# Regenerating to Improve Performance





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#### **Overview**

#### **Goals of the presentation:**

- Definitions of 'recovery' and 'regeneration'
- Theoretical and physiological basis of regeneration
- Factors affecting regeneration
- Evidence-based methods for athlete regeneration
  - Fundamentals: Food, fluid and sleep
  - Hydrotherapy
  - Other interventions
- Periodising recovery



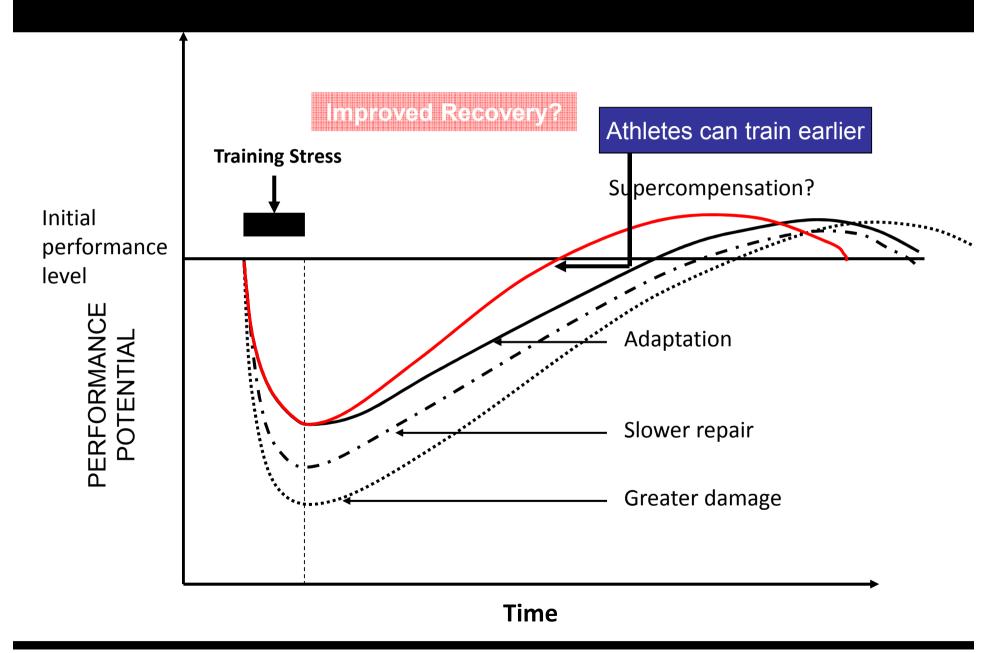
### What is Recovery?

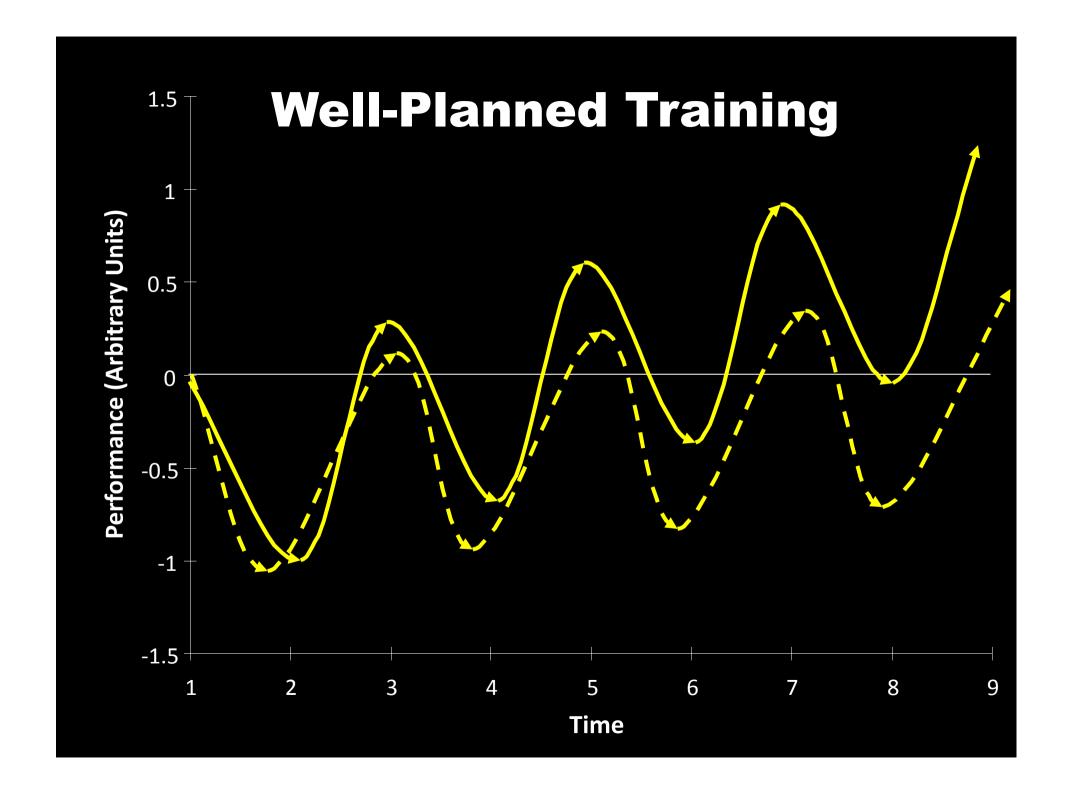
bio-psycho-social construct (multidimensional)

- Recovery compensates fatigue
- Restores physiological and psychological balance
- Processes that allow athletes renewed ability to meet [or exceed] previous performance
- Recovery period: the time for psychological and physiological parameters modified by exercise to return to resting levels
- Regeneration: is the processes that underpin recovery following training or competition-induced fatigue



# **How Can Recovery Improve Performance?**





So improving recovery (from fatigue / damage) can improve training & performance....

(in theory)

# **How Can Recovery Improve Performance?**

Recovery should lead to at least these major goals:

- Better adaptation to training
- Better training quality
- Decreased risk of overload / injury
- Improving the repeatability of performance

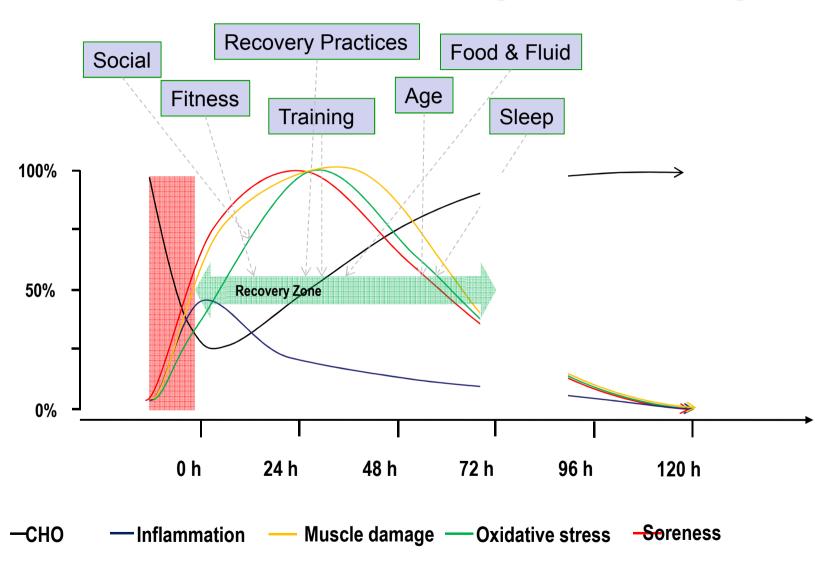
# **Principles of Recovery**

The actual amount/type of recovery is INDIVIDUAL and it depends on a number of factors including:

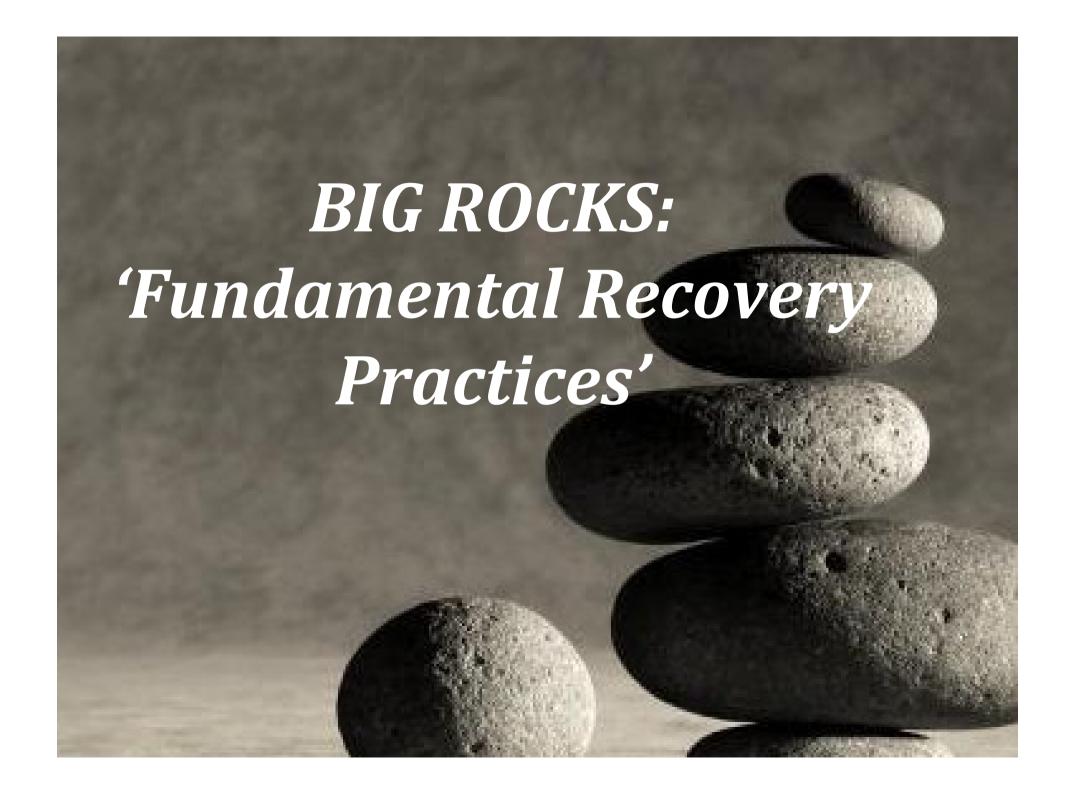
- The training stress applied
- Training experience an athlete of high training status means less dramatic functional reactions to a given training stimulus
- Age older athletes perceive their recovery to be slower
- Gender altered time course in strength recovery (poor research)
- Climatic factors, altitude and time differences should also be considered
- Training goals (performance vs. adaptation)



# **Factors Affecting 'Recovery'**







# **Fundamental Recovery Practices**

#### What Limits Performance in the Short-term?

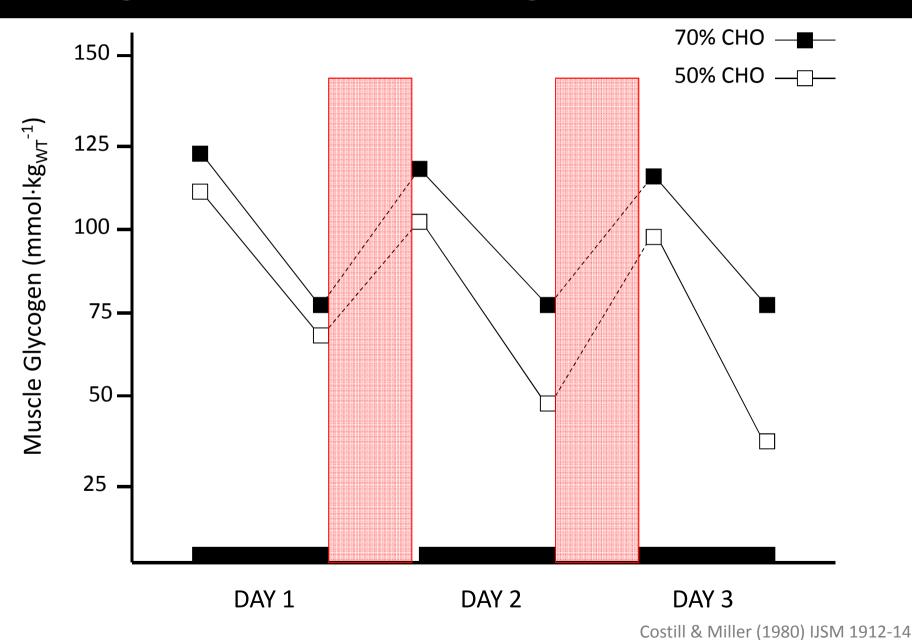
- CHO depletion
- Dehydration

#### Use these Regularly and Obtain

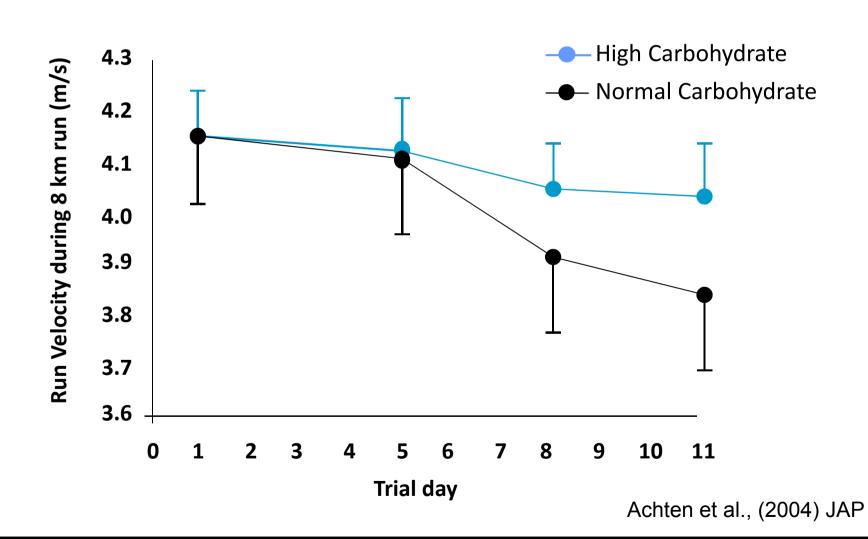
- Better recovery from workout?
- Better exercise quality during workout?



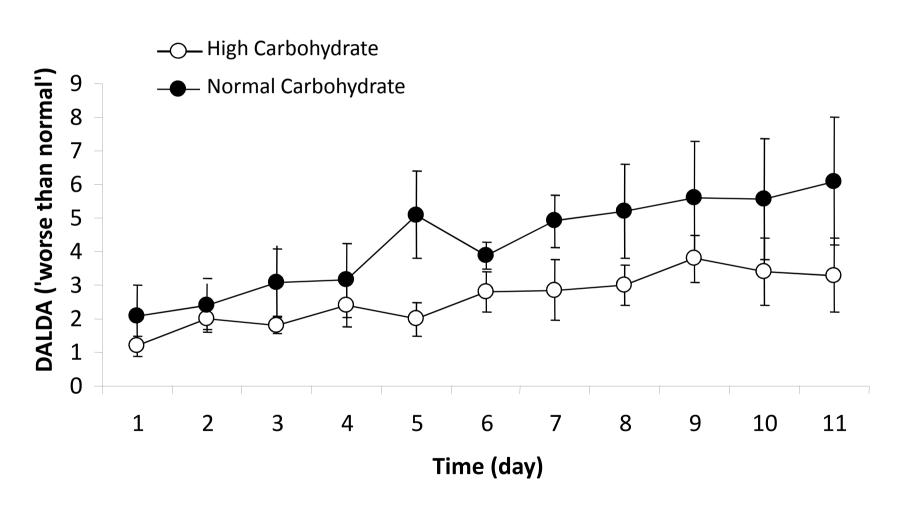
# Carbohydrates & Recovery



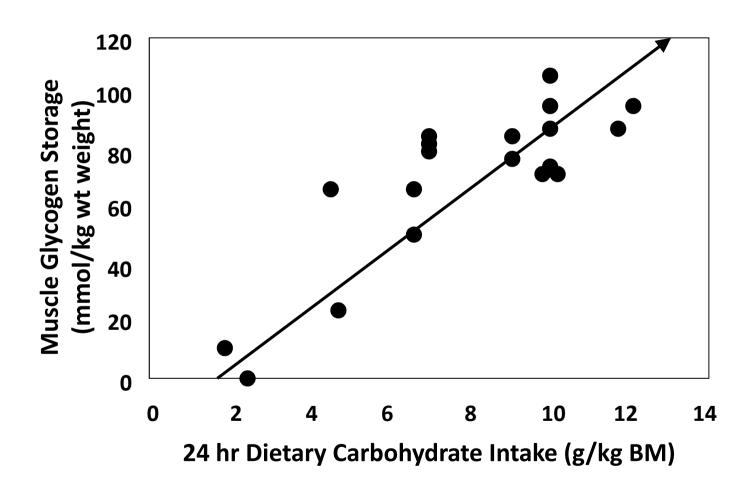
# **Carbohydrates and Intensive Training**



# **Carbohydrates and Intensive Training**

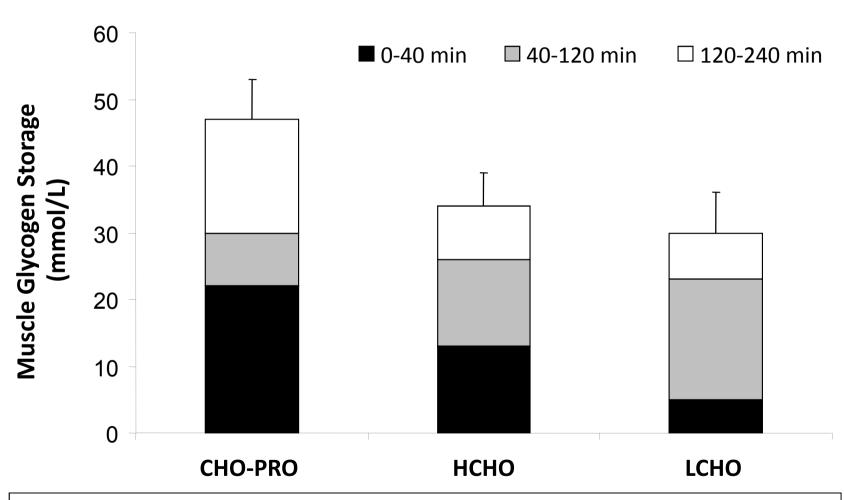


#### Carbohydrate Intake & Use...



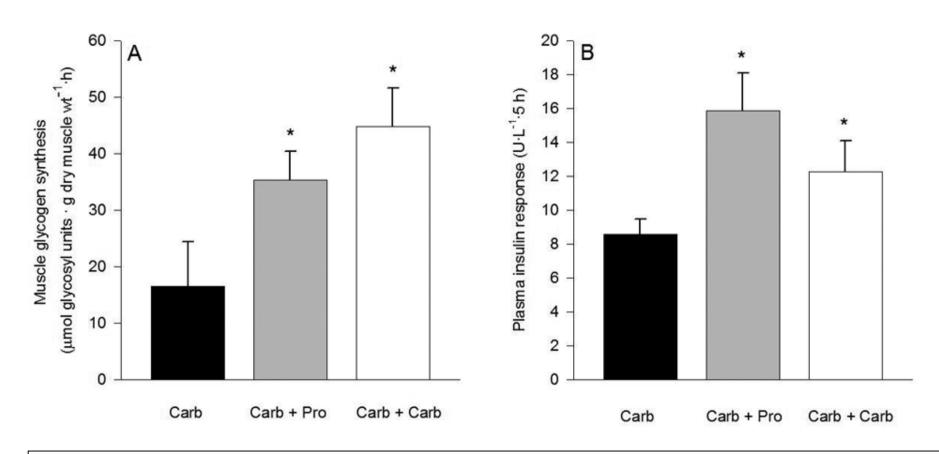
The more carbohydrate you eat after training & competition – the more that is taken in and stored by the muscle

#### **Adding Protein to Carbohydrate**



Adding Protein (leucine) to carbohydrate may increase the rate of glycogen replenishment after exercise

#### **CHO or Protein Post-Exercise?**



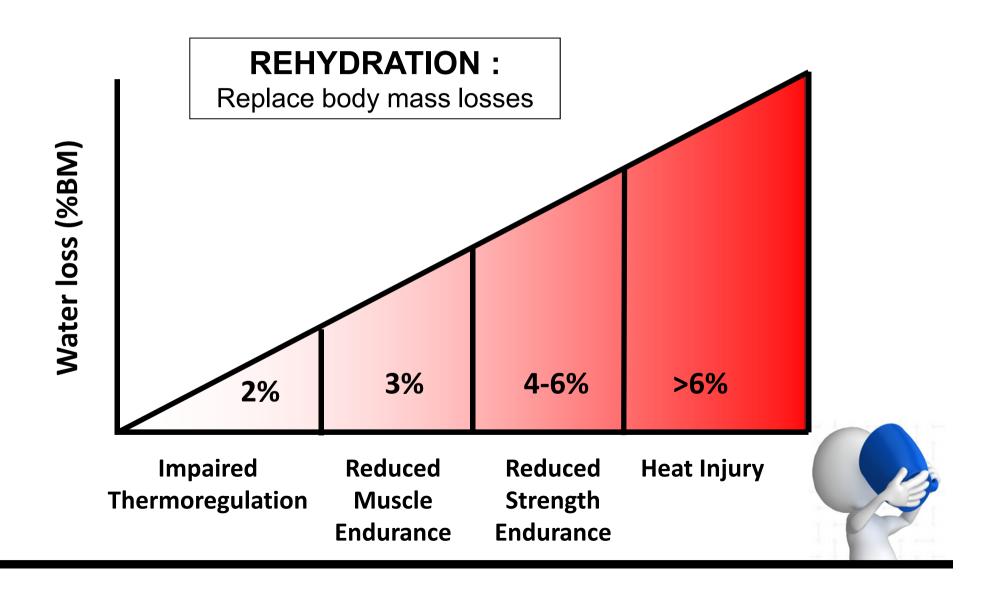
(A) Muscle glycogen synthesis rates and (B) plasma insulin responses (expressed as area under the curve minus baseline values) over a 5-hr recovery period after ingestion of 0.8 g  $\cdot$  kg<sup>-1</sup> · hr<sup>-1</sup> carbohydrate (Carb), 0.8 g  $\cdot$  kg<sup>-1</sup> · hr<sup>-1</sup> carbohydrate and 0.4 g  $\cdot$  kg<sup>-1</sup> · hr<sup>-1</sup> protein (Carb + Pro), or 0.8 g  $\cdot$  kg<sup>-1</sup> · hr<sup>-1</sup> carbohydrate and 0.4 g  $\cdot$  kg<sup>-1</sup> · hr<sup>-1</sup> carbohydrate (Carb + Carb).

#### **Carbohydrate Replacement Recommendations**

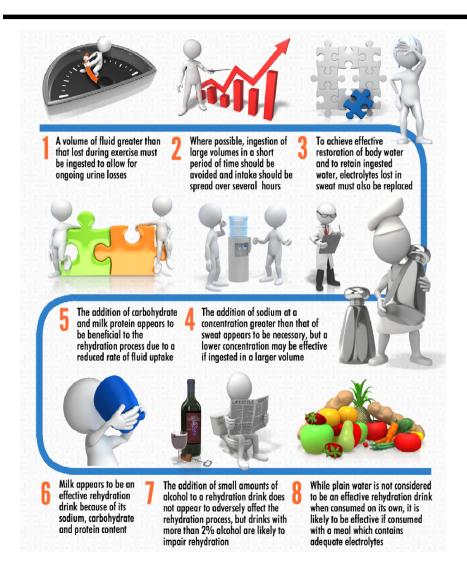
#### **Recommendations:**

- Immediately after exercise (0-4 hr post):
  - 1.2 grams of CHO/kg/hr (consumed frequently)
- Daily Recovery for <u>moderate duration / low intensity</u> training
  - 5-7 g/kg/day
- Daily Recovery for <u>moderate to heavy endurance</u> <u>training</u>
  - 7-12 g/kg/day
- Daily Recovery: <u>extreme exercise program</u> (4-6+ hr/day)
  - 10-12+ g/kg/day

# **Dehydration and Performance**



# **Optimising post-exercise rehydration**



- Consume greater volume than lost during exercise
- 2. Ingest fluid over longer period
- To retain water and replace sweat losses, ingest electrolytes
- 4. Add [Na<sup>+</sup>] at higher concentration of sweat to promote retention
- Adding CHO and milk protein assist due to reduced rate of fluid uptake
- 6. Milk is effective: has [Na<sup>+</sup>], CHO and protein
- Small amount of alcohol does not affect rehydrate (<2% alcohol)</li>
- 8. H<sub>2</sub>O effective when consumed with a meal

#### **Regular Recovery Routines**

#### Set the Body Clock

- Try to standardise sleep times
- Meal times
- Waking times
- Occasional disruption is OK

#### **Develop Good Sleeping Habits**

- Sleep hygiene
- Relax before going to bed (music, reading, PMR)
- Lie down to sleep ONLY when you are sleepy (teach yourself)
- If trouble sleeping, try some relaxation techniques
- Get up same time each day
- Avoid:
  - Caffeine, nicotine, alcohol, high protein meals etc..

## **Healthy Sleep Routines for Athletes**

#### 1. Set intense training before 6 pm

#### 2. Keep a regular sleep schedule.

- Set a regular time for going to bed and waking up.
- Nap for 30 minutes in the early afternoon to make up for lost sleep.

#### 3. Eat and drink correctly.

- Stay away from big meals at night.
- Avoid caffeine after lunch.
- Avoid drinking alcohol
- Avoid hyperhydration

#### 4. Create a relaxing bedtime routine.

- Turn off your television and screen devices.
- Take a hot shower or leisurely warm bath before bedtime.
- Reserve your bed for sleeping.

#### **Healthy Sleep Routines for Athletes**

Time of sleep

#### 5. Make your bedroom more sleep friendly.

Keep noise down.

Mixed frequency

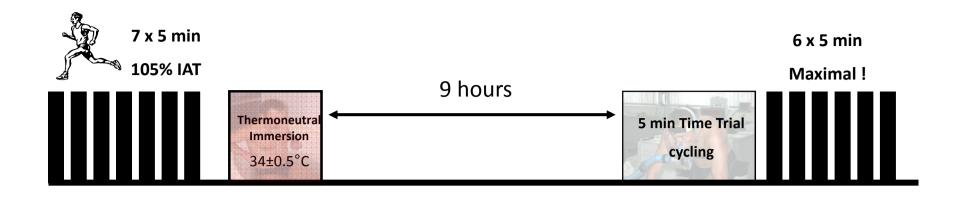
- Keep your room dark and cool.
- Make sure your bed is comfortable.
- Remove technology from the bedroom.
- 6. Manage anxiety and stress.
- 7. Utilize basic techniques to get back to sleep.
- Remain in bed in a relaxed position.
- Make relaxation your goal, not sleep.
- 8. Cold water immersion.
- Decreased core temperature
- Reduces soreness

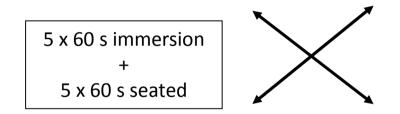


# **Hydrotherapy for Recovery**

#### How does it work?

- Reduces limb girth (swelling)
- Reduces core temperature
- Limits inflammation?
- May limit cell satellite signalling
- Alters perception of effort
- Improves sleep







# Effect of Cold Water Immersion (CWI) on subsequent training performance.

Measure	Mean Change	90% Confidence Limits (%)	Chances that the true effect is substantiala			
			Benefit	Harm	Practical	
	(%)	Lilling (70)	(%)	(%)	Assessment b	
Effect on 5-minute TT perfo	ormance		A TOP			
Power output (W·kg·BM <sup>-1)</sup>	1.5	1.7	4	10	Benefit very unlikely	
Effect on training set			The state of the s			
Power output (W·kg·BM <sup>-1)</sup>	2.1	1.7	78	0	Benefit likely	
La	18	18.1	86	2	Benefit likely	
HR (bpm)	1.6	1.1	74	0	Benefit possible	
RPE (6-20 scale)	-1.6	1.9	2	77	Benefit likely	



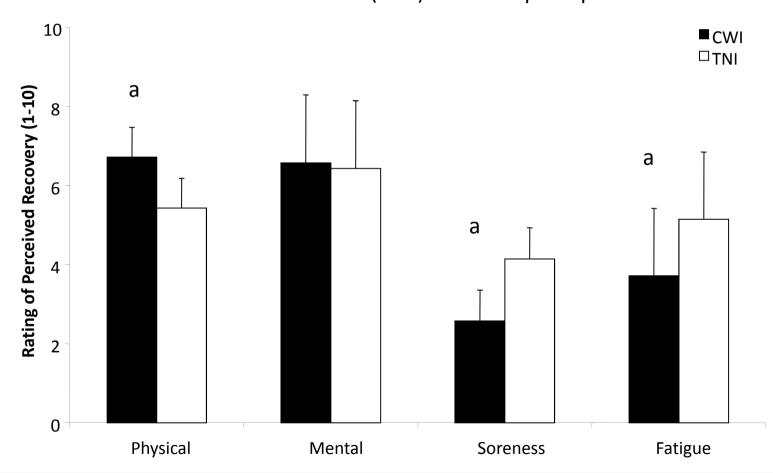
# Muscle Damage

# Effect of Cold Water Immersion (CWI) vs. Thermoneutral Immersion: Blood variables.

Measure	Mean	90% Confidence Limits (%)	Chances that the true effect is substantial <sup>a</sup>			
	Change		Benefit	Harm	Practical	
	(%)		(%)	(%)	Assessment <sup>b</sup>	
FABP (pg/mL)	-8.4	24.7	13	30	Unclear	
Creatine Kinase (U/L)	-12.4	49.2	16	61	Unclear	
LDH (U/L)	4.0	9.4	55	8	Unclear	
Myoglobin (ng/mL)	-22.5	60.6	9	73	Unclear	
Interleukin-6 (pg/mL)	13.4	104.0	48	23	Unclear	
Interleukin-10 (pg/mL)	20.0	13.4	94	1	Likely beneficial	

### **Twice-a-day Training in Triathlon**

Table 1: Effect of Cold Water Immersion (CWI) on subsequent performance.





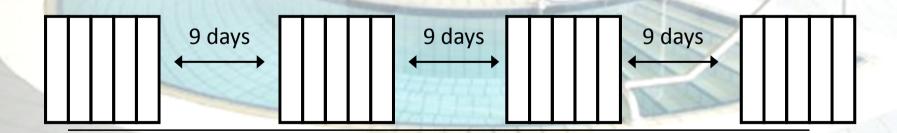
#### **Twice-a-day Training Summary**

- Cold water immersion can improve training intensity on second session (run cycle) in triathletes.
- Lower perception of soreness and fatigue
- Regulating pacing / effort regulation?
- Recommend that athletes use Cold Water Immersion when training twice-a-day.

# **Intensive Period of Cycling Training**

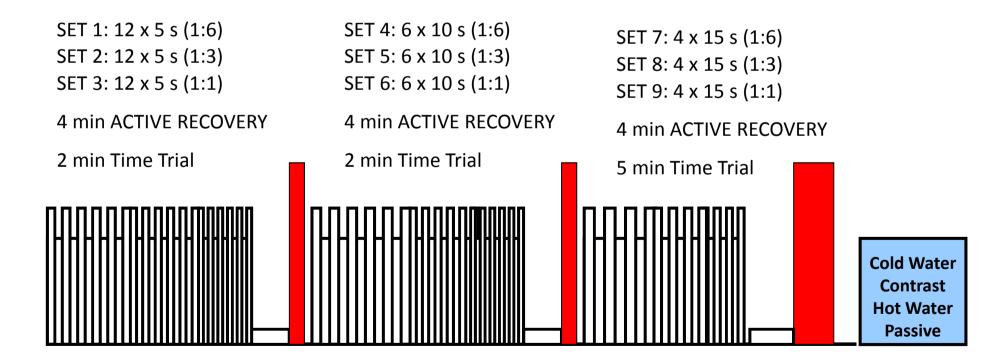
#### RANDOM ALLOCATION

- 1. CWI Cold Water Immersion
- 2. CWT Contrast Water Therapy (Hot-Cold)
- 3. HWI Hot Water Immersion
- 4. PAS Passive

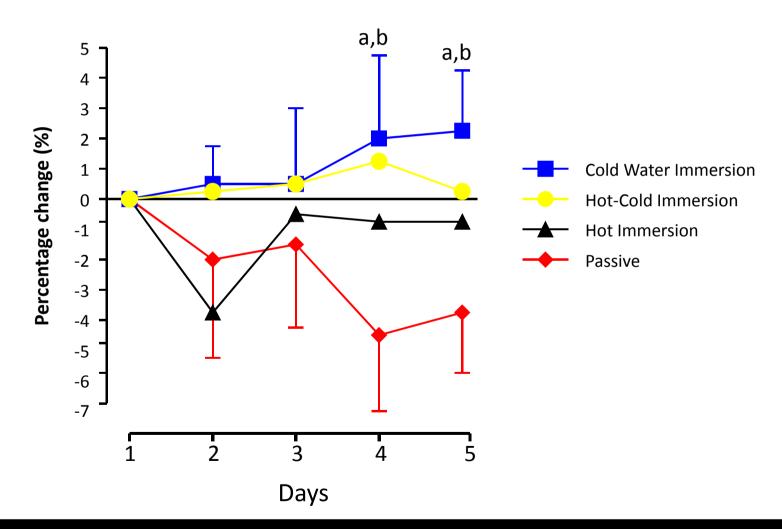


### **Intensive Training Session x 5 Days**

- Each day an exhausting 105 min cycle protocol was completed.
- Followed by a 14 min water immersion treatment.



# **Intensive Period of Training – Time Trial**

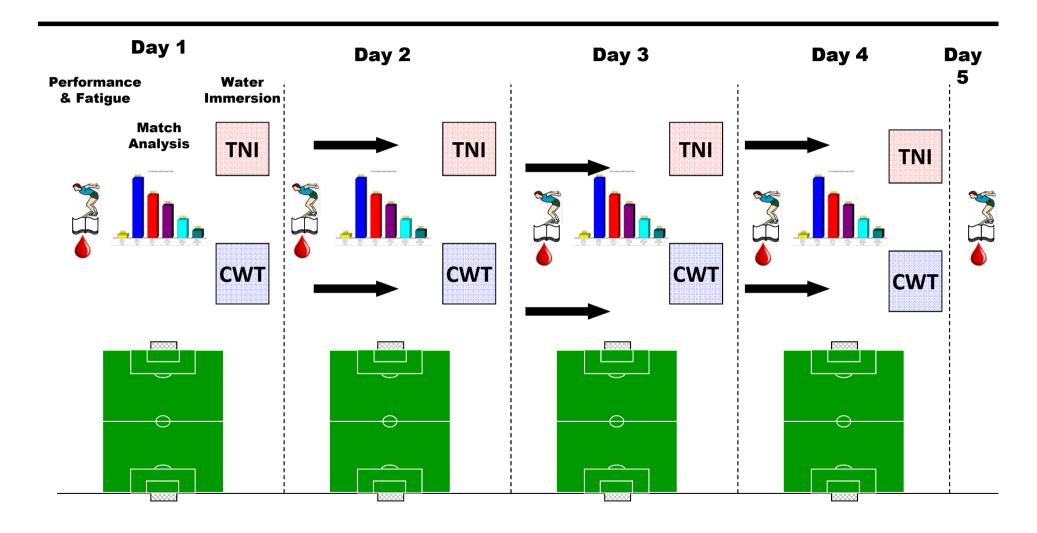




### **Intensive Training Summary**

- Reduced core temperature
- Lower perception of soreness and fatigue
- Better sprint & time trial performance over the 5 days.
- Recommend that athletes use CWI or CWT when training in heavy blocks.

#### **Soccer Tournament**



#### **Soccer Tournament: Physical Performance**

	Day 1	Day 2	Day 3	Day 4	Day 5			
COLD WATER IMMERSION	I							
RSA <sub>mean</sub> (s)	$3.53 \pm 0.16$	$3.61 \pm 0.19$	$3.53\pm0.16$	$3.58 \pm 0.17$	$\textbf{3.61} \pm \textbf{0.18}$			
Vertical jump (cm)	$49.5 \pm 7.7$	$48.3 \pm 8.5$	$46.8\pm8.6$	$47.8\pm8.7$	$46.0\pm7.9$			
RPE (6-20) submax run	$\textbf{11}\pm\textbf{2}$	$\textbf{14}\pm\textbf{1}$	$\textbf{13}\pm\textbf{1}$	$\textbf{14}\pm\textbf{1}$	12 ± 1 <sup>a</sup>			
THERMONEUTRAL IMMERSION								
RSA <sub>mean</sub> (s)	$\textbf{3.55} \pm \textbf{0.12}$	$3.58 \pm 0.09$	$3.51\pm0.10$	$3.61 \pm 0.09$	$3.60 \pm 0.09$			
Vertical jump (cm)	$51.1\pm4.6$	$50.3 \pm 4.5$	$48.7 \pm 4.8$	$47.4 \pm 6.2$	$48.4 \pm 5.7$			
RPE (6-20) submax run	11 ± 2	$14\pm1$	13 ± 1	15 ± 1	13 ± 1 <sup>a</sup>			

Players thought exercise was harder after 4 matches

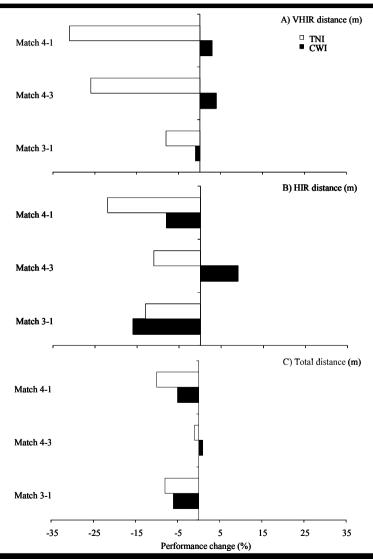
#### **Soccer Tournament: Blood Markers**

	Day 1	Day 2	Day 3	Day 4	Day 5
COLD WATER IMMERS	SION				
FABP (pg/mL)	$1660\pm1945$	$1985 \pm 2277$	$1991\pm2419$	$1920\pm2046$	$1787\pm2048^{\text{a}}$
Creatine Kinase (U/L)	$\textbf{207} \pm \textbf{127}$	$614\pm161$	$955 \pm 502$	$929 \pm 623$	$1075\pm680^{\:b}$
LDH (U/L)	$333 \pm 41$	$396 \pm 42$	$440 \pm 61$	$465\pm77$	$482\pm65^{\:b}$
THERMO-NEUTRAL W	ATER IMMERSION	N			
FABP (pg/mL)	$653\pm134$	$837 \pm 292$	$819 \pm 256$	$708\pm276$	$956 \pm 431^{\text{a}}$
Creatine Kinase (U/L)	$\textbf{258} \pm \textbf{129}$	$575 \pm 320$	$912\pm715$	$808 \pm 675$	$881\pm627^{\:b}$
LDH (U/L)	$365 \pm 65$	$380\pm33$	$432 \pm 45$	$432 \pm 60$	$469\pm91^{b}$

Increased muscle damage & inflammation over the tournament



## **Soccer Tournament: Match Analysis**



- Reduction in total distance over the tournament
- Likely protective effect of drop off in Very High Intensity Running after 4 games.
- ■Most changes between games 3-4.
- Significant effect on total distance run.
- ■The ability to sprint appears to be protected.



## **Research Summary: Hydrotherapy**

#### **Water Immersion**

#### **Recommendations:**

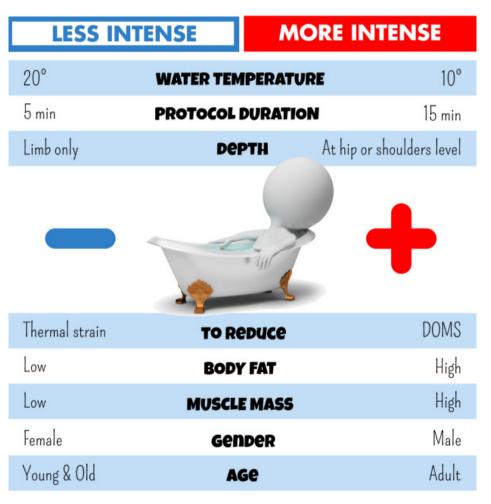
- Cold or Contrast Water Immersion
- > 10 min immersion time
- Reduced perception of pain
- Muscle damage / inflammation

#### How to use:

- Full body immersion (hydrostatic pressure)
- Interventions of 10-15 min shown to be effective
- Intermittent protocols: 10-12°C cold & 38-42°C hot with 1:1 immersion/rest ratio (shorter repeated bouts)
- Continuous protocols: 15°C (comfort enhances compliance)

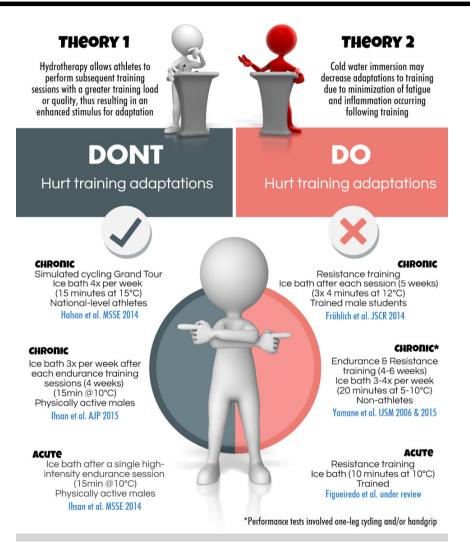
## **Individualizing Hydrotherapy:**

**One Size Does Not Fit All** 



- CWI for Training in the Heat
- CWI for recovery from Intense Training

# Do ice baths really hurt adaptations to training?



 Current data do not support suggestions that CWI hurts adaptations to endurance training

 CWI following resistance training needs to be handled carefully.



## Other Regeneration Interventions

#### Massage

- Does it work?
  - No difference in lactate removal
  - No effect on muscle damage (DOMS)
  - Animal studies: Decrease NF- $\kappa\beta$ , TNF $\alpha$ , leucocyte demargination, reduced swelling & number of damaged fibres
  - Anecdotal reports: it feels good! 🙂 😊 😊 😊

Hemmings (2001) *Physical Therapy in Sport* (2) 165-170 Best & Crawford (2016) *Br J Sports Med* 16;51:1386–1387

- Trivial/unclear effects on performance:
  - Strength 0.13 (-0.01-0.27) [N=273]
  - Sprint 0.28 (0.01-0.51) [N=55]
  - Jump 0.08 (-0.15-0.21) [N=67]
  - Endurance 0.28 (0.16-0.41) [N=48]

Poppendieck et al (2016)

## **Other Regeneration Interventions**

#### **Acupuncture / Acupressure**

- No reliable scientific studies
- Anecdotally, helps the athlete relax



#### **Hyperbaric Oxygen Therapy**

- Increased O<sub>2</sub> content
- No scientific evidence to show increased O<sub>2</sub> in blood gets to tissue

#### **Meditation**

- Relax parasympathetic (calming) nervous system
- Limited scientific evidence if increased O<sub>2</sub> in blood gets to tissue

## Regeneration Interventions

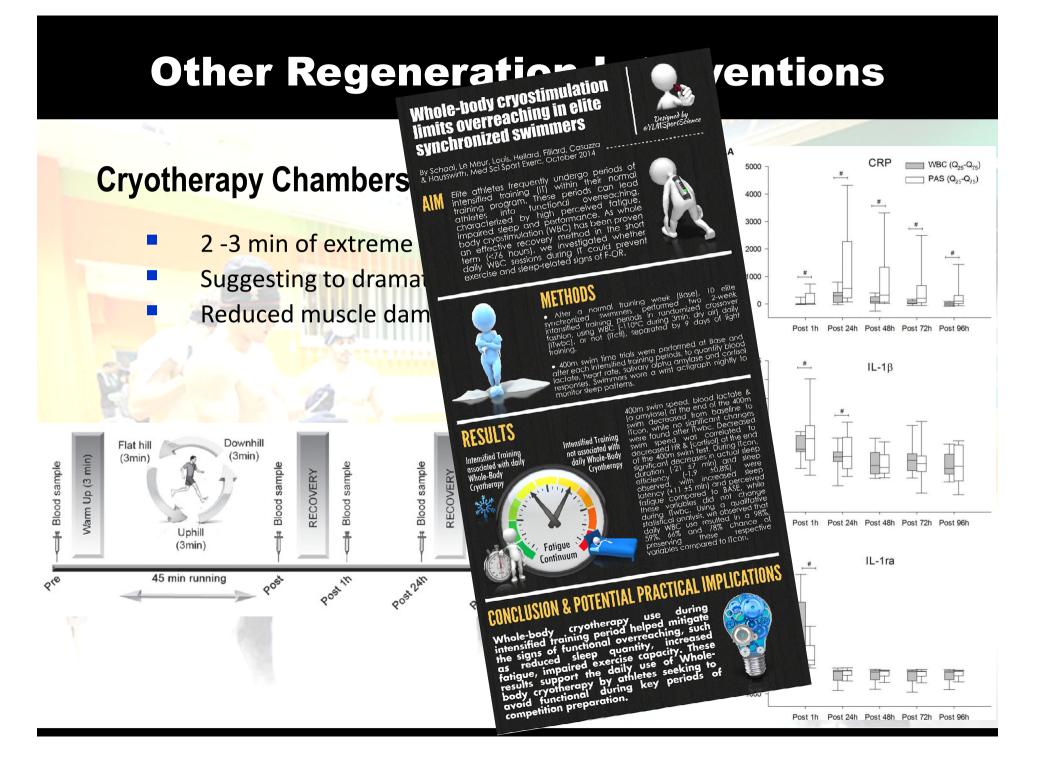
#### **Other Methods**

- Compression Garments
  - Increased muscle blood flow
  - Reducing plasma lactate
  - Reduced muscle damage
  - Lower perception of soreness
  - Improved forced production after recovery

Gill et al., (2006) BJSM







#### **Determining Efficacy of Recovery Strategies?**

- A lack of research evidence does not mean the intervention doesn't aid recovery
- Important to consider that most studies are not on trained athletes
- The effects of isolated strategies/protocols ≠ same effect with compound strategies (common to practice)
- Few studies have examined the longitudinal adaptation response



# **Common Recovery Activities**









1000P - Pa				
Fatigue Source	Endurance Sports	Team Sports	Explosive/Strength Sports	Precision Sports
Hydrotherapy	<b>√</b> ✓	<b>/</b> /	<b>✓</b>	<b>✓</b>
Compression	<b>√</b> ✓	<b>✓</b> ✓		
Fuelling	<b>/ /</b>	<b>/ /</b>	<b>✓</b> ✓	
Massage	<b>✓</b>	<b>//</b>	✓ ✓	✓
Mental Techniques	<b>✓</b>	✓		<b>√</b> ✓



## Periodising the Application of Recovery

#### Some important considerations in planning:

- When does the athlete need to 'perform' or train at high 'intensity' next?
- What have the acute vs. chronic loads been?
- What was the source of damage / stress / fatigue?
- What is the athletes injury history?



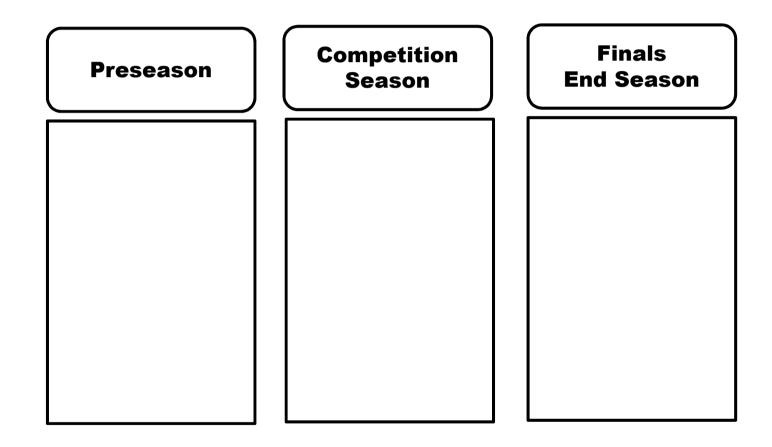
## Periodising the Application of Recovery

How do we periodise recovery?

- 1. Quantifying the work load and the responses
- 2.Control the work load
- 3. Match recovery activities to the specific sources of stress
- 4. Match recovery activities to the extent of stress
- 5. Ensure recovery activities meet future training goals



# **Periodising Recovery**





# **Periodising Recovery**

**Triathlon** 

**Morning** 

Long cycle

**Afternoon** 

Running intervals

**Team Sports** 

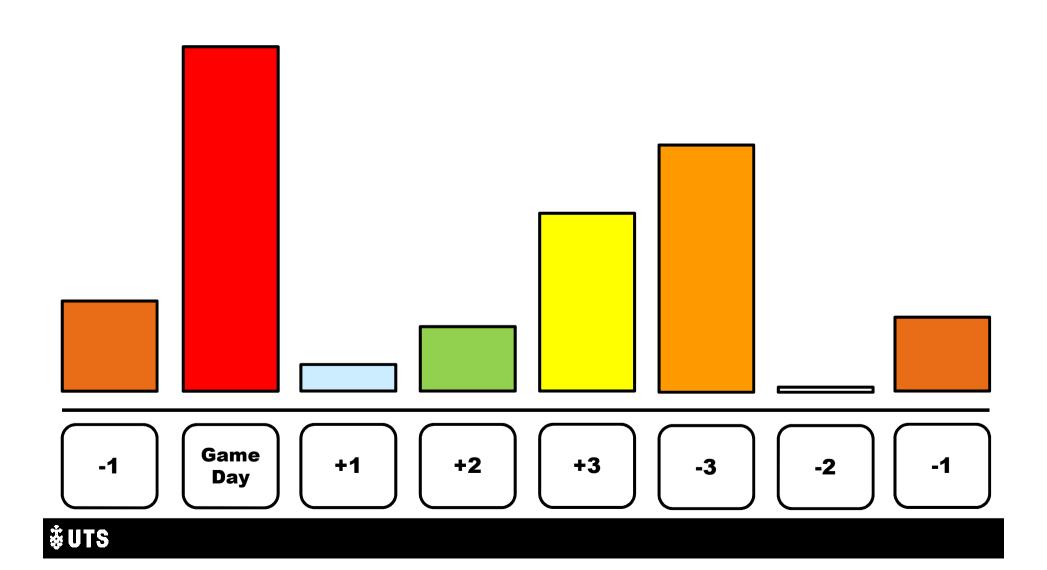
**Morning** 

**Team Training** 

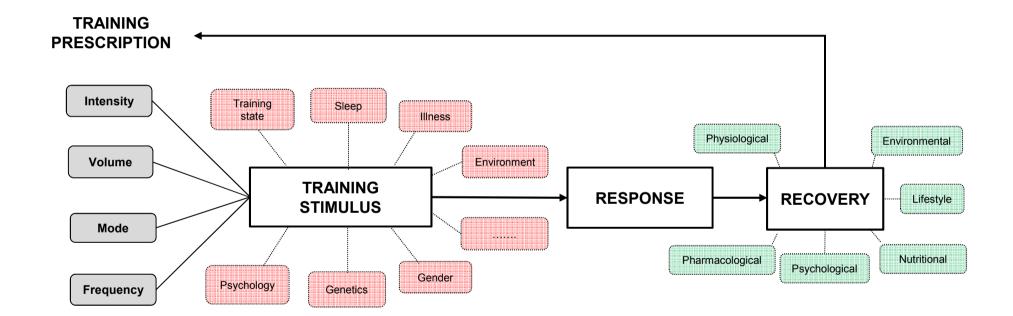
**Afternoon** 

**Resistance Training** 

# **Periodising Recovery**



# **Training-Recovery Cycle**





### **Summary**

- Fatigue is essential for adaptation
- Competition / matches cause excessive fatigue
- Excessive fatigue reduces performance
- Recovery activities from the training/competition removes fatigue
- Physiological, Nutritional & Psychological Strategies can be used
- Recovery interventions should be periodised to the individual and the logistical contraints

## **Take Home Message:**

