



# **Monitoring Training Load to Understand Fatigue in Youth Athletes**

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# Defining Fatigue

A practical definition of fatigue from a sport science perspective is *the inability to complete a task that was once achievable within a recent time frame.*

However, is the athlete, unfit, unwell, injured or unmotivated? What are the environmental conditions (heat, humidity, altitude)?

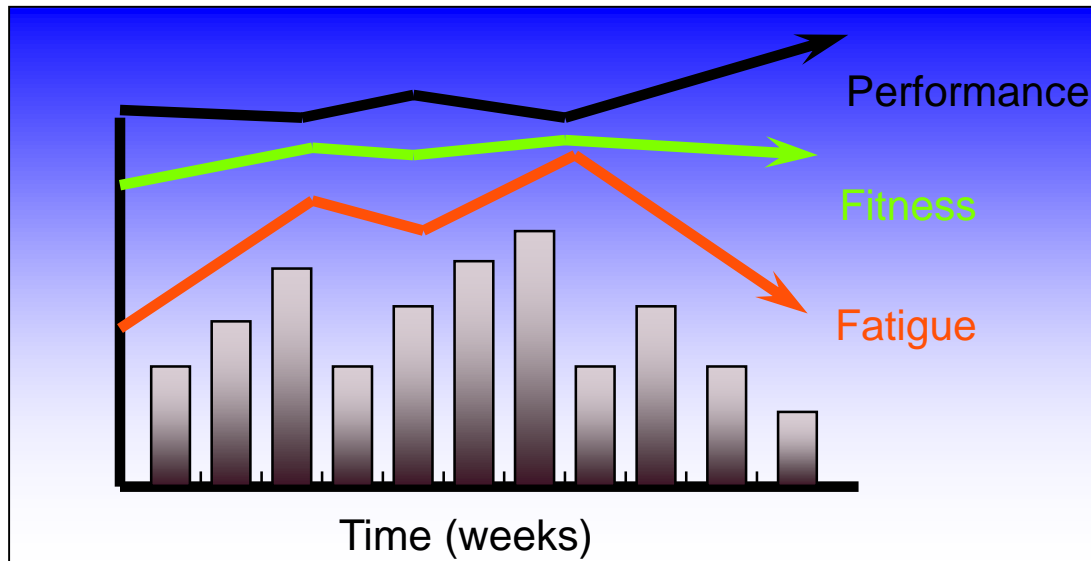
# Considerations

- Experienced coaches typically develop a *feel* for how different types of fatigue influence the training of their athletes.
- Fatigue may be short-term (acute) or long-term (chronic) depending on duration and severity.
- Is the expected performance capability restored after a period of recovery or does it persist?
- Perceptions of fatigue (e.g. “I feel tired”) AND performance incompetence (e.g. “I can’t perform at an expected level physically”) may indicate more severe fatigue
- Some “tired” athletes are still capable of outstanding performances.



# Performance = Fitness - Fatigue

Banister and Calvert (1980) Can J Appl Sport Sci. Sep;5(3):170-6.

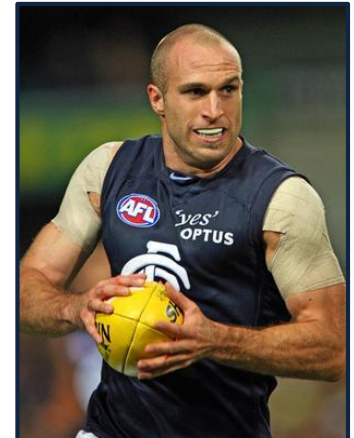
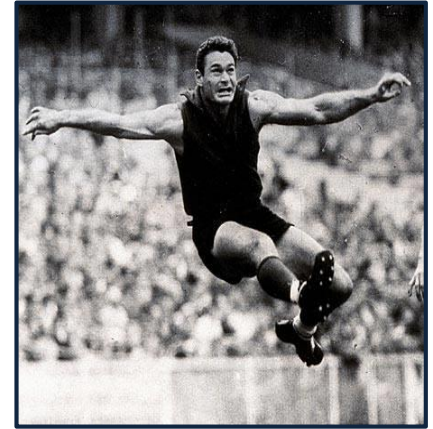


Fitness is a positive influence that is slow to develop and dissipate. Fatigue has a shorter time constant reflecting a trait that could accumulate and dissipate quickly. If we can measure training load we can begin to model performance.

**But how do we quantify load?**

# Traditional Approach

- Technology and science often evolve quickly, but conditioning practices and philosophies in sport are often based on long standing cultures and traditions.
- “Best practice” is often stifled by long-standing traditions and beliefs regarding how athletes should be trained and managed.
- The historical approach to monitoring fatigue has been to try to quantify training loads and a range of physiological and non-physiological responses



# Monitoring Fatigue

- Self reported measures of well-being including fatigue, muscle soreness, patterns of sleep, mood state, quality of training are used to monitor athletes.
- Maximal performance tests are difficult to get athletes to perform even when fresh and motivated.
- Submaximal tests in the laboratory and field are often used. These are usually based on HR, lactate, RPE at a given submaximal workload.

- No single biomarker has sufficient sensitivity and specificity
- Testing can be invasive and costly, and often yields little value in otherwise healthy individuals.
- Gold standard biomarkers are elusive, and multi-variate modelling is more likely to yield useful results than single measures.
- Both clinical experience and research are needed to develop practical guidelines.



# Individual Sports

- Management of fatigue centres primarily on careful prescription of both short- and long-term training loads.
- Periodisation of training remains an art as much as a science.
- Many different performance tests have evolved to monitor submaximal and maximal performance capacities in individual athletes.





# Team Sports

- In team sports, assessing training loads can be more challenging given the diverse range of training activities (e.g. general conditioning, resistance training, interval training and skill-based conditioning).
- The concept of “cognitive load” or fatigue that influences decision making is particularly interesting for athletes engaged in team sports.
- The training and coaching environment will influence performance.
- Team sports monitoring focuses on the changes in physiological factors such as heart rate, blood lactate, sprint ability or movement patterns (based on time-motion analysis or GPS) tracking.



# Internal Vs External Load

- Internal load can be calculated by (for example) perceptions, heart rate monitors, lactate concentrations
- External load can be quantified by speed/power meters
- Debate exists as to whether internal or external load units are more useful.
- However, monitoring the two dimensions may have merit. For example high power output (external load) with a low heart rate (internal load) may reflect a different training load to an athlete with the same power output but with a high heart rate.

# Quantifying Load in Cycling (Internal Load)

- Perception of Effort
- Heart Rate (bpm)
- Lactate (mM)
- Ventilation (L/min)
- $\text{VO}_2$  (L/min)
- Body Temperature

- Session RPE Unit ( $\text{RPE} \times \text{Time}$ )
- Training Impulse (TRIMP -  $\% \text{HR} \times \text{Time}$ )
- Cumulative Time in Lactate Zones
- Cumulative Time in  $\text{VO}_2\text{max}$  Zones
- EPOC Based Load

# Quantifying Load in Cycling (External Load)

- Speed (kph)
  - Gradient (%)
  - Power (Watts)
  - Average Effective Pedal Force (N)
  - Angular Velocity (rpm)
  - Kinetic Energy (kJ)
  - Acceleration (count)
- 
- Training Stress Score (TSS)
  - Cumulative Power Band Unit
  - Time at Climbing Intensity
  - Time in Force-Velocity Quadrants
  - Total Work (kJ)

# Questionnaires

- Sport-specific questionnaires are available, but issues with validity and compliance can limit their usefulness.
- Athletes often tire of completing a daily questionnaire for long periods.
- The quality and timing of feedback for athletes is an important issue for the sport scientist.

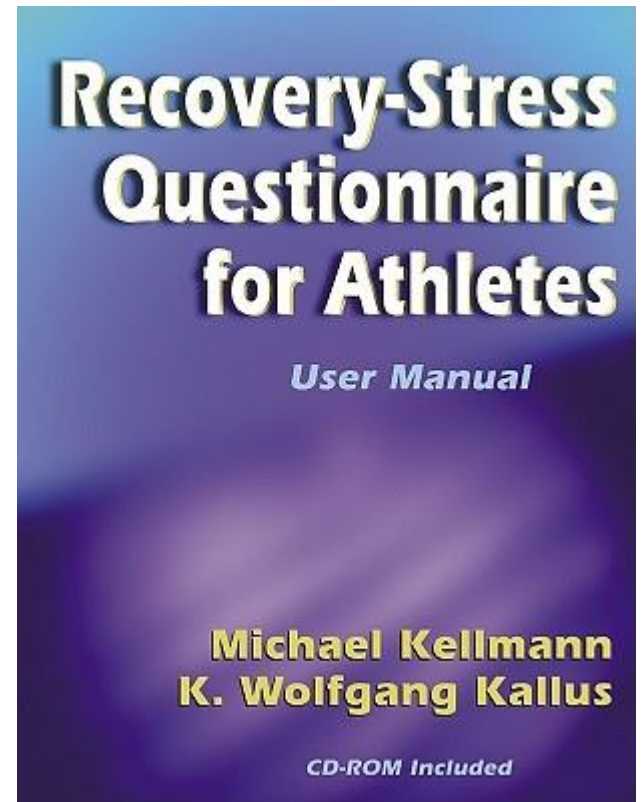


# Monitoring Recovery

## REST-Q

- Assesses the recovery-stress state of an athlete
- Physical and mental aspects
- 77 questions
- 7 general stress scales:

*General Stress, Emotional Stress,  
Social Stress, Conflicts/Pressure,  
Fatigue, Lack of Energy,  
Physical Complaints*



# Monitoring Recovery

## Recovery-Stress Monitoring



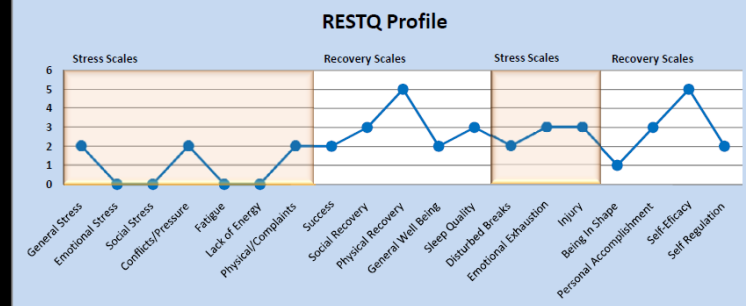
Australian Institute of Sport  
Department of Physiology  
Fatigue & Recovery



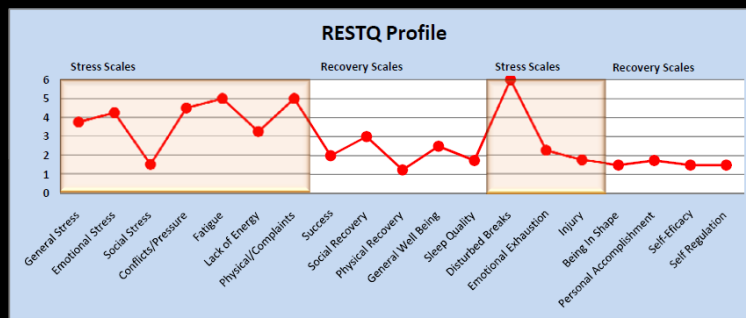
## RESTQ - Sport Profile

Name: Sport: Track and Field - V Questionnaire: RESTQ-19 Sport

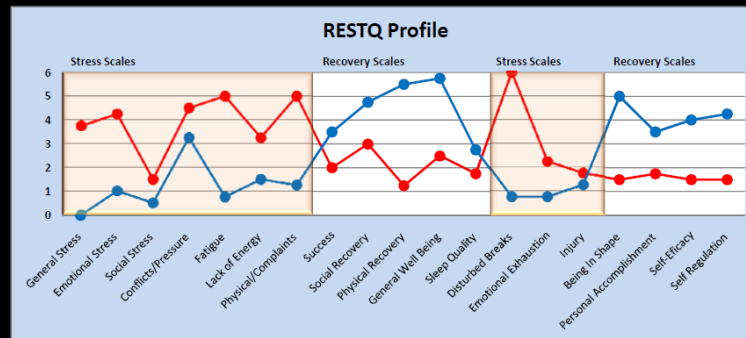
Current Profile 28/11/2009



Previous Profile 18/08/2009



Comparison



# Monitoring Sleep

- **Wrist Activity Monitors**

- *Large sample sizes*
- *Non-invasive*
- *Causes the least amount of disruption*



- **Sleep Diaries**

- *Detailed information about sleep and wake patterns*

### Sleep Diary (TDU-2007)

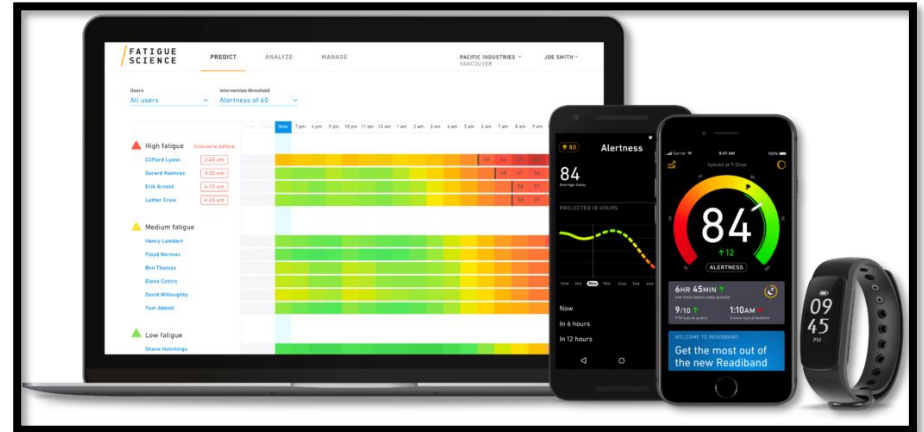
	Sleep Location	Start Date dd/mm	Start Time hh:mm	End Time hh:mm	Pre-sleep Fatigue Level	Post-sleep Fatigue Level	Sleep Quality	Remarks
eg	Home Away	13/01	23:00	07:00	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5	
1	Home Away				1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5	



# Monitoring Sleep

- Variables derived from the activity monitor data
  - Bed time: *the clock time the athlete went to sleep*
  - Wake Up time: *the clock time the athlete woke up*
  - Time in Bed: *the amount of time spent in bed*
  - Total Sleep Time: *the total amount of sleep obtained from bedtime to wake up time, less awakenings*
  - Sleep Efficiency: *the percentage of time in bed that actually spent sleeping*
  - Wake in sleep: *the amount of time spent awake from sleep onset and offset*
  - Sleep Latency: *the time it takes to fall asleep*
  - Subjective sleep quality: *rating of sleep quality on a scale of one (very good) to five (very poor).*

# How to assess sleep



# How to assess sleep?

## The Athlete Sleep Behavior Questionnaire (ASBQ)

No.	In recent times (over the last month)...	Never	Rarely	Sometimes	Frequently	Always
1	I take afternoon naps lasting two or more hours					
2	I use stimulants when I train/compete (e.g caffeine)					
3	I exercise (train or compete) late at night (after 7pm)					
4	I consume alcohol within 4 hours of going to bed					
5	I go to bed at different times each night (more than $\pm 1$ hour variation)					
6	I go to bed feeling thirsty					
7	I go to bed with sore muscles					
8	I use light-emitting technology in the hour leading up to bedtime (e.g laptop, phone, television, video games)					
9	I think, plan and worry about my sporting performance when I am in bed					
10	I think, plan and worry about issues not related to my sport when I am in bed					
11	I use sleeping pills/tablets to help me sleep					
12	I wake to go to the bathroom more than once per night					
13	I wake myself and/or my bed partner with my snoring					
14	I wake myself and/or my bed partner with my muscle twitching					
15	I get up at different times each morning (more than $\pm 1$ hour variation)					
16	At home, I sleep in a less than ideal environment (e.g too light, too noisy, uncomfortable bed/pillow, too hot/cold)					
17	I sleep in foreign environments (e.g hotel rooms)					
18	Travel gets in the way of building a consistent sleep-wake routine					

Scoring:

Never = 1, Rarely = 2, Sometimes = 3, Frequently = 4, Always = 5

Total Global Score: \_\_\_\_\_

Global score:  $\leq 36$  = good sleep behavior,  $\geq 42$  = poor sleep behavior

# How to assess sleep?

## The Athlete Sleep Behavior Questionnaire (ASBQ)

No.	In recent times (over the last month)...	Never	Rarely	Sometimes	Frequently	Always
1	I take afternoon naps lasting two or more hours	X				
2	I use stimulants when I train/compete (e.g. caffeine)		X			
3	I exercise (train or compete) late at night (after 7pm)	<del>X</del>		X		
4	I consume alcohol within 4 hours of going to bed	X				
5	I go to bed at different times each night (more than ±1 hour variation)		X			
6	I go to bed feeling thirsty				X	
7	I go to bed with sore muscles		X			
8	I use light-emitting technology in the hour leading up to bedtime (e.g. laptop, phone, television, video games)					X
9	I think, plan and worry about my sporting performance when I am in bed		X			
10	I think, plan and worry about issues not related to my sport when I am in bed		X			
11	I use sleeping pills/tablets to help me sleep	X				
12	I wake to go to the bathroom more than once per night		X			
13	I wake myself and/or my bed partner with my snoring	X				
14	I wake myself and/or my bed partner with my muscle twitching		X			
15	I get up at different times each morning (more than ±1 hour variation)	X				
16	At home, I sleep in a less than ideal environment (e.g. too light, too noisy, uncomfortable bed/pillow, too hot/cold)	X			<del>X</del>	
17	I sleep in foreign environments (e.g. hotel rooms)			X		
18	Travel gets in the way of building a consistent sleep-wake routine			X		

Scoring:

Never = 1, Rarely = 2, Sometimes = 3, Frequently = 4, Always = 5

Total Global Score: \_\_\_\_\_

Global score: ≤ 36 = good sleep behavior, ≥ 42 = poor sleep behavior

# How to assess sleep?

ASSESSMENT TOOL	ADVANTAGES	DISADVANTAGES	WHEN TO USE	EXAMPLES
<b>POLYSOMNOGRAPHY (PSG)</b>	Gold standard of sleep assessment	Expensive	Suspected sleep disorder	Lab or home based systems
	Allows determination of sleep architecture	Does not determine schedules	Research	
	Identification of medical sleep disorders	Intrusive unnatural sleep environment		
	Useful for assessment of daytime sleepiness			
<b>ACTIVITY MONITORING</b>	Non-intrusive	Does not measure sleep architecture	Research	Phillips ActiWatch
<b>Research grade devices</b>	Less expensive than PSG	Does not measure breathing	Monitoring (1-2 wks)	Fatigue Science
	Provides data on schedules	Device can be removed		
	Validated against PSG	Requires some expertise		
		More expensive than commercial devices		
<b>WEARABLES</b>	Increase sleep awareness	Lack of validation	Limited expertise and	Fitbit
<b>Commercial devices</b>	Promote athlete- staff interaction	Likely to overestimate sleep	funds available	Whoop
	Inexpensive	May cause increased anxiety		
	Accessible			
	Device is worn by the individual			
	May promote further evaluation			
<b>NEARABLES AND APPS</b>	Increase sleep awareness	Lack of validation	Limited expertise and	Beddit
<b>Commercial devices</b>	Promote athlete- staff interaction	Device not worn by individual	funds available	Resmed S+
	Inexpensive	Apps may increase screen time		SleepScore
	Accessible	May cause increased anxiety		
	May promote further evaluation			
<b>SLEEP DIARY</b>	Cost effective	Requires compliance	Limited expertise and	Multiple available and
	Provides information on schedules	May be influenced by recall bias	funds available	can be tailored
	May be more accurate than questionnaires		Schedule assessment	
			Screening	
<b>QUESTIONNAIRES AND SUBJECTIVE RATINGS</b>	Cost effective	May be influenced by response bias	Limited expertise and	Athlete Sleep Behaviour Questionnaire
	Can provide information on sleep disorders, daytime sleepiness and sleep hygiene	Lack of standardised data for athletes	funds available	Pittsburg Sleep Quality Index
			Limited time	Epworth Sleepiness Scale
			Screening	Sleep Hygiene Index
			Visual Analogue Scale	
			Ratings	

# Providing Feedback

- **Stress** and **anxiety** are related to sleep
- Care needs to be given to **how** and **what information** is provided

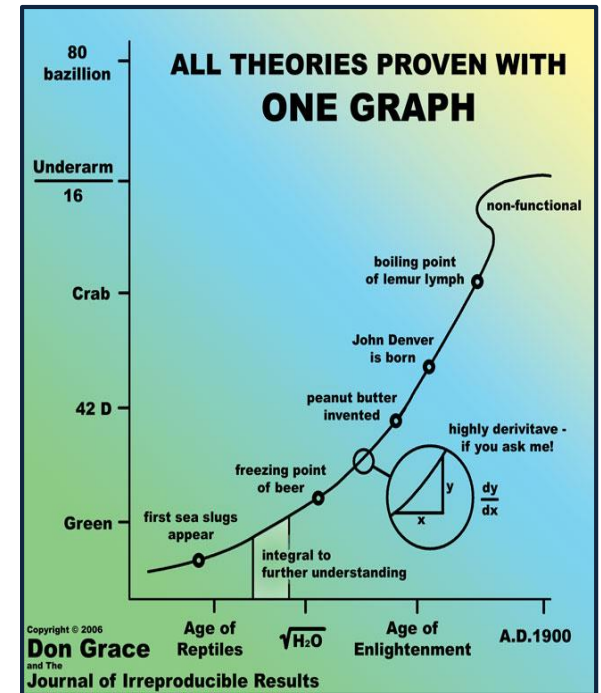


# Monitoring Tools



# Data Analysis

- Huge data generated by SRM and power cranks in cycling, digital video of team sports, and rapid expansion of GPS monitoring.
- Practical/clinical significance with magnitude-based inferences and precision of estimation:
  - Sports-specific reference or threshold values
  - Typical error of measurement

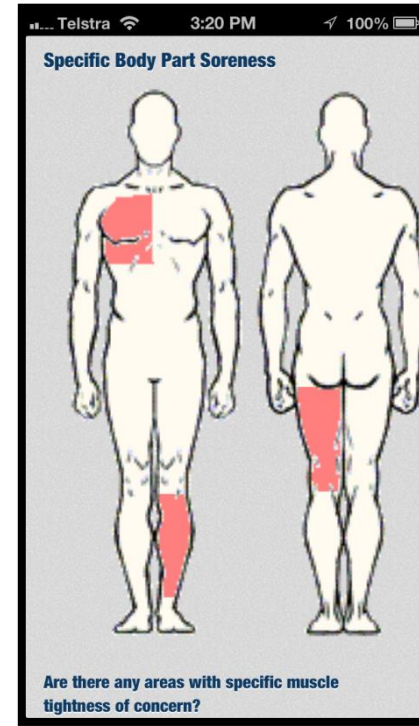
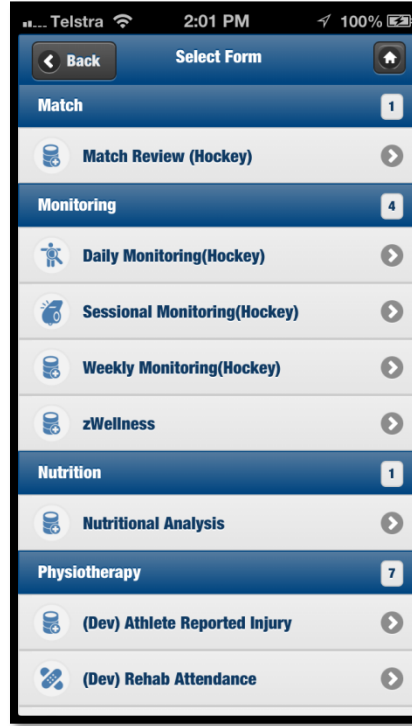
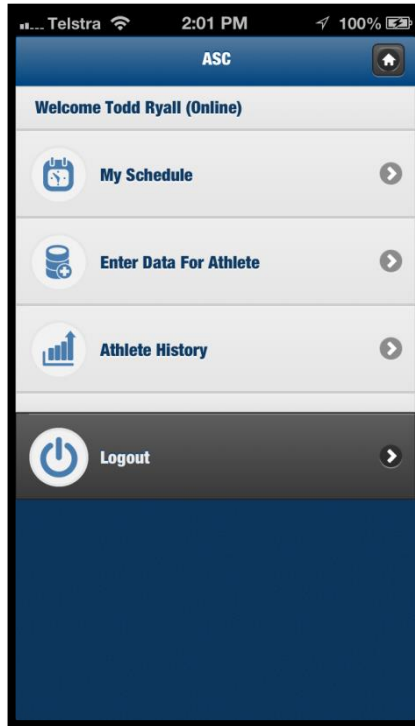




# Systems-Based Approach

“A systems-based approach that integrates well chosen diagnostic tests, with smart sensor technology, and a real-time database and data management system, is the future for fatigue management in elite sport.”

# Monitoring- AIS AMS



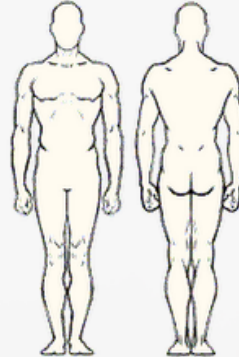
On Date  from  to

This  Daily Monitoring is marked as Completed

### Body Soreness

General Body Soreness Rating  1 - Minimal  2  3  4  5  6  7  8  9  10 - Severe

Specific Body Part Soreness



Are there any areas with specific muscle tightness of concern?

Did you get any new injuries yesterday?  Yes  No

### Specific Soreness Ratings

Rate the specific sore areas (previous body diagram selections)

### General Wellbeing

Sleep Quality  1 - Terrible  2  3  4  5  6  7  8  9  10 - Fantastic

Time Went to Sleep

Time Woke Up

Total Hours Sleep

Motivation  1 - Low  2  3  4  5  6  7  8  9  10 - High

Your desire to train/play?

Confidence  1 - Low  2  3  4  5  6  7  8  9  10 - High

How confident are you feeling?

General Health  1 - Poor  2  3  4  5  6  7  8  9  10 - Great

How would you rate your overall health and well-being?

Nutrition  1 - Poor  2  3  4  5  6  7  8  9  10 - Great

How would you rate your diet?

Fatigue - General  1 - Flat  2  3  4  5  6  7  8  9  10 - Energised

Fatigue - Train/Play  1 - Flat  2  3  4  5  6  7  8  9  10 - Energised

Mood  1 - Poor  2  3  4  5  6  7  8  9  10 - Great

How do you feel emotionally?

Stress  1 - Stressed  2  3  4  5  6  7  8  9  10 - Chilled

General Comments

### Training/Game Information

Did you have a game in the last day  Yes  No

Did you have training in the last day  Yes  No

Training Status Full Training ▼  
 Training Status Score 1  
 Time of Session 6.00am ▼  
 Is this your last session of the day?  Yes  No

#### Training Session Details

Session - WP Fitness  Yes  No  
 Session - Game  Yes  No  
 Session - WP Skills  Yes  No  
 Session - Strength & Conditioning  Yes  No  
 Session - Other  Yes  No

#### Load

Duration (mins)   
 RPE 5 ▼  
 Session Load 215  
(Duration x RPE)  
 Progressive Daily Load 299.0  
Load today so far  
 Rolling 7 day total load 1054.0  
Load in last 7 days  
 Daily Load 299  
Final Daily Load  
 Acute Training Load 175.7  
Average load of last 5 days  
 Chronic Training Load 175.7  
Average load of last 25 days  
 Training Stress Balance 0.00  
Chronic Load - Acute Load  
 Max TSB 273.60  
 TSB Flag No  
if TSB > 100 for more than 1 week

#### Recovery

Recovery Session Type  Active  
 Stretching  
 Ice Bath  
 Massage  
 Compression  
 Recovery Food  
 Nap  
 Other

Recovery Session Comments

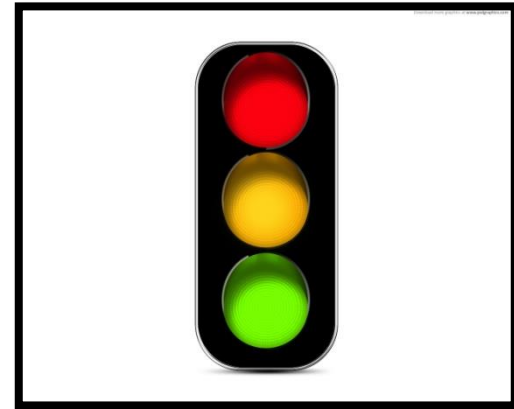
# Monitoring- AIS AMS

Training Load Trends. Click on a row to view the record in more detail. [PDF](#) [Refresh](#)

Date	About	Training Status	Last 3 Days	Last 7 Days	1 Wk (M-S)	4 Wks (M-S)	Acute (5 Day Avg)	Chronic (25 Day Av)	TSB
05-02-2014		Full Training	300	1490	300	5745	377	330	-47
04-02-2014		Rest day	720	1960		7145	443	457	14
04-02-2014		Injured	330	1010	330	3870	162	264	102
04-02-2014		Injured	350	1130	350	1640	317	235	-82
03-02-2014		Injured	1170	1650	540	1650	550	550	0
03-02-2014		Full Training	260	1270	120	3610	203	297	94
02-02-2014		Other training	960	1710	1710	7940	400	409	9
02-02-2014		Full Training	420	1380	1380	5920	340	334	-6
02-02-2014		Full Training	960	2070	2070	8190	470	435	-35
02-02-2014		Full Training	900	1695	1695	7273	319	351	32
02-02-2014		Full Training	880	1780	1780	4810	332	281	-51
02-02-2014		Full Training	1045	1945	1945	5995	396	368	-28
02-02-2014		Full Training	1250	2260	2260	8025	406	428	22
02-02-2014		Full Training	1080	1350	1350	6610	338	374	36
02-02-2014		Other training	960	1635	1635	6840	296	329	33
02-02-2014		Full Training	1380	2750	2750	6945	495	322	-173
02-02-2014		Full Training	740	1730	1730	6490	298	314	16
01-02-2014		Modified Training	120	120	120	1275	120	312	192
01-02-2014		Full Training	420	1410	1410	5970	282	298	16
01-02-2014		Injured	900	1260	1260	4915	315	281	-34
29-01-2014		Full Training	645	1225	645	4855	322	303	-19
14-01-2014		Full Training	340	1810	340	2695	433	337	-96

# Key Features of a Sustainable Monitoring System

- Simple to use
- With or without internet connection
- Efficient result reporting
- Data translated into simple outcome
- Flexible- adaptable for different sports
- Able to be utilised effectively remotely
- Understand what a meaningful change is
- Include an assessment of cognitive function
- Individual responses vs. group responses (elite athletes are not normal)
- Link to social media





**Thankyou**