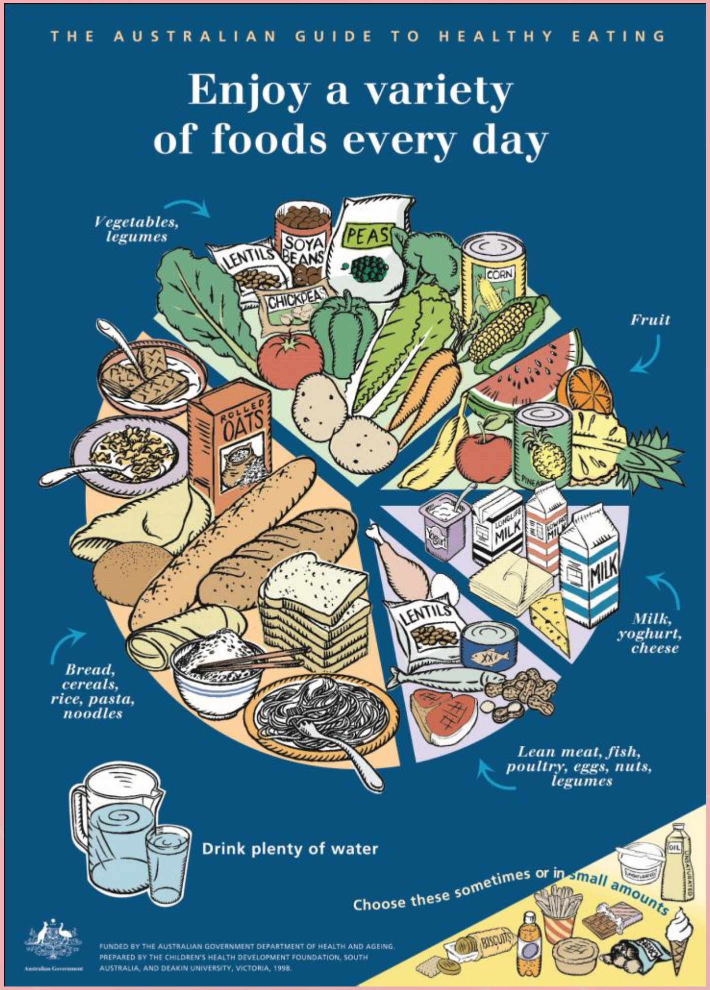
Fat

Carbohydrate

Protein

Nutritional Considerations for Exercise

The Australian Guide to Healthy Eating represents the types and proportions of different foods we should aim to consume each day for good health and well-being.



Carbohydrate

Carbohydrates account for ~55% of total energy intake.

The carbohydrate intake of an endurance athlete may account for up to 70% of total energy intake.

Carbohydrates include:

- simple sugars (such as honey, table sugar and fruit juice)
- complex carbohydrates (such as potatoes, bread, cereal, rice and pasta).

Carbohydrate

Carbohydrates are digested to a single small molecule called glucose.

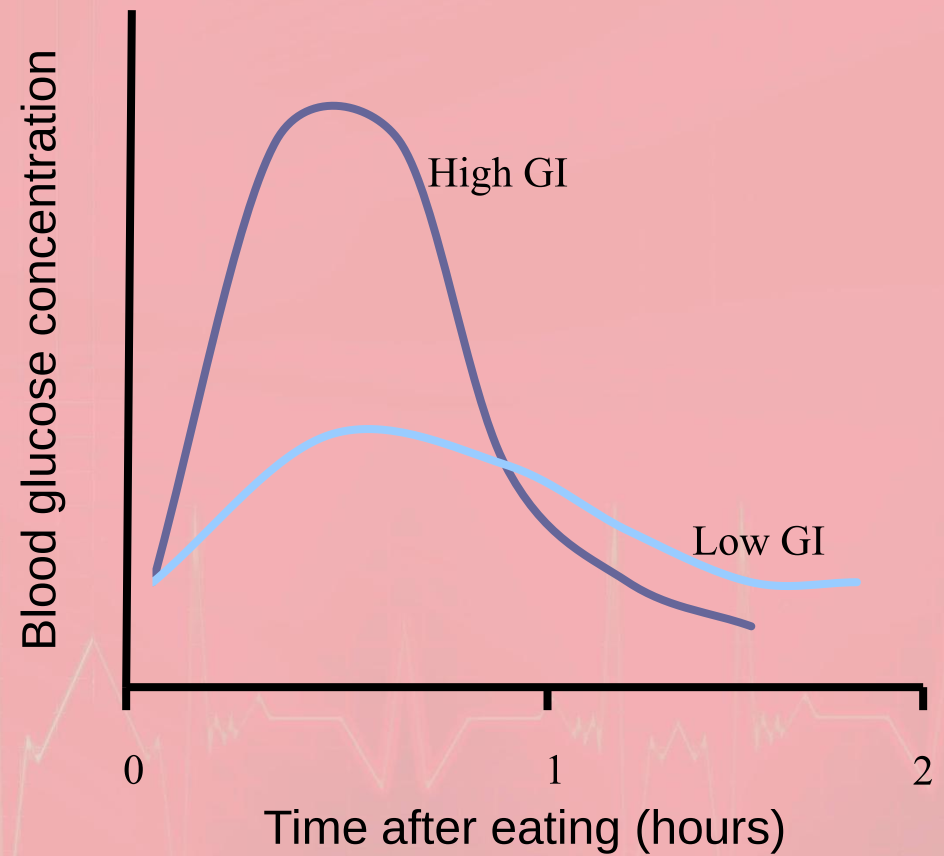
Glucose obtained from dietary carbohydrate is either:

- released into the bloodstream for circulation
- converted into glycogen for storage in the muscle and in the liver.

The amount of glycogen that can be stored in the body is limited to 600-800 g.

Glycaemic Index

The glycaemic index (GI) is a measure of the speed at which glucose is released into the bloodstream after eating carbohydrates.



Glycaemic Index

	Food	Glycaemic Index
High Glycaemic Index Foods (GI > 70)	Watermelon	72
	Jellybeans	76
	Coco Pops™ cereal	77
	Honey	87
Low Glycaemic Index Foods (GI < 55)	Banana	50
	Apples	40
	Egg Pasta	46
	All-Bran™ cereal	30

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Fat

Dietary fat accounts for ~30% of total energy intake.

Saturated fatty acids (found in full cream milk, cheese and fatty meats) are considered unhealthy.

Unsaturated fatty acids (avocados, fish, nuts and olive oil) can be beneficial for health if consumed in moderation.

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Fat

Dietary fats are broken down in the digestive system to free fatty acids.

Free fatty acids obtained from dietary fat are either:

- released into the bloodstream for circulation
- stored as triglycerides (a molecule resulting from the combination of three fatty acids) in adipose tissue.

Fat stored as triglycerides in the body provides a plentiful source of energy.

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Protein

A protein intake of ~15% of total energy, or 0.8 g per kilogram of body mass is adequate for most active men and women.

Strength and endurance athletes may require a protein intake of up to 1.6 g per kilogram of body mass.

Protein consumed in the diet is digested into amino acids.

The primary role of protein is to maintain the body's structures, growth and repair of muscle tissue.

Fluid Intake

A balanced diet includes drinking plenty of water to ensure optimal health and performance.

The body loses about 2 L of fluid per day from general living.

Plain water is adequate to replace fluid lost due to normal daily activities.

Daily fluid requirements are impacted by exercise and the environmental conditions.

Nutritional Requirements for Physical Activity

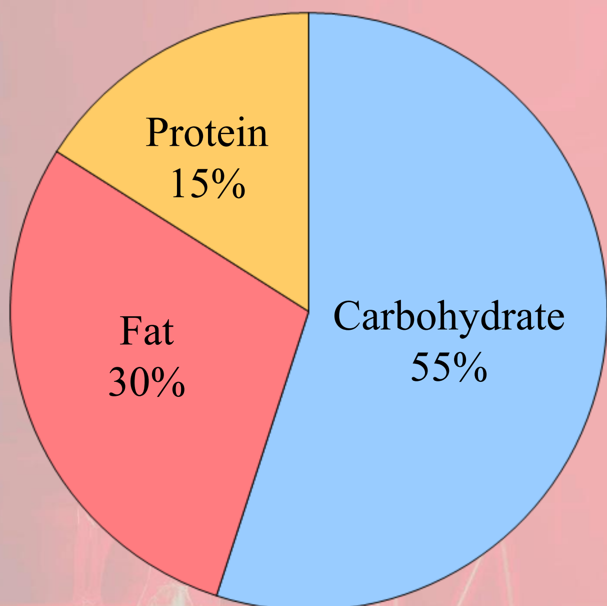
It is typically recommended that the general population should obtain ~55% of energy intake from carbohydrates, less than 30% from fat, and ~15% from protein.

For an athlete, the optimal percentage of carbohydrate, fat and protein in the diet is dependent upon the specific sport of interest.

The total amount of energy (kJ) consumed is also highly variable depending upon the specific sport of interest.

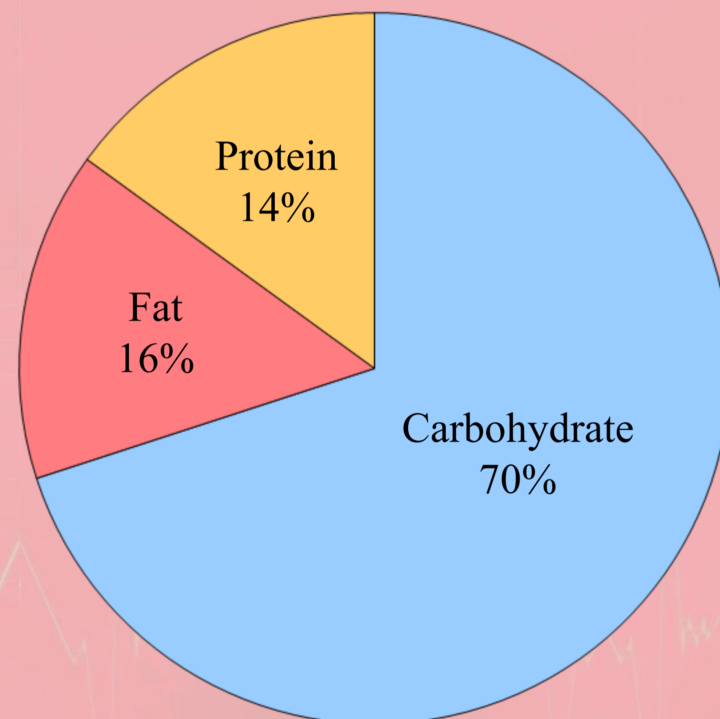
Nutritional Requirements for Physical Activity

Inactive individual



Total energy intake = 8,000 kJ

Endurance athlete



Total energy intake = 17,000 kJ

Nutrition

Exam style question

Using a specific sporting example for each of the following, identify how an athlete's overall diet may vary from that recommended in the 'Australian Guidelines for Healthy Eating' for:

i. Carbohydrate

ii. Protein

iii. Total kilojoule intake

Nutrition

Answer

Using a specific sporting example for each of the following, explain how an athlete's overall diet may vary from that recommended in the 'Australian Guidelines for Healthy Eating' for:

i. Carbohydrate

Because carbohydrate is the primary fuel source for an endurance athlete (i.e. Olympic distance triathlete) the percentage of carbohydrate in the diet may increase from 55% up to 70%.

ii. Protein

Because protein plays a vital role in the growth and repair of muscle tissue, for athletes that undertake intense resistance training (i.e. Bodybuilding, shot put) the percentage of protein in the diet may increase from 15% up to 30%.

iii. Total kilojoule intake

While sedentary people may have a kilojoule intake need of approximately 6000-8000 kJ, athletes such as competition road cyclists expend high levels of energy and therefore may have nutritional intake requirements of 25,000 kJ or beyond.

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Nutritional Considerations by Phase of Activity

The specific foods and drinks consumed before, during and after competition may influence athletic performance.

Pre-competition Nutrition

Pre-competition meal

Should focus on providing adequate carbohydrate and fluid for the commencement of exercise.

Pre-competition carbohydrate consumption is particularly important for endurance events lasting > 1 hour in duration.

The pre-competition meal should be:

- high in carbohydrate (low in fat and protein)
- consumed 3–4 hours prior to the event
- consider gastrointestinal upset (liquid versus solid meal?).

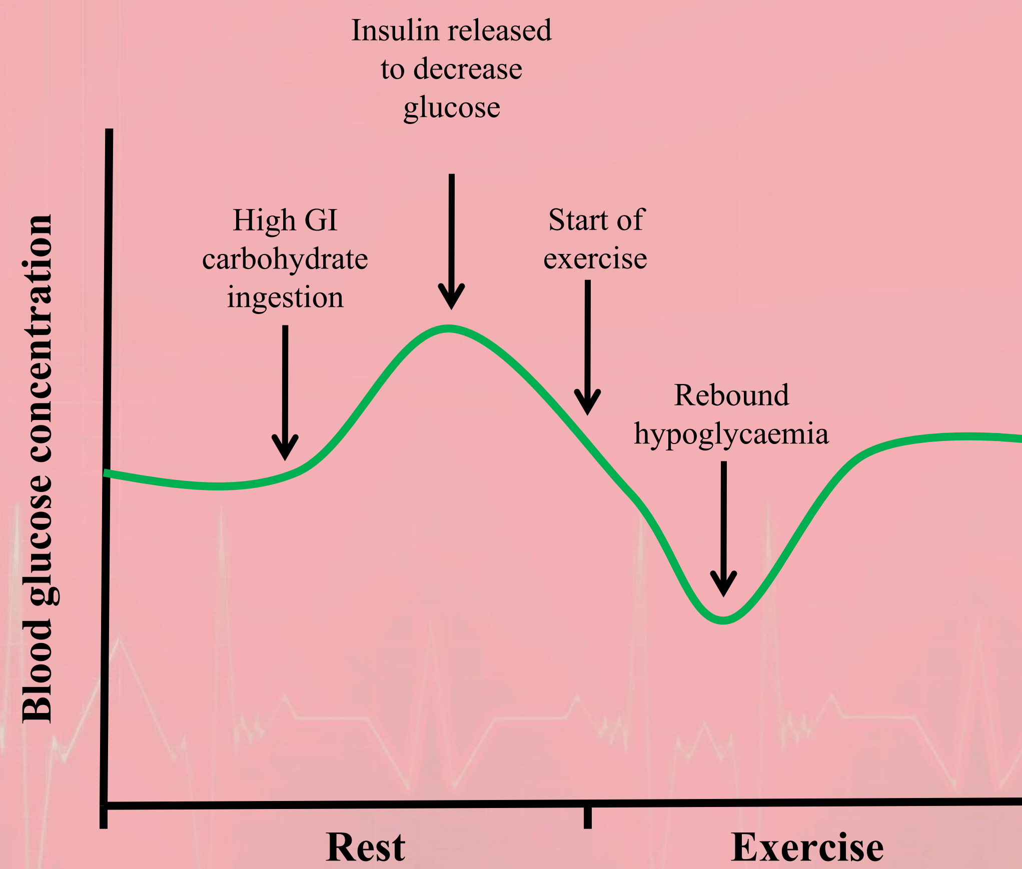
Pre-competition Nutrition

Pre-competition snack

Low-medium GI carbohydrate ingested 30–60 min prior to exercise will 'top up' carbohydrate stores.

Low-medium GI carbohydrate may be better (possibility of rebound hypoglycaemia?).

Liquid snack may be better tolerated.



Pre-competition Nutrition

Pre-competition fluid intake

Pre-competition fluid intake is important to ensure adequate hydration prior to the commencement of exercise.

As a general guide, athletes may consume 350–500 mL ~4 hours prior to competition.

If urine is still dark and concentrated in colour, or no urine is produced at all, the athlete should drink another 200–350 mL two hours prior to the event.

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Nutrition During Exercise

The goal of nutritional strategies during exercise should be to minimise the depletion of carbohydrate stores and to replace fluid lost via sweat.

Nutrition During Exercise

Carbohydrate consumption

Carbohydrate gels

For endurance events, the athlete should aim to consume 30–60 g of carbohydrate for each hour of activity.

It is generally best to consume carbohydrate in a liquid form during exercise, since solid food is typically not well tolerated.

Moderate to high GI carbohydrates are preferable to low GI carbohydrates to ensure the rapid release of glucose into the bloodstream for use.

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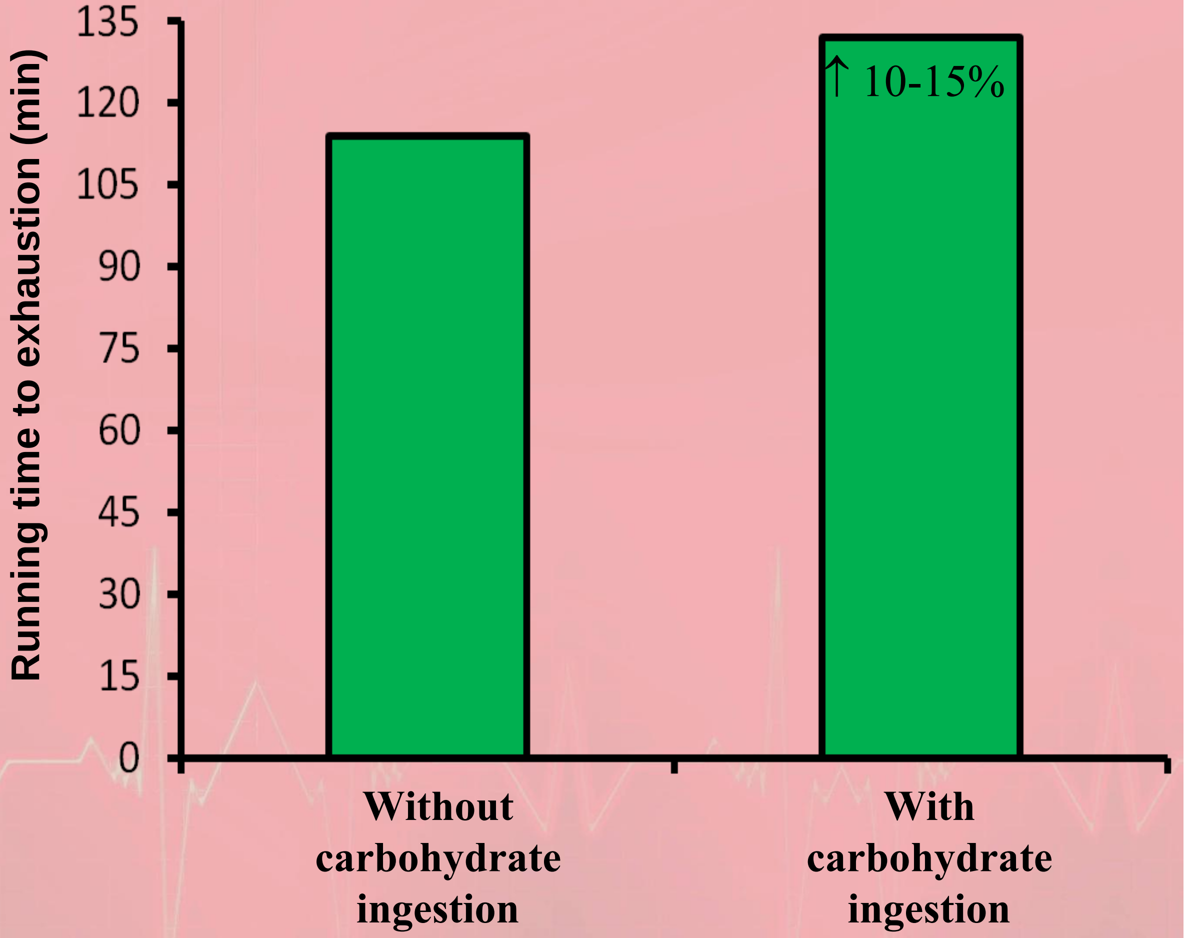
Nutrition During Exercise

Carbohydrate feeding during exercise will assist in prolonging endurance performance.



Nutrition During Exercise

Fluid consumption

Drinking during exercise (400–800 mL per hour) will decrease the risk of dehydration during prolonged events.

For short duration events, aim to drink 100–200 mL per 15 minutes.

Drinking plain water is adequate for exercise < 1 hour in duration.

For exercise > 1 hour, combining carbohydrate with fluid is beneficial.

Nutrition During Exercise

Fluid consumption

A carbohydrate concentration of 6–8% in solution is optimal for absorption in the gastrointestinal tract.

Cold and flavoured fluids encourage increased consumption.

Electrolytes increase the desire to drink and fluid absorption in the gastrointestinal tract.

Consuming the recommended amount of fluid during exercise may still not equate to the amount of fluid lost from sweat during exercise in hot conditions.

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Recovery and Post-exercise Nutrition

Carbohydrate intake during recovery

Post-exercise nutrition should focus on replacing fuel stores (predominately carbohydrate) and body fluid losses.

Consumption of high GI carbohydrates immediately post-exercise will accelerate glycogen replenishment.

Recovery and Post-exercise Nutrition

Fluid intake during recovery

When fluid replacement is based on voluntary thirst, athletes typically drink only 50% of what is needed to replace sweat loss through exercise.

During recovery, athletes should aim to consume 1.5 times the nett fluid lost during exercise.

Post-exercise consumption of drinks containing electrolytes may speed rehydration by reducing urine production and stimulating thirst.

Sample Nutrition Plan for Half Ironman Triathlon

(Prepared by Dr Peter Peeling, Western Australian Institute of Sport)

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TIME	FOOD	CHO (g)
Pre-race meal (3 hours prior)	6 Weetbix with hot water and honey 600 mL Powerade 300 mL water	80 g 35 g -
Pre-race snack (60 min prior)	1 x vanilla powerbar 300 mL Powerade 100 mL water	40 g 17 g -
Swim (28-30 min)	-	-
Swim-cycle transition	-	-
Cycle (2.5 hours)	2 x 600 mL Powerade 600 mL water 3 x Carboshotz 1 x vanilla powerbar	70 g - 90 g 40 g
Cycle-run transition	1 x Carboshotz	30 g
Run (1.5 hours)	500 mL water 1 x Carboshotz 300 mL Powerade	- 30 g 17 g
Post race (within 1 hour)	600 mL Powerade 500 mL water 2 x banana sandwich	35 g - 120 g

Sample Nutrition Plan for a Footballer

TIME	FOOD	CHO (g)
Pre-game meal (3–4 hrs before)	Spaghetti with napolitana sauce	70 g
	600 mL Sports drink	35 g
Pre-game snack (1–2 hrs before)	Banana and honey sandwich	60 g
During game	1.5 x Sports drinks	50 g
Half-time	1 x Sports drink	35 g
	Muesli bar or banana	27 g
Post-game (within 30 min)	Sports drink / Sustagen sport	50 g
	Lollies	35 g

Nutrition

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Exam style question

A high-performance kayaker is competing in the 'Avon Decent' (2 days, paddling for 6 hours per day). Identify the sports nutrition principles for the following.

i. Pre-competition snack

ii. In-competition fluid replacement

iii. Post-day 1 competition – food and fluid replacement

Nutrition

Answer

A high-performance kayaker is competing in the 'Avon Decent' (2 days, paddling for 6 hours per day). Identify the sports nutrition principles for the following.

i. Pre-competition snack

A low to medium GI snack (e.g. Fruit like strawberries, apples, oranges) consumed 30-60 minutes prior to the race to top-up carbohydrate stores and fluid.

ii. In-competition fluid replacement

Drink 400-800 mL per hour during the event – or the equivalent of the volume of fluids lost. The fluid should be cold and contain a carbohydrate concentration of 6-8% solution and some electrolytes (like Powerade).

iii. Post-day 1 competition – food and fluid replacement

Consume high GI carbohydrate immediately post-exercise. Evening meal should be low to medium GI – complex carbohydrate to replace the total kJ expended. Consume 1.5 times the nett fluid lost during exercise.

Environmental Influences on Performance

In order to understand the implications of preparing for and performing exercise in the heat or cold, you must first understand how the body regulates its temperature.

The body's core temperature is maintained close to 37°C.

If core temperature deviates too far from 37°C (± 3°C), performance is severely impaired and the results can be life-threatening.

Environmental Influences on Performance

The body uses four mechanisms to regulate core temperature:

Radiation – transfer of heat by electromagnetic waves

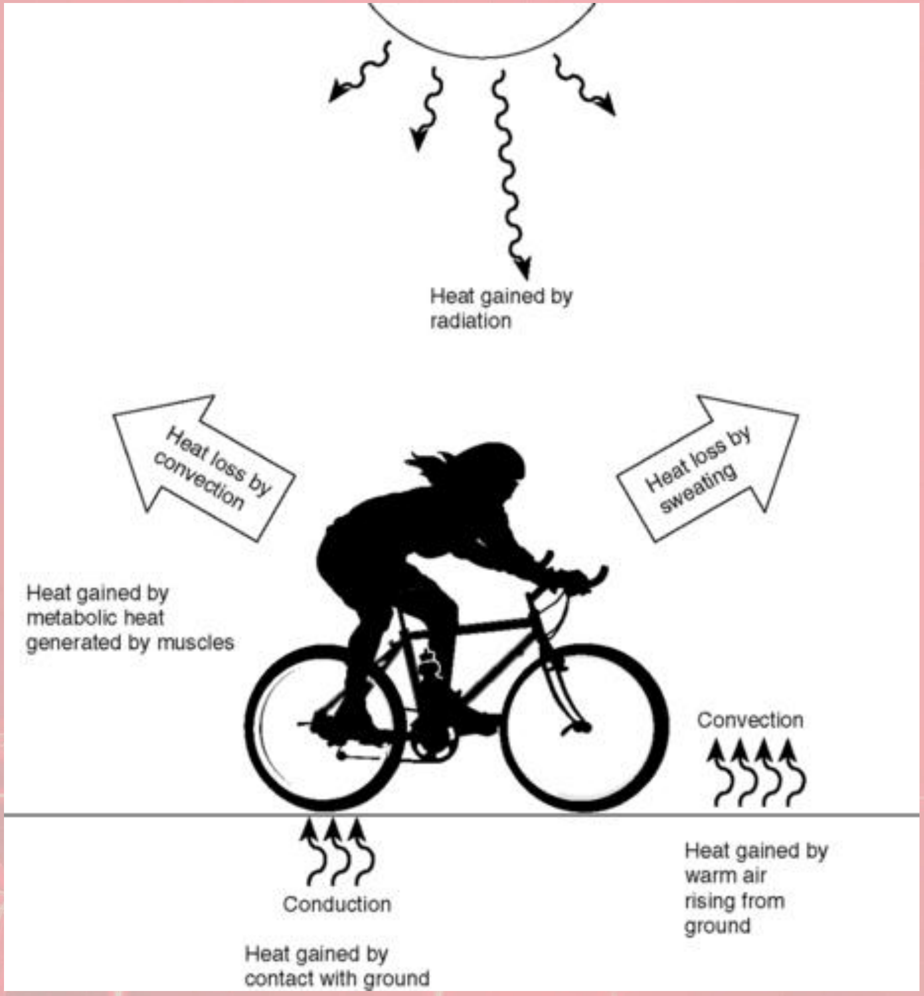
Conduction – transfer of heat through direct contact

Convection – transfer of heat by the motion of moving substances (typically air or water)

Evaporation – transfer of heat resulting from the evaporation of water (sweat) on the skin surface.

*Note: the transfer of heat is always from warmer objects to cooler objects. Also, the amount of heat transferred is relative to the temperature gradient (the temperature difference) between the two objects.

Environmental Influences on Performance



Exercise in the Heat

During exercise, the rapid increase in chemical reactions required to produce muscular work causes a major increase in heat production by the body.

This heat must be dissipated from the body in order to prevent a rise in core body temperature to a dangerous level.

During exercise in the heat, evaporation is the primary mechanism by which heat can be dissipated from the body.

Exercise in the Heat

When exercising in the heat, a significant amount of body fluid (water) is lost via sweat.

A team sport player may lose ~2 L of fluid per hour during intense exercise in the heat.

An elite marathon runner may lose up to 6 L of sweat in a race, even if taking on fluids at drinks stops along the way.

Ultimately, this amount of fluid loss causes dehydration which will impair both performance and continued heat dissipation.

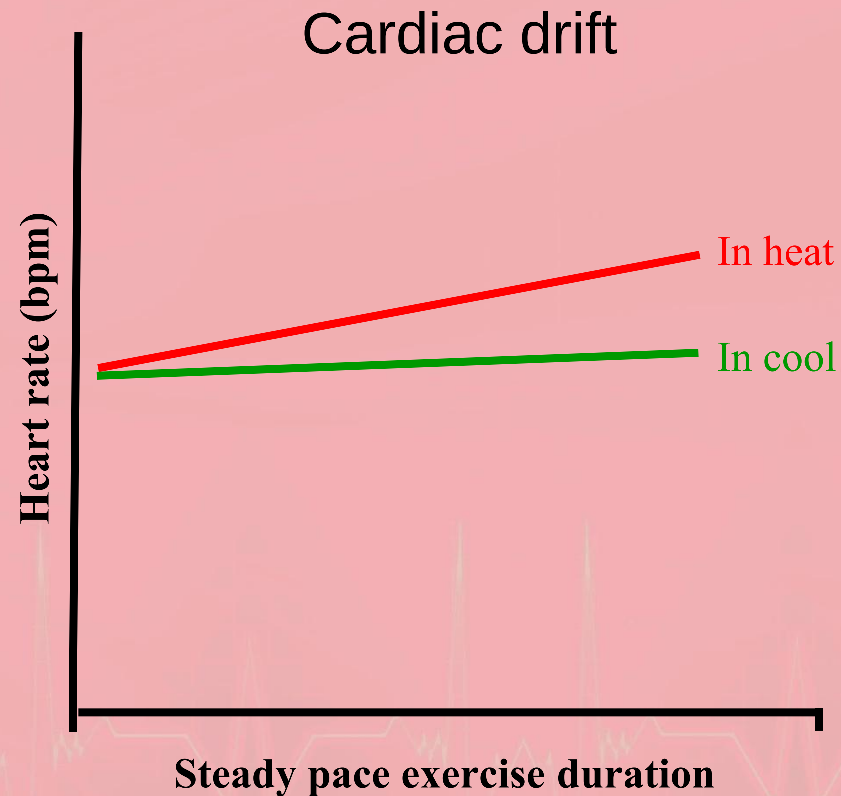
A loss of fluid equal to 1–2% of body mass during exercise will significantly impair both athletic performance and mental function.

Exercise in the Heat

Fluid loss during exercise in the heat results in reduced blood plasma volume and therefore:

- a ***double heat load***
(↓ blood flow to both the working muscles *and* the skin)

- a ***cardiac drift***
(↓ stroke volume leading to an ↑ heart rate to compensate).



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Exercise in the Heat

Physiological responses to a 40 min treadmill run in the heat (37°C and 36% humidity)

Time	Body mass	Heart rate	Core temperature	Skin temperature	Oxygen consumption	Blood lactate
Pre-exercise	75.7 kg	52 bpm	37.23°C	31.17°C	-	1.3 mM
20 min of exercise	-	177 bpm	39.11°C	37.26°C	4.12 L/min	4.0 mM
37 min of exercise	-	182 bpm	39.53°C	37.45°C	4.17 L/min	4.3 mM
Post-exercise	73.65 kg	-	-	-	-	-
Body mass loss 2.35 kg						

Exercise in the Heat

Pre-event hydration strategies

Adequate hydration is crucial prior to exercise in the heat.

The amount of water intake required to achieve adequate hydration will vary considerably between individuals.

As a general guide, athletes may consume 350–500 mL ~4 hours prior to competition.

If urine is still dark and concentrated in colour, or no urine is produced at all, the athlete should drink another 200–350 mL two hours prior to the event.

Hyperhydration is the consumption of excess fluid in preparation for loss of fluid in upcoming exercise.

Exercise in the Heat

Hydration strategies during exercise

Drinking during exercise (400–800 mL per hour) will decrease the risk of dehydration.

For short duration events, aim to drink 100–200 mL per 15 minutes.

Drinking plain water is adequate for exercise < 1 hour in duration.

For exercise > 1 hour, combining carbohydrate with fluid is beneficial.

Exercise in the Heat

Hydration strategies during exercise

A carbohydrate concentration of 6–8% in solution is optimal for absorption in the gastrointestinal tract.

Cold and flavoured fluids encourage increased consumption.

Electrolytes increase the desire to drink and fluid absorption in the gastrointestinal tract.

Consuming the recommended amount of fluid during exercise may still not equate to the amount of fluid lost from sweat during exercise in hot conditions.

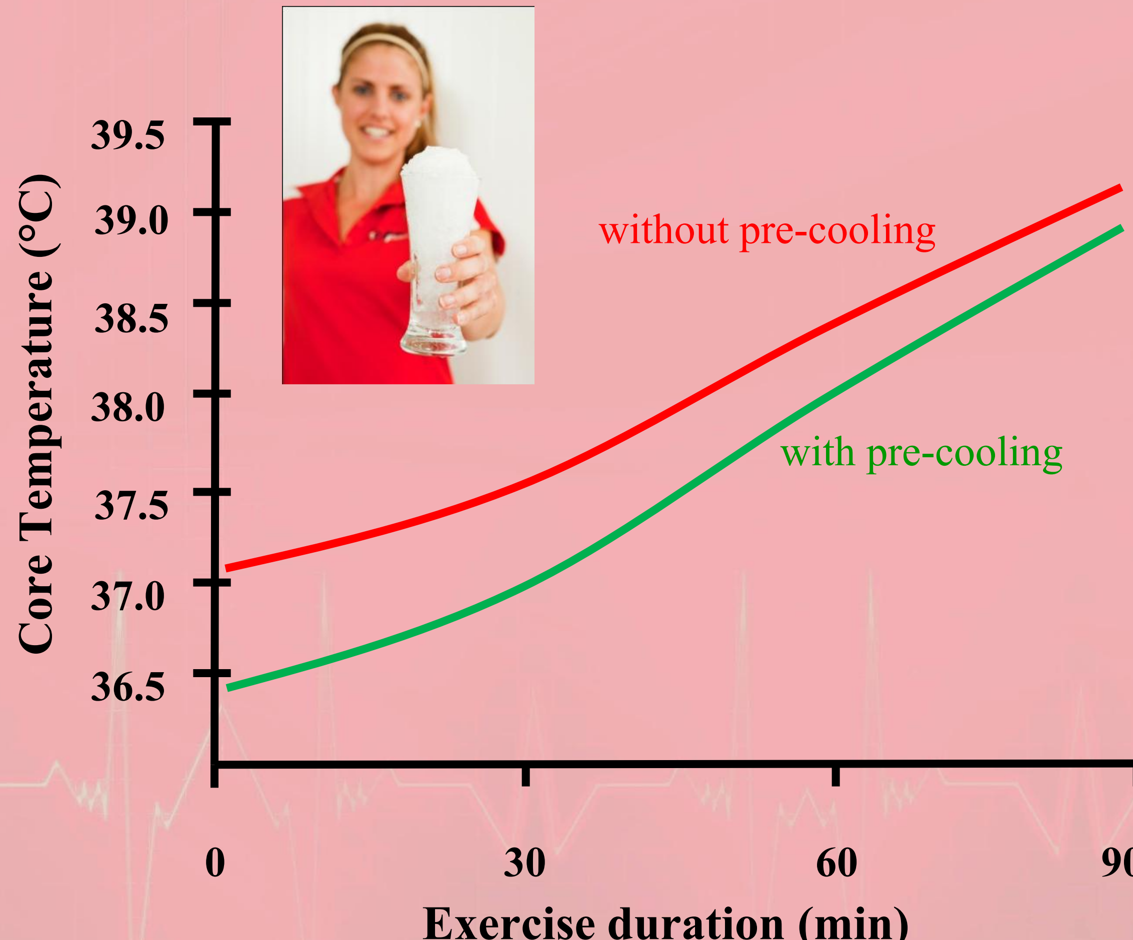
Exercise in the Heat

Other strategies for coping with exercise in the heat

Pre-cooling lowers core temperature prior to exercise allowing for a greater increase before the critical threshold is reached.

Methods of pre-cooling include:

- using cooling jackets
- cold water immersion
- crushed ice ingestion.



Exercise in the Heat

Other strategies for coping with exercise in the heat

Wear thin, light coloured cotton clothing
- the less clothing the better to allow increased skin exposure for evaporative cooling)

Individuals with a large skin surface area to body mass ratio may tolerate heat better (like endurance runners) than individuals with a low skin surface area to body mass ratio (like wrestlers, or rugby players).

Exercise in the Heat

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Heat Acclimatisation

The ability to tolerate heat can be enhanced through ***heat acclimatisation***.

Heat acclimatisation involves a period of exercise training (typically 5–10 days) in a similar environment to that which is expected for competition.

This results in:
- earlier onset of sweating
- greater rate of sweating
- increased plasma volume.

Training in a climate chamber

Exercise in the Humidity

Humidity represents the proportion of water in ambient air.

This has relevance for the effectiveness of evaporation as a mechanism of heat loss from the body.

If the relative humidity is high (i.e. the ambient air is already carrying a high proportion of water), there is nowhere for the sweat on the skin to evaporate to.

Under these conditions sweat will drip from the body, which is of no use for cooling and simply represents a waste of precious body water.

Environment

Exam style question

i. A triathlete competing in a race has been running for 1 hour in hot conditions. Despite running at a consistent intensity they have noticed that their heart rate is beginning to creep higher and they feel hotter. Explain what they are experiencing.

ii. Identify how crushed ice ingestion and heat acclimatisation training will potentially improve an endurance athletes performance in hot conditions.

Environment

Answer

i. A triathlete competing in a race has been running for 1 hour in hot conditions. Despite running at a consistent intensity they have noticed that their heart rate is beginning to creep higher and they feel hotter. Explain what they are experiencing.

A cardiac drift, steady increase in heart rate, occurs when the athlete's blood volume is decreasing. They have a decreased venous return and stroke volume. A double heat load is also being experienced which refers to the reduced blood plasma volume from sweating. This impairs the body's ability to deliver blood to both the working muscles and the periphery for cooling via sweat evaporation.

ii. Identify how crushed ice ingestion and heat acclimatisation training will potentially improve an endurance athletes performance in hot conditions.

Crushed ice ingestion prior to performance will lower the core body temperature – providing scope for more time before a critical temperature threshold is reached.

Heat acclimatisation training will assist to hasten the onset of sweating, increase sweat rate and increase plasma volume. All changes serve to decrease the rate at which the core temperature increases during exercise in the hot conditions.

Exercise in the Humidity

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Physiological responses to a 10 km run in hot and humid conditions

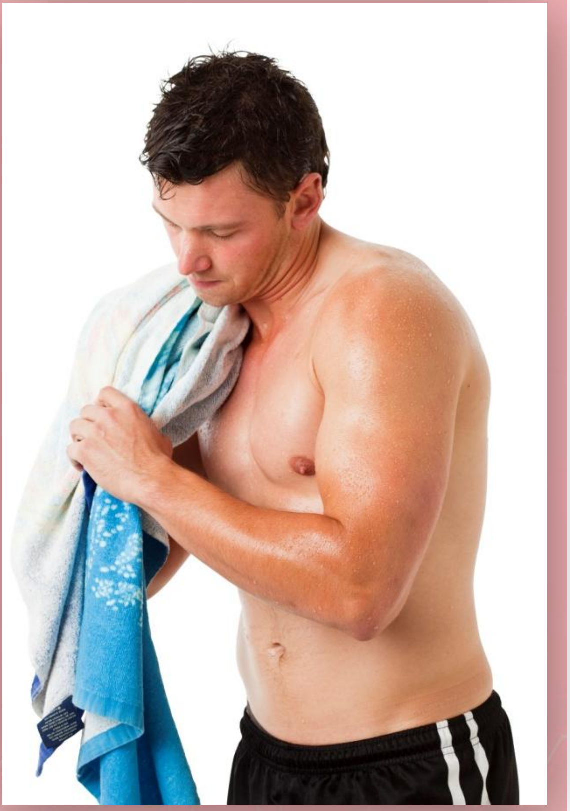
	Perth	Darwin
Ambient temperature	22°C	32°C
Relative humidity	43%	73%
Performance time	41 min 09 sec	43 min 53 sec
Pre-run core temperature	37.0°C	37.1°C
Post-run core temperature	39.0°C	40.3°C
Pre-run skin temperature	32.3°C	33.9°C
Post-run skin temperature	27.9°C	35.7°C
Exercise heart rate	190 bpm	198 bpm
Pre-run body mass	73.2 kg	73.2 kg
Post-run body mass	72.7 kg	71.5 kg
Estimated fluid loss (L)	0.5 L	1.7 L
Estimated fluid loss (% body mass)	0.6%	2.3%

Exercise in the Humidity

Strategies for coping with humidity

The strategies for coping with humidity are similar to preparing for competition in the heat:

- pre-event hydration
- hydration during exercise
- pre-cooling techniques
- acclimatisation.



Acclimatisation can only assist to a certain extent given that there is limited evaporation of sweat in high humidity.

Exercise in the Cold

When exposed to a cold environment, the body is forced to conserve heat in order to maintain a stable core body temperature.

This is achieved by a number of mechanisms including:

Peripheral vasoconstriction – constriction of the blood vessels just below the skin surface to shunt blood away from the periphery towards the core instead.

Shivering – uncontrolled muscular contractions to elevate heat production.

Piloerection – when the hairs on the body stand on end to trap a warm layer of air close to the skin to keep the skin surface warm.

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Exercise in the Cold

Strategies to cope with exercise in the cold

Acclimatisation may be of some use prior to competition in the cold.

Wear multiple layers of clothing which can be removed as the athlete's body 'warms up' from the heat produced by muscular work.

Insulation from body fat, animal fats rubbed on the skin and wetsuits help minimise heat loss from the body in cold, wet conditions.

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Exercise at Altitude

The air is thinner at altitude due to lower barometric pressure.

With ‘thinner’ air, there is less absolute oxygen available resulting in hypoxia (lack of adequate oxygen).

The lower oxygen availability at altitude translates to lower oxygen availability in inspired air, and therefore the amount of oxygen transported in the blood to the working muscles.

Exercise at Altitude

The lack of oxygen at altitude impairs the maximal rate of oxygen consumption (an therefore aerobic exercise performance).

Performance in repeated sprint exercise is also impaired due to the lower oxygen availability to replenish creatine phosphate stores and remove lactic acid.

Performance in one-off sprint or power events may be enhanced at altitude due to lower air resistance and drag.

Exercise at Altitude

Gold medal performances at the 1968 Olympic Games in Mexico City (altitude 2300 m)

Event	Gold Medal performance in 1968	World Record in 1968
100 m Men	9.95 sec	New world record
100 m Women	11.0 sec	New world record
1500 m Men	3 min 34.9 sec	3 min 33.1 sec
10,000 m Men	29 min 27.4 sec	27 min 39.4 sec
Marathon Men	2 hr 20 min 27 sec	2 hr 12 min 0 sec
Long jump Men	8.90 m	New world record set
Long Jump Women	6.82 m	New world record set
Javelin Men	90.10 m	91.98 m
Javelin Women	60.36 m	62.40 m

Exercise at Altitude

Adaptations to altitude

Acute adaptations upon arrival at altitude include:

- increased pulmonary ventilation
- decreased plasma volume
- increased heart rate and cardiac output at rest and during submaximal exercise.

Long-term adaptations to a prolonged stay at altitude include:

- increased red blood cells and haemoglobin concentration
- increased capillarisation
- increased mitochondria
- increased aerobic enzymes.

Exercise at Altitude

Strategies to cope with altitude

Acclimatisation improves the ability to cope with hypoxia.

The duration of acclimatisation required varies with the specific elevation (i.e. the higher the elevation, the longer period of acclimatisation required).

Acclimatisation to one altitude only ensures partial acclimatisation to further increases in altitude.

Negative effects of a prolonged stay at altitude include a loss of body mass and reduced training capacity (eventually leading to detraining).

Exercise at Altitude

Altitude training

Sea level performance may be enhanced by living at altitude, but returning to sea level for training to ensure high intensity quality training sessions (live high, train low).

Hypobaric chambers or altitude tents allow athletes to sleep in conditions similar to altitude, but still train at sea level during the day.

'Living' in an altitude tent

Environment

Exam style question

An endurance athlete is preparing for an up-coming 2-hour event at altitude. They are debating if they should ‘train high live low’ or ‘train low and live high’. Provide and justify an answer to their question.

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Environment

Answer

An endurance athlete is preparing for an up-coming 2-hour event at altitude. They are debating if they should 'train high live low' or 'train low and live high'. Provide and justify an answer to their question.

Train high live low is the recommended approach. It allows for the benefits of living at altitude:

- *Increased red blood cell and haemoglobin concentration*
- *Increased capillarisation*
- *Increased mitochondria*
- *Increased aerobic enzymes.*

Training at sea level (low) also allows high intensity training sessions; whereas, while living at altitude the athlete cannot train as hard, leading to a detraining effect and a loss of muscle mass.

Performance Enhancers

Elite athletes are always looking for an edge to help them run that spilt second faster or jump 1 cm further.

For this reason, a range of ***performance enhancers***, or ***ergogenic aids,*** are applied in sport to gain any advantage.

Some methods of enhancing performance are widely accepted, while others are prohibited or controversial.

In general, those ergogenic aids that are prohibited in sport are those that result in potential harmful consequences or have detrimental side effects.

Performance Enhancers

Some substances are prohibited both in and out of competition, including:

- anabolic steroids
- certain hormones and growth factors such as erythropoietin (EPO; which stimulates the production of red blood cells) and growth hormone (which stimulates muscle growth)
- diuretics and masking agents (which may prevent the detection of other performance enhancers in a blood or urine test).

Other substances are prohibited during competition only, for example:

- stimulants such as cocaine and amphetamines (which may enhance alertness and decrease fatigue).

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Legal Performance Enhancers

Carbohydrate loading

Carbohydrate loading (or glycogen loading) is a routinely used method to improve endurance performance by enhancing the amount of carbohydrate stored in the muscle.

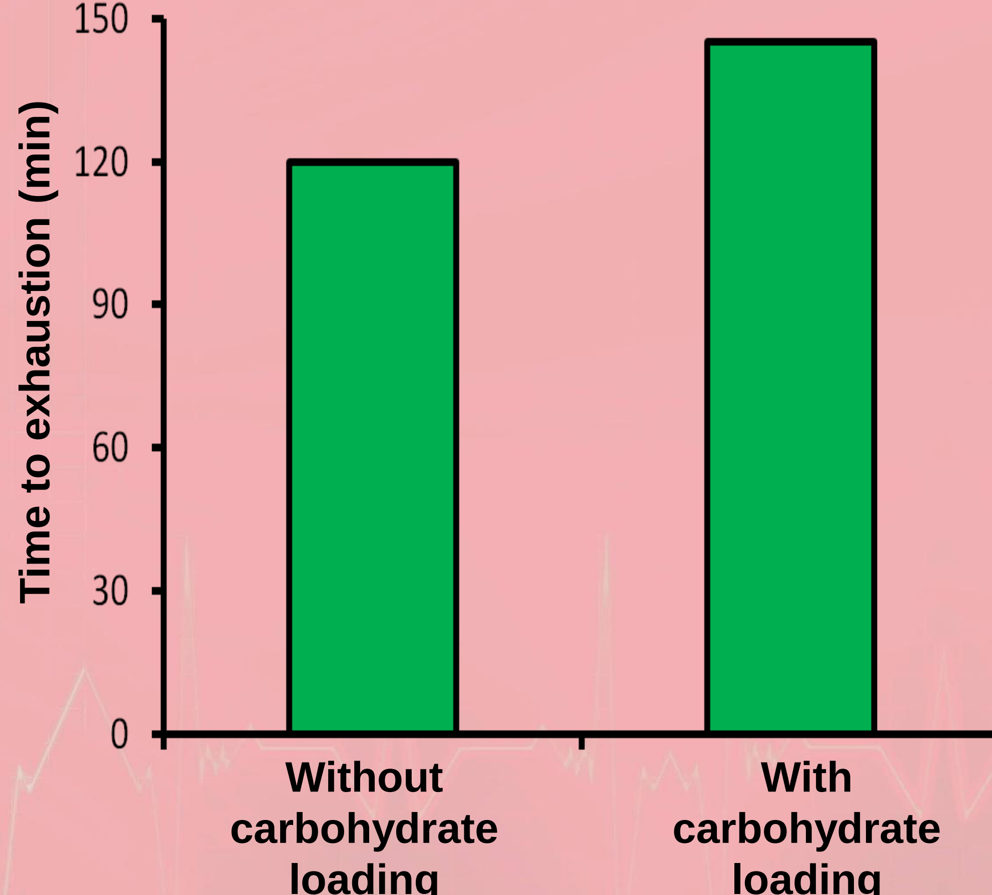
Involves consuming high amounts of dietary carbohydrate (10–12 g per kg of body mass) in the days leading up to competition, in combination with reduced training load.

Results in higher than normal (almost double) levels of glycogen stored in the muscle ready for use on the day of competition.

Legal Performance Enhancers

Carbohydrate loading

By carbohydrate loading, an athlete will be able to work for longer at a higher intensity before the limited carbohydrate stores become depleted.



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Legal Performance Enhancers

Carbohydrate loading

Carbohydrate loading will benefit events > 1 hour in duration such as a marathon or Olympic distance triathlon.

For team sports, carbohydrate loading may be useful in situations where games extend beyond 1 hour. However, it is often difficult for these athletes to carbohydrate load effectively since they cannot properly ‘taper’ within the context of a weekly training schedule.

In sprint or power events, carbohydrate loading may be detrimental to performance since weight gain of about 2 kg is not uncommon following a period of carbohydrate loading.

Sample carbohydrate loading diet for a 70 kg person

Meal	Food	Carbohydrate (g)
Breakfast	8 weetbix with low-fat milk and honey 2 slices of toast with strawberry jam 1 banana 2 cups of orange juice	118 g 40 g 27 g 60 g
Lunch	2 rounds of sandwiches with choice of filling 1 muffin with honey 1 apple 1 Sports drink	80 g 60 g 25 g 35 g
Dinner	Large serving of spaghetti bolognese (3 cups of pasta) 3 slices of garlic bread 1 can of lemonade 1 serve of vanilla ice cream	150 g 35 g 38 g 30 g
Snacks	1 x museli bar 1 x tub yoghurt 1 x glass of cordial	23 g 30 g 20 g
	TOTAL	**770 g (11 g/kg)**

Legal Performance Enhancers

Carbohydrate loading

Is a potential advantage because it:

- leads to higher than normal (almost double) levels of glycogen stored in the muscle
- allows endurance athletes to work for longer at a higher intensity.

Is a potential disadvantage because it:

- increases pre-competition weight.

Legal Performance Enhancers

Protein supplementation

Many athletes, particularly weightlifters and bodybuilders, consume extra protein or amino acids in the form of powders.

The rationale for this is that increased protein intake will translate to increased muscle bulk and repair of muscle damage.

However, there appears to be little benefit in consuming these products for individuals that already have adequate protein intake from a balanced diet.

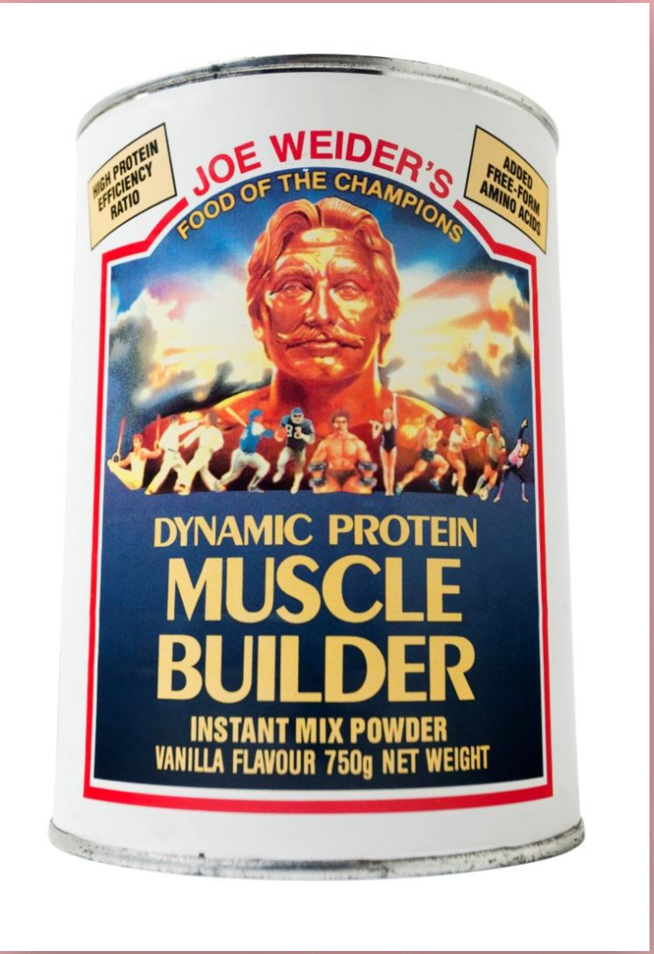
Excess protein intake alone will not stimulate muscle growth and development – resistance training is needed!

Legal Performance Enhancers

Protein supplementation

The adaptations to resistance training may be enhanced by consuming a protein and high GI carbohydrate snack immediately following weight lifting sessions

- due to enhanced production of naturally occurring anabolic hormones and protein building.



Legal Performance Enhancers

Protein supplementation

Is a potential advantage because it:

- may enhance the adaptations to resistance training (increased muscle hypertrophy), particularly if protein intake from the normal diet is inadequate.

Is a potential disadvantage because:

- high protein levels in the diet may increase the risk of osteoporosis and colonic cancers, and impair kidney function in the long-term.

Legal Performance Enhancers

Creatine supplementation

Increases creatine stores in the muscle.

May benefit the performance of a single sprint

- by extending the time before CP becomes depleted, meaning an athlete can maintain peak speed for longer.

May benefit the performance of repeated sprints

- enhanced recovery between bouts due to increased availability of free creatine allowing for a faster rate of CP repletion.

May enhance muscular strength and development.

May benefit short-term endurance performance in events lasting 2–10 minutes due to an increase in muscle buffer capacity.

Legal Performance Enhancers

Creatine supplementation

Is a potential advantage because it:

- increases the amount of CP stored in the muscle, thereby extending the time before CP becomes depleted
- increases availability of free creatine allowing for a faster rate of CP repletion
- enhances muscular strength and development
- increases muscle ‘buffer’ capacity.

Is a potential disadvantage because it:

- results in a weight gain of around 1 kg
- is unknown what the long-term side effects are.

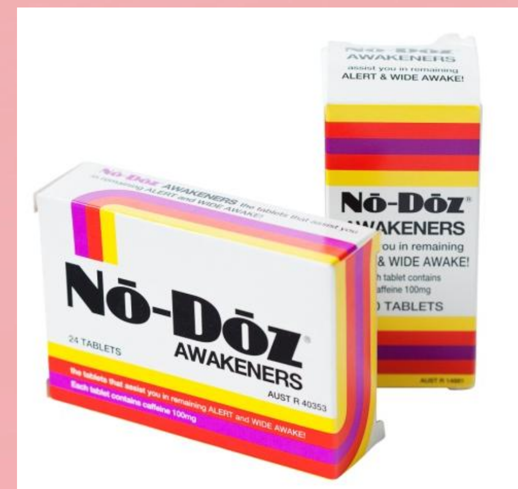
Legal Performance Enhancers

Caffeine supplementation

Caffeine is a stimulant

Effects on the body:

- increased arousal
- improved reaction time
- improved concentration and decision making ability
- reduced perception of fatigue / effort
- increased availability of free fatty acids for ATP production (may spare some muscle glycogen).

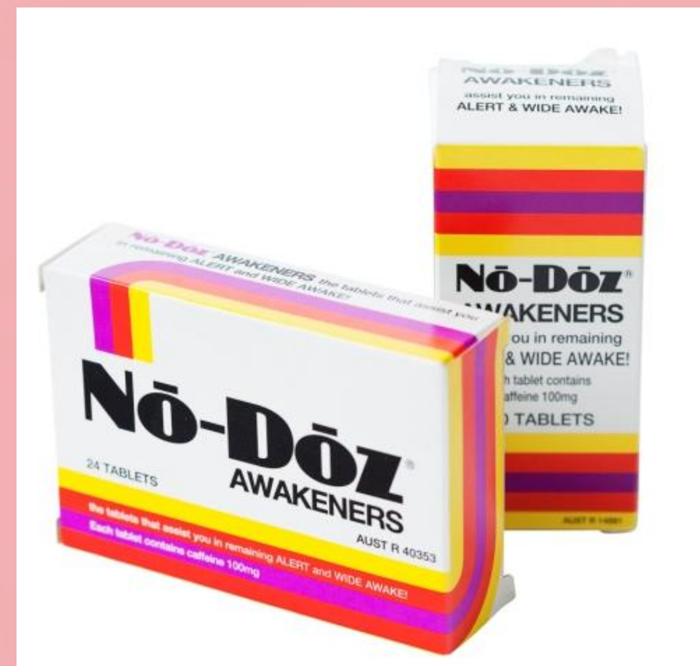


Legal Performance Enhancers

Caffeine supplementation

Typically consumed in tablet form (3–6 mg per kg of body mass) approximately one hour prior to exercise

- equivalent to consuming 6–10 cans of Coca Cola or 1.5 kg of chocolate for a 70 kg man.



The effect may be greater in individuals that do not regularly consume caffeine.

Legal Performance Enhancers

Caffeine supplementation

Is a potential advantage because it:

- increases arousal which may improve reaction time, concentration and decision making ability
- may reduce an athlete's perception of fatigue or effort
- increases the availability of free fatty acids for ATP production, which may spare muscle glycogen, thereby enhancing prolonged endurance performance.

Is a potential disadvantage because it:

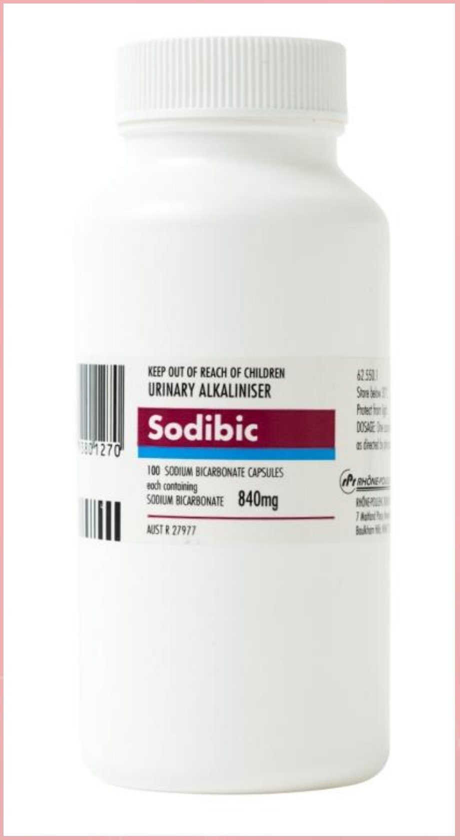
- may lead to restlessness, feeling overanxious, muscle twitching, irritability, increased heart rate and blood pressure
- is a diuretic and may increase the risk of dehydration.

Legal Performance Enhancers

Sodium bicarbonate supplementation

Ingestion of sodium bicarbonate 90–120 min prior to exercise has been shown to reduce the build up of hydrogen ions and therefore minimise the acidosis resulting from exercise activities relying on the lactic acid system.

Ingestion of sodium bicarbonate will not benefit performance in activities in which lactic acid levels remain low and steady.



Legal Performance Enhancers

Sodium bicarbonate supplementation

Is a potential advantage because it:

- neutralises or ‘buffers’ accumulating hydrogen ions resulting from anaerobic glycolysis.

Is a potential disadvantage because it:

- may cause abdominal cramps and diarrhoea
- is not known what the long-term effects of regular supplementation are.

Illegal Performance Enhancers

Anabolic steroids

Can be taken in oral form or injected directly into the muscle.

These drugs simulate the anabolic actions of the male sex hormone testosterone which is responsible for many of the secondary sex characteristics of the male body such as facial hair and a deep voice.

Testosterone also plays a crucial role in muscular development.

Illegal Performance Enhancers

Anabolic steroids

Enhance performance in events involving muscular strength and power.

May benefit endurance performance by improving the rate of tissue repair (so athletes can train harder and longer with less recovery needed).

Banned in sport due to side-effects.

It is believed that many athletes have died prematurely as a result of prolonged use of anabolic steroids.

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Illegal Performance Enhancers

Anabolic steroid use

Is a potential advantage because it:

- facilitates muscle development, assisting performance in strength and power events
- improves the rate of tissue repair, meaning athletes can train harder and longer with less recovery needed.

Is a potential disadvantage because it:

- leads to increased levels of aggression and hostility, infertility, acne, decreased testicular volume, liver dysfunction, heart disease and possibly even death
- causes a deepened voice, facial hair and menstrual irregularities in women.

Illegal Performance Enhancers

Track and field athlete Marion Jones won five medals at the 2000 Sydney Olympic Games. She was later stripped of her medals when it was found that she had been taking steroids. She still believes she would have won even without taking the drugs; however, nobody will ever know for sure.

Illegal Performance Enhancers

Blood doping

A procedure by which the oxygen carrying capacity of the blood is enhanced.

Achieved by increasing the number of red blood cells (haematocrit) and therefore, the amount of haemoglobin in the body

- via injection of erythropoietin (a hormone that stimulates red blood cell production)
- via red blood cell infusion.

Results in improved aerobic performance.

Illegal Performance Enhancers

Blood doping

Is a potential advantage because it:

- increases haematocrit and therefore the oxygen carrying capacity of the blood.

Is a potential disadvantage because it:

- increases the thickness of the blood (viscosity), which increases the risk of blood clotting, heart attack and stroke, especially when dehydrated.

Performance Enhancers

Exam style question

Athletes have a limited capacity to store carbohydrate. Explain the benefits of carbohydrate loading in the lead-up to a competition.

Performance Enhancers

Answer

Athletes have a limited capacity to store carbohydrate. Explain the benefits of carbohydrate loading in the lead-up to a competition.

An increased carbohydrate intake and reduced training load results in almost double the levels of glycogen stored in the muscle. Therefore, an athlete will be able to work for longer at a higher intensity before carbohydrate stores become depleted. There is also an increased store of water in the body with increased levels of stored the glycogen.

Performance Enhancers

Exam style question

A 50 kg female marathon runner decides to significantly reduce her coffee consumption in the week leading up to a race. On the morning of the event she consumes 150 mg of caffeine. Provide a rationale for this approach and identify how it may assist her performance. Also, identify how caffeine may inhibit performance.

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Performance Enhancers

Answer

A 50 kg female marathon runner decides to significantly reduce her coffee consumption in the week leading up to a race. On the morning of the event she consumes 150 mg of caffeine. Provide a rationale for this approach and identify how it may assist her performance. Also, identify how caffeine may inhibit performance.

The body generally cannot store enough carbohydrate to meet the energy demands of running a marathon (2.5+ hours). Caffeine increases the availability of free fatty acids for ATP production, which in turn stimulates increased fat oxidation. This may assist in sparing some muscle glycogen and consequently enhance performance, particularly late in the race. Coffee contains caffeine, and for a regular coffee user, a reduction in coffee consumption in the lead up to the race, will assist to washout caffeine and increase the physiological effects of her race day caffeine consumption. The amount of 150 gm is equivalent to 3 mg per kg of body mass, within the suggested dose for the desired affect.
However, caffeine is also a diuretic, which may lead to dehydration and limit endurance performance.

Training Programs

A successful training program involves thorough planning and is structured in a specific way to ensure that an athlete's best performances will be achieved at the right time of the season.

This is achieved through a process called ***periodisation*** whereby the training program is organised into different periods or blocks of time.

The training program for an entire season or year is typically divided into three main phases:

- ***Preparatory Phase*** (pre-season)
- ***Competition Phase*** (in-season)
- ***Transition Phase*** (off-season).

Training Programs

Preparatory Phase (Pre-Season)

To prepare for competition.

- *General preparation phase*
  - to establish a base-level of fitness and skills
  - emphasises a high volume of moderate intensity exercise.
- *Specific preparation phase*
  - training becomes more sport and competition specific
  - intensity of training is increased
  - increased focus on skill development and technique.

Training Programs

Competition Phase (In-Season)

- *Pre-competition phase*
  - the period leading up to competition
  - goal is to approach peak condition
  - highly specialised training, with an emphasis on quality (intensity) rather than quantity (total volume)
  - early season races or ‘scratch matches’ for experience.
- *Competition phase*
  - when the athlete is ready to perform at their peak
  - full development of all of the physical capacities and technical components required for optimal performance
  - training for maintenance of fitness levels (reduced volume, maintained intensity)
  - focus on psychological and tactical aspects of performance.

Training Programs

Transition Phase (Off-Season)

The period of time following the major competitive season.

Aim to maintain cardiorespiratory fitness, while recovering from demands of the competitive season.

'Active rest' is encouraged to prevent complete detraining.

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The phases of training for a soccer player

Training phase	Type of activity	Purpose
General preparatory phase	• Moderate intensity & increased volume (e.g. long runs) • Cross training	• Develop fitness (especially cardiorespiratory endurance)
Specific preparatory phase	• Increased intensity (e.g. intervals, time trials) • Skills • Repeated sprint ability	• Further develop fitness • Enhance and develop skills & technique
Pre-competition phase	• Skills & tactics • Small sided games • Scratch matches	• Gain competitive experience • Fine tune technical aspects of game • Hit top form
Competition phase	• Training (reduced volume) • Weekly Games	• Maintain peak form • Adequately recover
Transition phase	• Swimming & cycling • Social indoor soccer	• Maintain base fitness while recovering from soccer season

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Training

Exam style question

A netball team has been performing poorly and the coach decides to ‘make them pay’ by doubling their training volume, including some additional high intensity intervals. Explain, using the principles associated with the competition-phase of training, why this may be inadvisable?

Training

Answer

A netball team has been performing poorly and the coach decides to ‘make them pay’ by doubling their training volume, including some additional high intensity intervals. Explain, using the principles associated with the competition-phase of training, why this may be inadvisable?

The competition-phase should be focused on maintaining peak form. A one-off significant increase in training volume will potentially impact on recovery from the game and therefore, could lead to fatigue and increase the likelihood of poor performance and injury.

Training Programs

Macrocycles

- periods of time within the training plan (typically 4–6 weeks) in which there is a specific focus/goal for training.

Microcycles

- smaller periods of time within the training plan (typically a week) which combine to contribute towards the goal of the macrocycle.

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Relationship between microcycles and macrocycles for a triathlete

<table>
<tr><th colspan="48">Annual Plan</th></tr>
<tr><th colspan="4">June</th><th colspan="4">July</th><th colspan="4">Aug</th><th colspan="4">Sep</th><th colspan="4">Oct</th><th colspan="4">Nov</th><th colspan="4">Dec</th><th colspan="4">Jan</th><th colspan="4">Feb</th><th colspan="4">Mar</th><th colspan="4">April</th><th colspan="4">May</th></tr>
<tr><th colspan="48">Phases of Training</th></tr>
<tr><td colspan="8">General Preparation</td><td colspan="12">Specific Preparation</td><td colspan="8">Pre-Competition</td><td colspan="16">Competition</td><td colspan="4">Transition</td></tr>
<tr><th colspan="48">Macrocycles</th></tr>
<tr><td colspan="4">1</td><td colspan="4">2</td><td colspan="4">3</td><td colspan="4">4</td><td colspan="4">5</td><td colspan="4">6</td><td colspan="4">7</td><td colspan="4">8</td><td colspan="4">9</td><td colspan="4">10</td><td colspan="4">11</td><td colspan="4">12</td></tr>
<tr><th colspan="48">Microcycles</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
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Training Programs

Specific energy system requirements

The activities performed within each training session are dependent upon the components of fitness and energy systems related to the sport.

The health-related components of fitness include:

- cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition.

The performance/skill-related components of fitness include:

- agility, balance, coordination, reaction time, speed, and power.

The three energy systems include:

- ATP-CP, lactic acid and aerobic energy system.

Typical weekly in-season training program for a 100 m sprinter

Time/Day	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday
AM	GYM 8 exercises 3 sets x 8 reps Focus: Maintain Strength Power Development	OFF	OFF	OFF	REST DAY	COMPETITION **Maximal intensity performance**	RECOVERY SESSION **Beach** 15 min Light Sand Jog 10 min Group Stretch Flags/short beach sprints 10 min in Ocean (Wade/Swim)
PM	TRACK SESSION 1 km jog w/up 10 min stretching 10 min drills 4 x 5 reps through (60 m, 80 m, 100 m, 120 m, 140 m) walk back recovery 1 km c/down	GRASS SESSION 1 km jog w/up 10 min stretching 10 min drills Plyometrics 2 x 3 x 20 m bounding 2 x 3 x 20 m hopping 2 x 6 reps 80 m 1 km c/down	GYM 8 exercises 3 sets x 8 reps Focus: Maintain Strength Power Development	TRACK SESSION 1 km jog w/up 10 min stretching 10 min drills 2 x 6 reps block starts 3 x 6 reps speed play (maximal 30 m sprint, coast 30 m, sprint 30 m)	REST DAY	OFF 	OFF

Energy system = ATP-CP system

Components of fitness = Speed, muscular strength, power, reaction time

Typical weekly in-season training program for an open water swimmer

Time/Day	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday
AM	1500 m w/up Easy swim + drills 5 x 800 m Depart on 12' Target = 11' / rep 2 x 400 m c/dwn (swim/kick/pull/swim) **TOTAL - 6.3 km**	Gym 10 Exercises 4 Sets of 15 Reps Focus = Endurance	800 m w/up Easy swim + drills 1000 m + 800 m + 400 m Depart on 15', 12',6' Target = 13'30, 11', 5'15 **TWICE THRU** 5 x 200 dps c/dwn **TOTAL - 6.2 km**	Gym 10 Exercises 4 Sets of 15 Reps Focus = Endurance	1200 w/up Easy swim + drills 4 x 500 descending 1-4 Rep 4 @ MAX EFFORT Departing on 7' 8 x 200 IM tempo Departing on 3' 400 (kick/swim) c/dwn **TOTAL - 5.2 km**	Race 5 km Open Water Ocean Swim **MAX RACE EFFORT** **TOTAL - 5 km**	REST DAY
PM	800 m w/up Easy swim + drills 400m+300m+200m+100m Depart on 5'45, 4'15, 3', 2' **FOUR TIMES THRU** 4 x 200 (100 kick/100 pull) **TOTAL - 5.6 km**	1500 m w/up Easy swim + drills 8 x 400 m Depart on 6' Target = 5'10/rep 1000 m Tempo c/dwn **TOTAL - 5.7 km**	1000 m w/up Easy swim + drills 30 x 100 m Depart on 1'30 Target = 1'15/rep 3 x 200 m c/dwn **TOTAL - 4.6 km**	1500 m w/up Easy swim + drills 3 x 1000 m Pull/Paddles Depart on 14' 10 x 100 Fartlek c/dwn Depart on 1'45 **TOTAL - 5.5 km**	OFF	OFF	REST DAY

Energy system =
Aerobic energy system

Components of fitness =
Cardiorespiratory & muscular endurance

Typical weekly in-season training program for a hockey player

Time/Day	Monday	Tuesday	Wednesday	Thrusday	Friday	Saturday	Sunday
AM	OFF	OFF	GYM 15 min Aerobic Cycle (on ergo) 6 Exercises (2 Push, 2 Pull, 2 Legs) Focus: Maintain Strength Power Development	OFF	REST DAY	GAME **Maximal** **Game Intensity**	RECOVERY SESSION **Beach** 10 min Light Sand Jog 10 min Group Stretch 10 min in Ocean (Wade/Swim)
PM	PITCH SESSION 30 min Match Analysis 30 min W/up + Light Skills 15 min Penalty Corners 15 min Top-up Conditioning: 8 x Pitch Lap (Stride Length/Jog Width) Departing every 2 min	PITCH SESSION 20 min w/up + skills 5 x 3:30 4 v 3 (SSG) ⅓ Pitch (width) 2 min Recovery / Rep 5 min Recovery 4 x 2:00 ½ Pitch Press Attack vs Defense 1 min Recovery / Rep 10 min c/dwn + Stretch	X-TRAIN Optional 30 min Swim Session or LSD Jog	PITCH SESSION 20 min w/up + skills 8 x 1:30 3 v 3 (SSG) ⅓ Pitch (width) 1 min Recovery / Rep 20 min Penalty Corners 10 min c/dwn + Stretch	REST DAY	OFF 	OFF

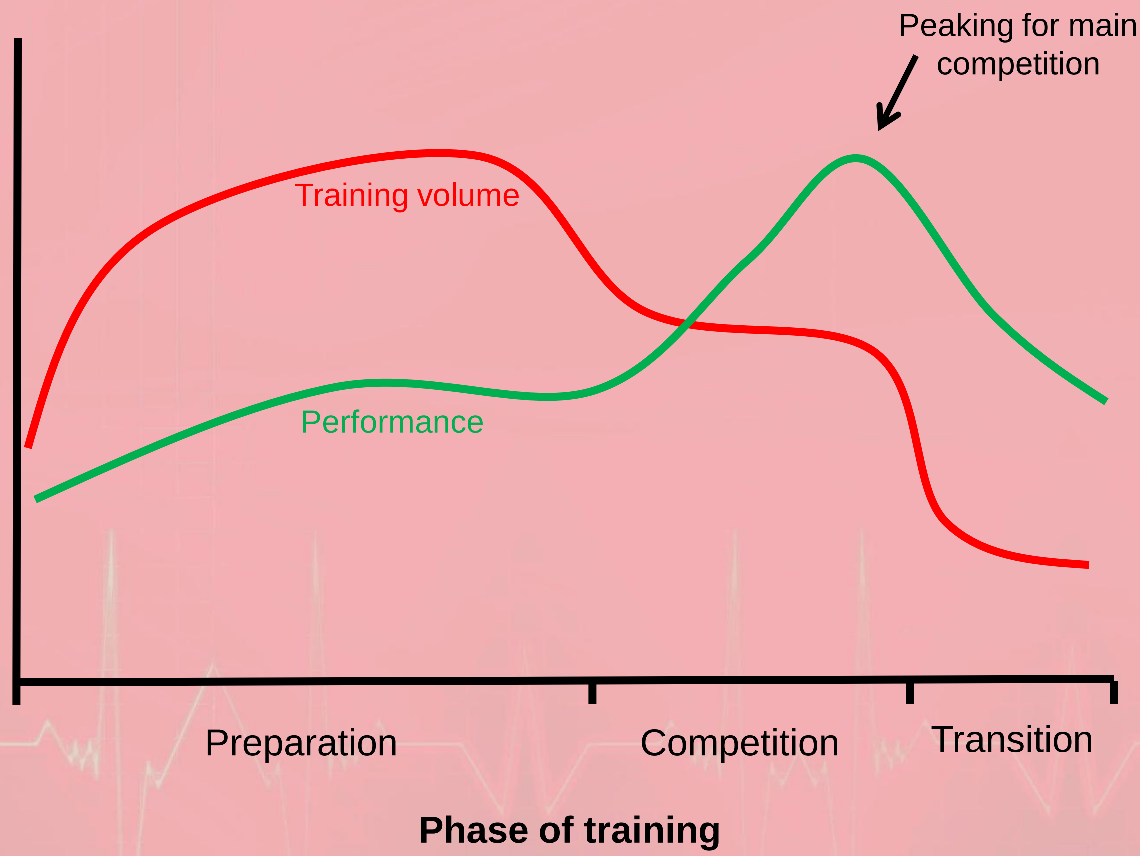
Energy system =
ATP-CP, lactic acid & aerobic systems

Components of fitness = Cardiorespiratory endurance, agility, reaction time, speed, muscular strength, power & endurance

Training Programs

Peaking

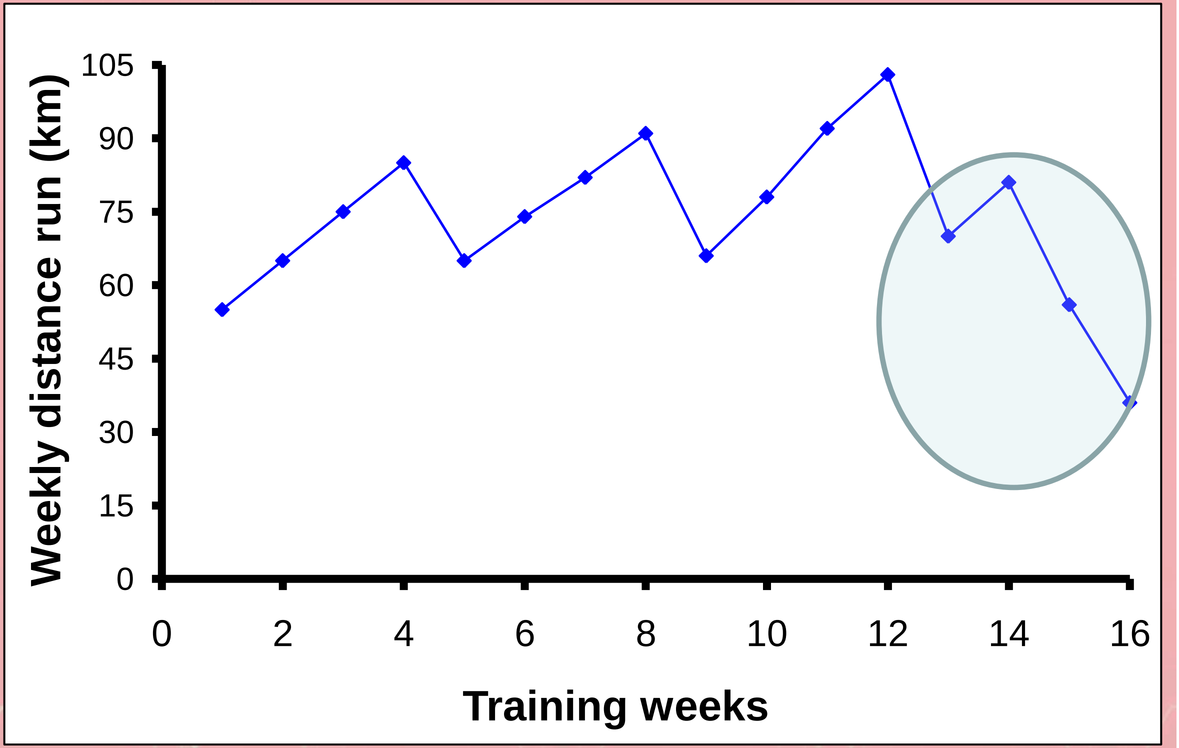
The achievement of optimal performance at the appropriate time in the training plan.



Training Programs

Tapering

The reduction of training volume in the days/weeks leading up to a competition to allow the body to recover and perform optimally.



Training Programs

Maintenance

Fitness levels need to be maintained throughout the season with an appropriate training load that permits maximum performance.

During this period, the amount of work completed in training is simply enough for the maintenance of fitness levels (reduced volume and maintained intensity), rather than continued overload to try to stimulate further improvement.

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Training

Exam style question

The coach of a 400 m swimmer is training to peak her athlete for a major competition. Outline the rationale of peaking and periodisation and how they would be incorporated into a training program to ensure maximum performance.

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Training

Answer

The coach of a 400 m swimmer is training to peak her athlete for a major competition. Outline the rationale of peaking and periodisation and how they would be incorporated into a training program to ensure maximum performance.

Periodisation: Will ensure the best performances occur at the appropriate time.

Peaking: Achieved by appropriate periodisation and the inclusion of a taper.

Taper: A decease in the volume of training with an increase or maintenance of intensity, with increased time for recovery.

The implementation of these training principles will serve to decrease fatigue and improve performance.

Training Programs

Recovery

Adequate recovery between training sessions is needed to allow a physiological training effect (overcompensation).

Recovery strategies commonly employed by athletes include: massage, compression garments, cold water immersion, warm water immersion, contrast water therapy, and stretching.

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Training Programs

Overtraining

An inadequate balance between training load and the time allowed for recovery may result in a state of ***overtraining***.

Symptoms of overtraining include:

- a lack of energy, muscle aches, impaired performance, lack of enthusiasm, increased risk of injury and illness (especially colds).

Risk may be reduced by allowing 24–48 hours of recovery between ‘heavy sessions’ and ensuring adequate rest, sleep and nutrition.

Training Programs

One-legged cycling

The injured athlete

The primary goal for the injured athlete is to limit the amount of detraining that results during the period in which they are unable to compete in their sport.

The injured athlete should be included as much as possible in team activities.

Training

Exam style question

The school netball team undertakes a ten-week training program prior to a major competition. At the end of each training session the players were fatigued. The coach conducted a warm-down activity.

List specific actions, other than a warm-down, the players could undertake to ensure they recover as rapidly as possible after each session.

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Training

Answer

The school netball team undertakes a ten-week training program prior to a major competition. At the end of each training session the players were fatigued. The coach conducted a warm-down activity.

List specific actions, other than a warm-down, the players could undertake to ensure they recover as rapidly as possible after each session.

Recovery strategies:

- *Cold water immersion, warm water immersion, contrast water therapy*
- *Massage*
- *Compression garments.*

Nutrition:

- *Carbohydrate feeding*
- *Fluid replacement.*