University *of* Limerick

BSc Sport and Exercise Sciences

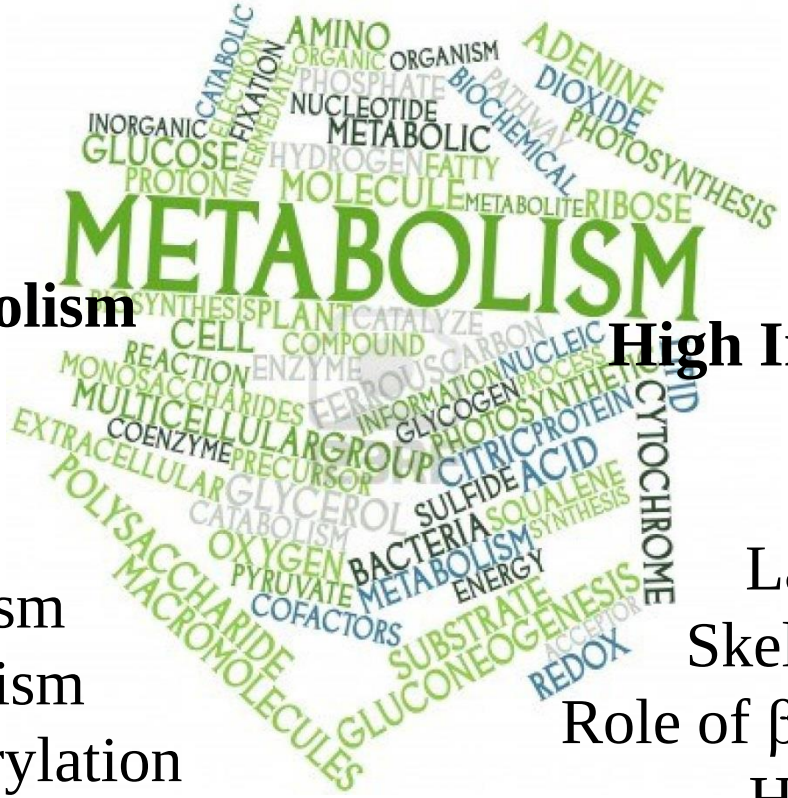
Module SS4205 Year 3

Nutrition, Exercise Metabolism and Sports Performance

Fluid and Electrolyte Balance

Module SS4205 Year 3

Part II: Integrative Exercise Metabolism



Endurance Metabolism
(oxidative metabolism)

Glycolysis
Gluconeogenesis
Glycogen Metabolism
Fatty Acid Metabolism
Oxidative Phosphorylation
Amino Acid Metabolism
Carbohydrate and protein supplements

High Intensity Metabolism
(non-oxidative metabolism)

Anaerobic glycolysis
Lactic acid metabolism
Skeletal muscle buffering
Role of β-alanine supplements
High energy phosphate metabolism
Role of creatine supplements

Fluid Balance

Principles of Fluid Balance and Exercise.

- Dehydration by -2% of body mass is common at the end of 1.5 h of exercise with sweat rates (~1.0 ℓ/h);
- Exercise performance is reduced when an individual is dehydrated by >2% of body mass (~ 1.5 litres);
- Different strategies are required to maintain fluid balance ***during*** exercise to those for restoration of fluid balance ***after*** exercise.

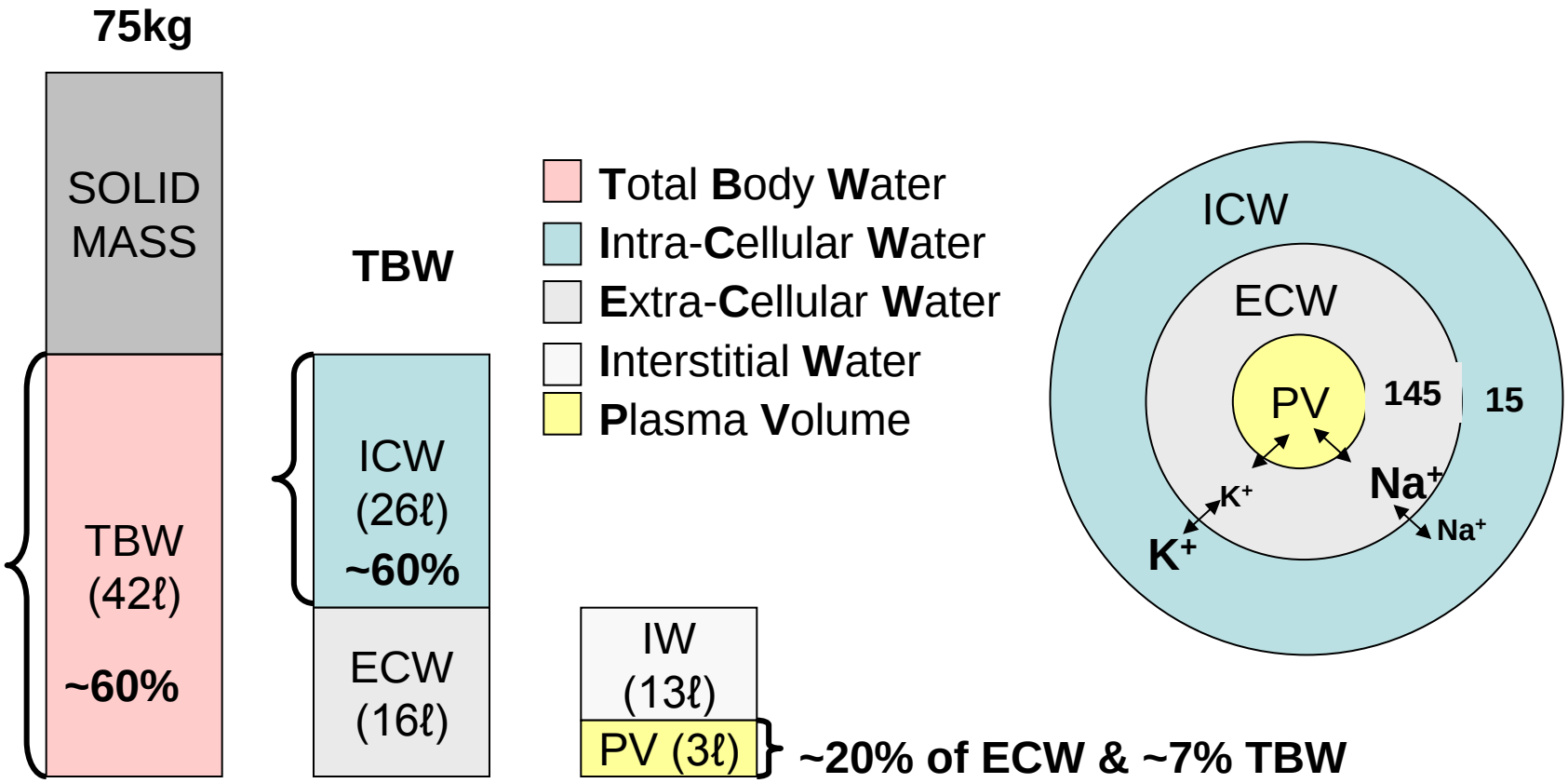
Fluid Balance

2 components

1. Fluid (water)

2. Sodium (salt)

Body Fluid and Sodium



Body Fluid Composition

mEq/ℓ	Na^+	Cl^-	K^+	Mg^{++}	mOsm/ℓ
Sweat	40-60	30-50	4-5	1.5-5	80-185
Plasma	140	101	4	1.5	302
Muscle	9	6	162	31	302

Note: 50 mEq/ℓ Na^+ = **50 mmol/ℓ Na^+ ~ 3g/ℓ salt (NaCl)**

g/ℓ as Na/KCl	Sodium Na^+	Potassium K^+	mOsm/ℓ
Sweat	3.0	0.4	80-185
Plasma	9.0	0.4	300
Muscle	0.5	12.2	300

Fluid Loss During Exercise

Monitor fluid **loss** by change in body mass

During exercise;

- Sweat rates can exceed 1.0 ℓ/h, especially in hot, humid environments;
- 'Typical' fluid loss of 1.5ℓ during 90-120min exercise results in ~ 2% loss of body mass (BM) depending on intensity of exercise, temperature and humidity;
- > 2% loss of BM through dehydration results in impaired exercise performance/capacity ('typical').

Sodium Loss During Exercise

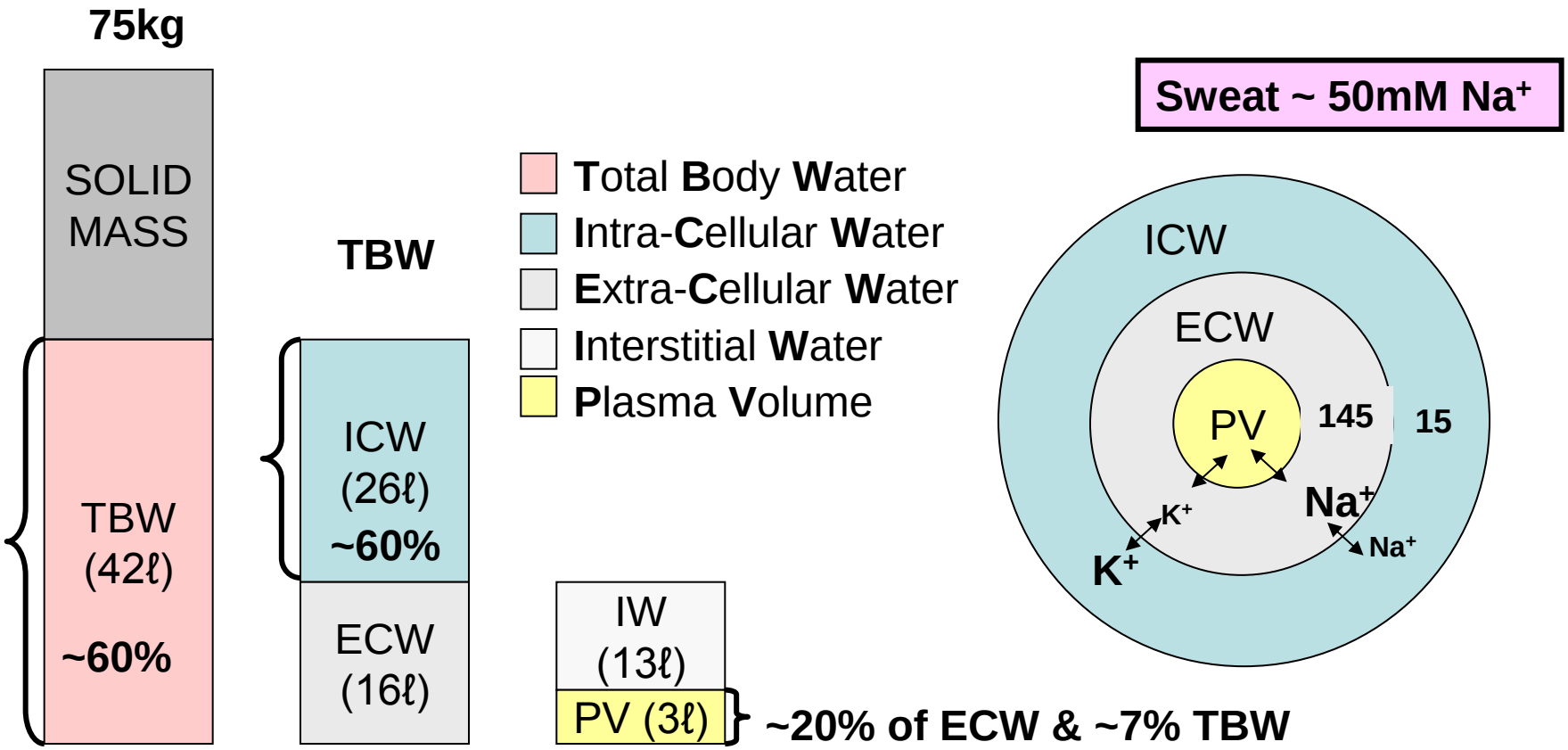
Daily sodium intake is **< 6g SALT (NaCl)per day**

During exercise sodium is lost in sweat **but**;

- The concentration of sodium in sweat is **less** than in plasma. Sweat is therefore **HYPO**tonic *vs.* plasma.
- ∴ 2ℓ sweat loss during exercise excretes 'normal' daily sodium intake!

g/ℓ as SALT	Sodium Na^+	Potassium K^+	mOsm/ℓ
Sweat	3.0	0.4	80-185
Plasma	9.0	0.4	300
Muscle	0.5	12.2	300

Sweat Loss and Plasma Sodium



- -2% ΔBM ~ 1.5ℓ TBW; -8% (240 ml) ΔPV;

∴ Sweat loss makes plasma **HYPER**tonic!

Intake of Fluid and Sodium

Recommended daily fluid intake is **~ 2-2.5ℓ per day**

- The rate of fluid intake is limited by the rate of emptying from the stomach - **gastric emptying**;

- 'Typical' maximal rate of gastric emptying is 1ℓ /h;

- Gastric emptying is facilitated by low concentration of sodium and carbohydrate but retarded by high concentration (> 8g/100ml; 8%) carbohydrate drinks that are **HYPER**tonic and draw water into the stomach

∴ Use **HYPO**tonic drinks **during** exercise

HYPO = < 300mOsm/ℓ

Fluid and Sodium for hydration

Recommended daily sodium intake is **< 6g SALT per day**

The 'typical' hydration drink contains **50 mg/100mℓ of Na^+**

50 mg/100mℓ Na^+ = 22 mmol/ℓ Na^+ = **1.27 g/ℓ of salt (NaCl)**

1.27g of table salt ~ half a level teaspoon

plus 1g/100ml (1%) carbohydrate; energy 24kJ, 5.8 kcal

1% carbohydrate = 10 g/ℓ ~ 1 level tablespoon of sugar

Which combined is **HYPO**tonic @ **100-120mOsm/ℓ**

Pre-exercise hydration utilises a **HYPO**tonic drink

- ~ 500-1000ml 1h prior to competition

Fluid Balance During Exercise:

When possible, **HYPO**tonic fluid should be ingested at rates that most closely match sweating rate, ~250ml (1 cup) every 15-20 minimum up to maximum 800 to1000mℓ per hour;

- When **not** possible or practical, **some** athletes can tolerate body water losses up to -2% of body mass without significant risk to performance or physical well-being in a temperate environment (e.g., 21-22 ^{o}C);

- However when exercising in a hot / humid environment (i.e., > 30^{o}C), dehydration by - 2% BM impairs power production and predisposes individuals to heat stress.

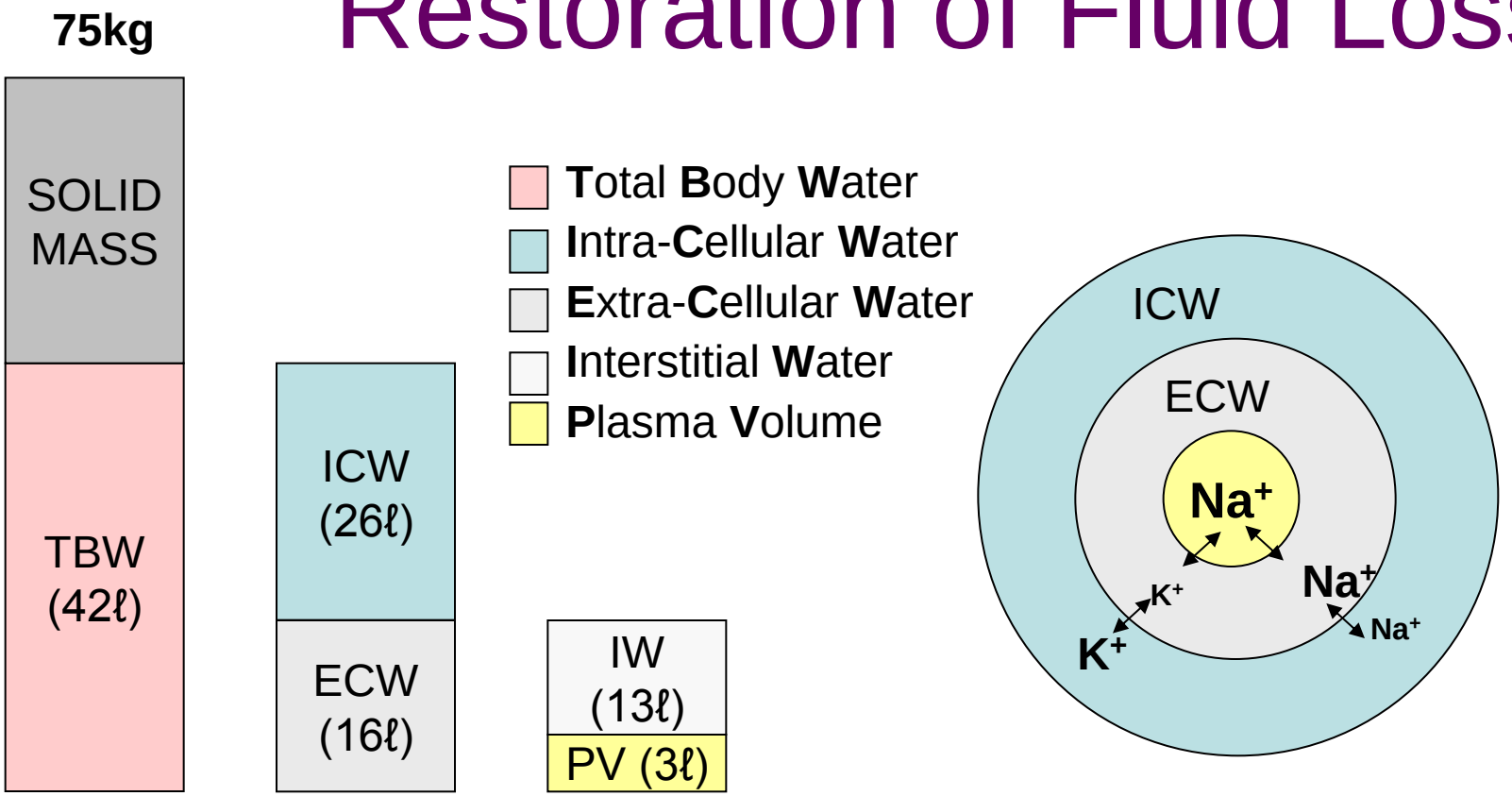
Good Sense and Good Practice

Noakes and Martin [2002] recently advises;

"runners should aim to drink as needed between 400-800 ml per hour, with the higher rates for the faster, heavier runners competing in warm environmental conditions and the lower rates for the slower runners/walkers competing marathon races in cooler environmental conditions".

This is a reasonable starting point from which the **individual sportsperson should begin the trial and error process.**

Restoration of Fluid Loss



- -2% ΔBM ~ 1.5ℓ TBW; -8% (240 ml) ΔPV;
- **FLUID FOLLOWS SODIUM to restore PV loss quickly and then <u>slowly</u> to restore ECW and ICW loss.**

Rehydration Post-Exercise

If, dehydrated by 1.5 kg (-2 % body mass) then;

- loss of fluid as sweat = 1500mℓ
- loss of sodium in sweat = 4g (~70 mmol)

To restore fluid and sodium loss

- Fluid volume = **1.5 times body mass loss (~2.25 ℓ)**
- How much SALT (sodium) should a **re**hydration drink contain?

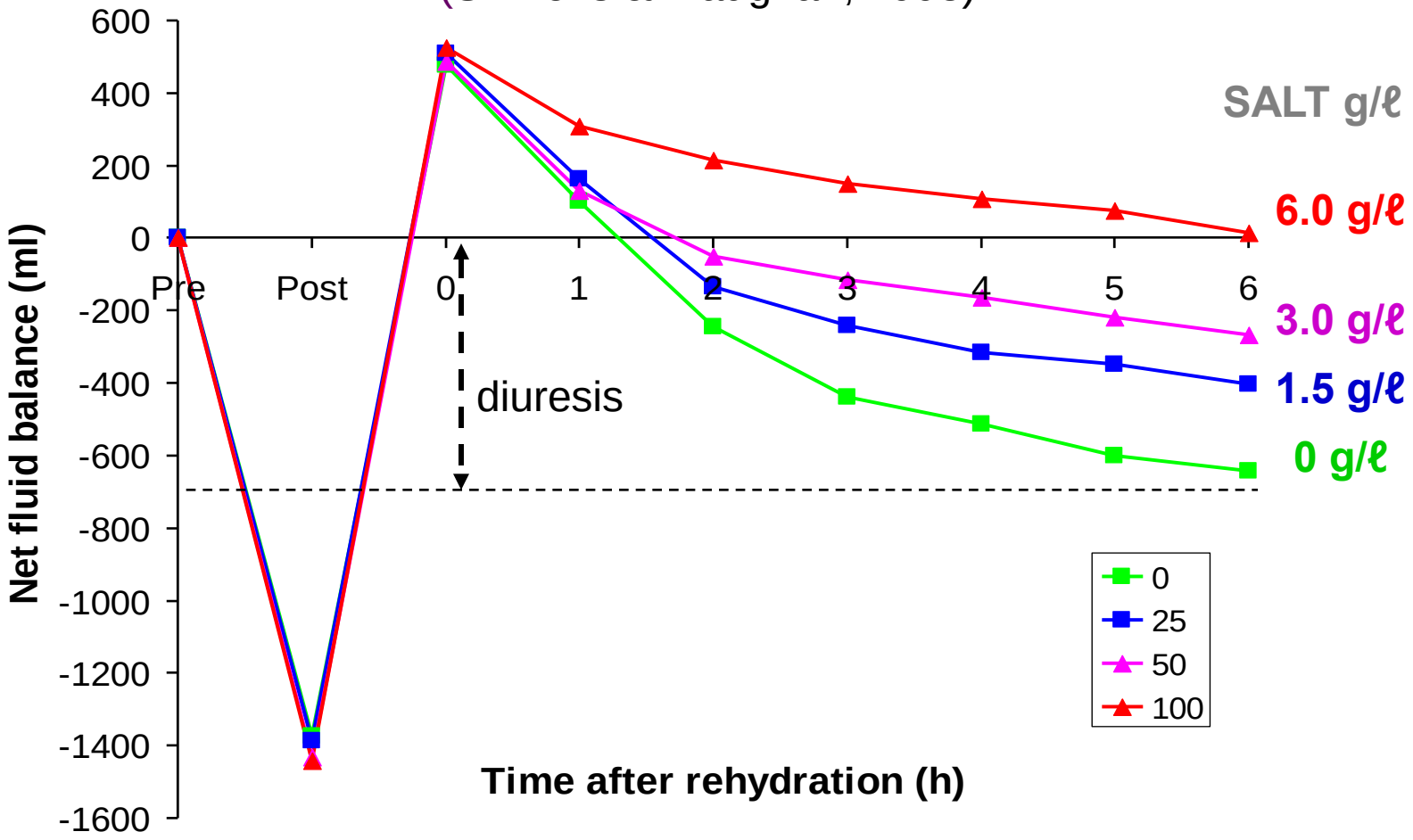
1.5 g/ ℓ (25 mmol/l Na^+)

3.0 g/ ℓ (50 mmol/l Na^+)

6.0 g/ ℓ (100 mmol/l Na^+)

Post-Exercise **Re**hydration

(Shirreffs & Maughan, 1998)



- Use **HYPER**tonic drinks for **re**hydration;
- Verify **re**hydration by BM @ 6h post-exercise.

Summary statements regarding fluid and electrolyte needs before and after exercise (I.O.C. 2004)

What we know and recommend with reasonable certainty – clear consensus **FOR**:

- Post-exercise rehydration can only be achieved if a fluid volume greater than the sweat volume lost is consumed.
- Replacement of the sodium lost in sweat is a pre-requisite for retention of drinks consumed after exercise.

What common practices and theories that we know to be unsound – clear consensus **AGAINST**:

- Plain water is not an effective post-exercise rehydration drink UNLESS sodium is ingested at the same time via food.

The controversial issues in which recommendations need very specific qualifiers:

- Plain water **can be** an effective rehydration drink **IF a source of sodium is available at the same time via food.**
- Pre-exercise hyperhydration with glycerol and sodium supplementation appear to give no consistent benefits over and above starting exercise in a euhydrated situation.

Recommended Hydration Assessment

Assessment Technique	Athlete Practicality	Acceptable Euhydration Cut-Off
Change in Total Body Water (L)	Low	< 2%
Plasma Osmolality (mOsm)	Medium	< 290
Urine Specific Gravity (g/ml)	High	< 1.020
Urine Osmolality (mOsm)	High	< 700
Urine Color (#)	High	< 4
Change in Body Mass (kg)	High	< 1%

Fluid balance should be considered **adequate** when the combination of **<u>any two</u>** assessment outcomes is consistent with **euhydration**.

http://www.gssiweb.org/Article/sse-97-hydration-assessment-of-athletes

References on fluid balance:

Shirreffs, Susan M., and Ronald J. Maughan.
Volume repletion after exercise-induced volume depletion in humans: replacement of water and sodium losses.
Am. J. Physiol. 274 (*Renal Physiol.* 43): F868–F875, 1998.
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Ronald J. Maughan, Susan M. Shirreffs & John B. Leiper
Errors in the estimation of hydration status from changes in body mass, Journal of Sports Sciences 2007, 25; 797-804
PDF Copy in Sulis Folder
http://dx.doi.org/10.1080/02640410600875143

Gatorade Research Labs Article 97
http://www.gssiweb.com/Article_Detail.aspx?articleid=706&level=2&topic=1

Electrolyte Containing Sports Drinks

	Na^+	Na^+	NaCl
	mg/100mℓ	mmol/ℓ	g/ℓ
	50	21.7	1.26
FM Na+ =	23		
FM Cl- =	35	1 Mol =	1 mmol =
FM NaCl =	58	58g/ℓ	58mg/ℓ

The average sports drink contains **50 mg/100mℓ of Na^+**

50 mg/100mℓ Na^+ = 22 mmol/ℓ Na^+ = **1.27 g/ℓ of salt (NaCl)**

1.27g of table salt ~ half a level teaspoon