

Measuring and Monitoring Training Fatigue and Recovery

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Objectives of the presentation

- **To introduce the emerging science and technology of heart rate variability as applied to sport**
- **To look at some of the methods and measurements to monitor training fatigue and recovery**
- **To look at some case examples**

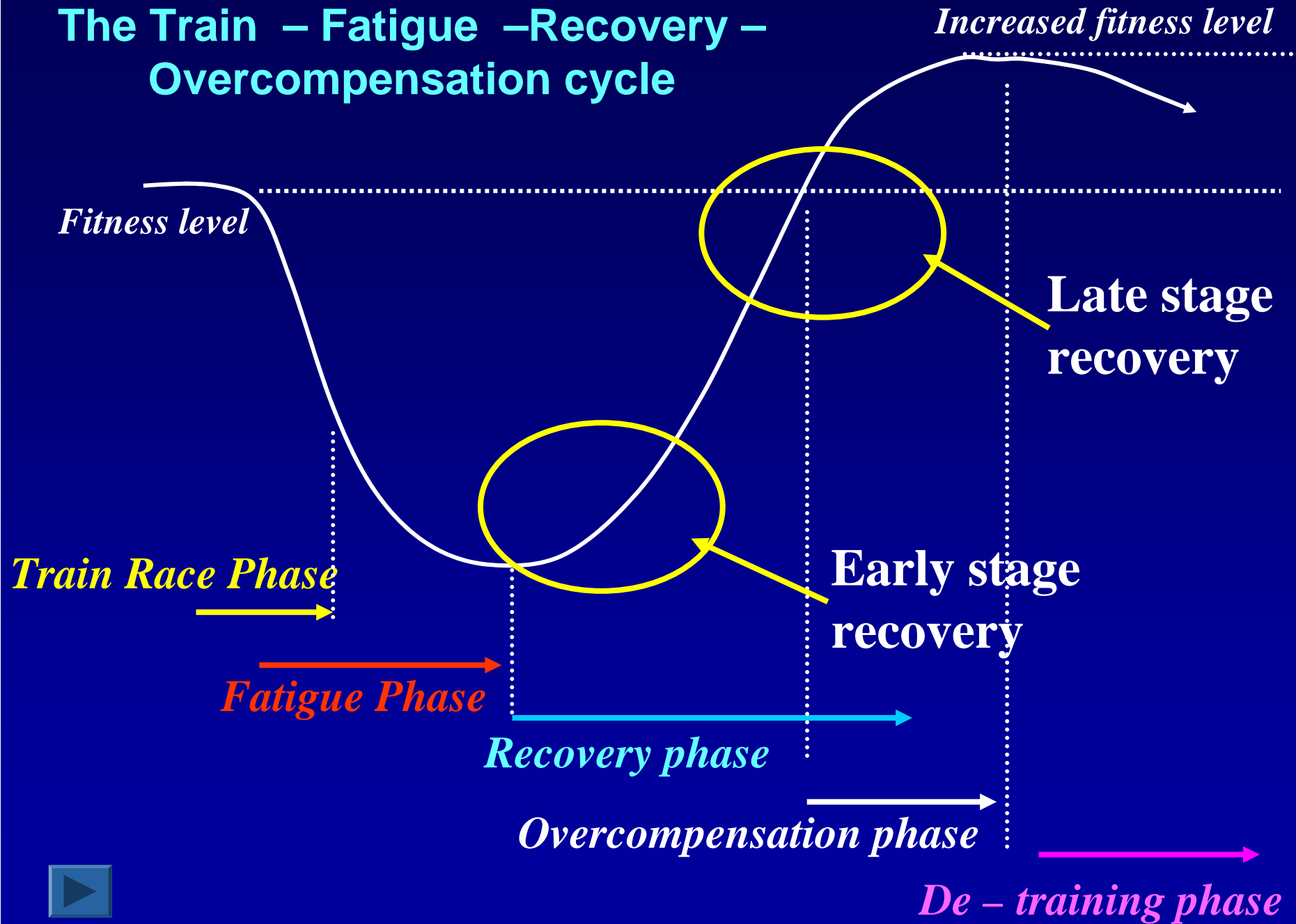
It is not about the various methods to aid recovery such as rest, recovery training, nutrition etc

Some Major Problems and Challenges - especially with High Performers

- **Recognising Overreaching & Overtraining**
- **Knowing when to back off and how long to wait**
- **Knowing when it is safe to train hard again**
- **Knowing how hard the envelope can be pushed**
- **Knowing how long to taper down to major events**

The solution or part solution - reliable information and measurements

The Train – Fatigue – Recovery – Overcompensation cycle



**“3 to 6 days after a muscle damaging
bout of exercise athletes can no longer
perceive that their muscles are still
weak”**

**Prof Mike Gleeson and Prof Ron Maughan
School of Sport and Exercise Sciences
Loughborough University**

In ‘Sports Performance’ pub by OUP Press 2004

**The risk of training hard again too soon is all to
great**

But how can we know ?

Use any of :

Subjective Feel ?

Resting heart rates ?

Training heart rates ?

Borg scale ?

Power measures ?

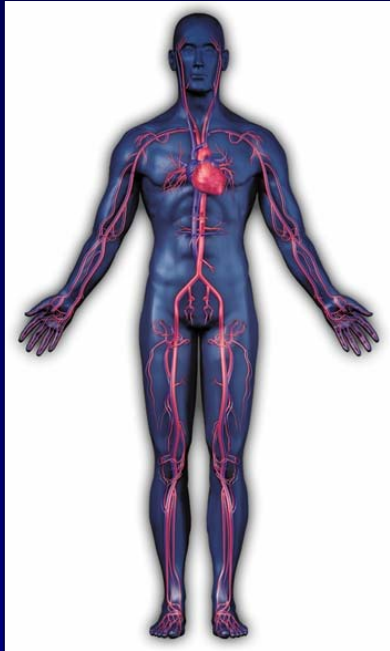
Performance levels ?

Varying strengths - but all have major limitations

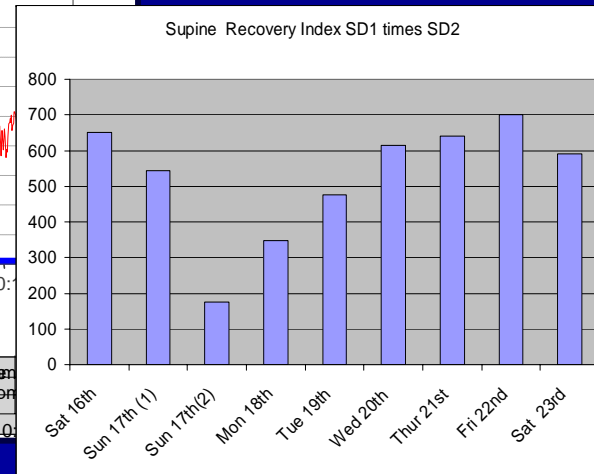
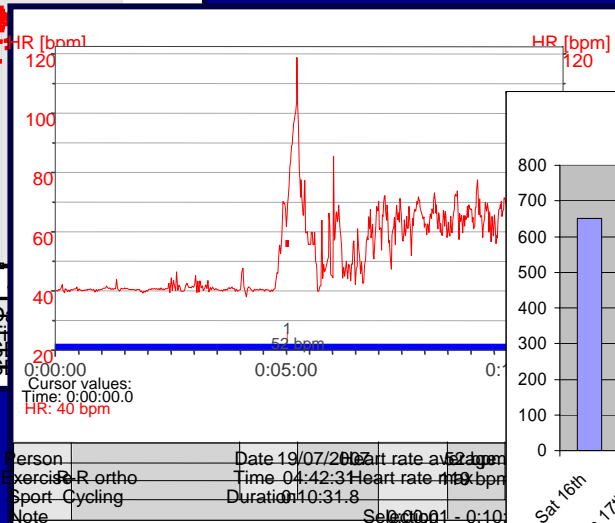
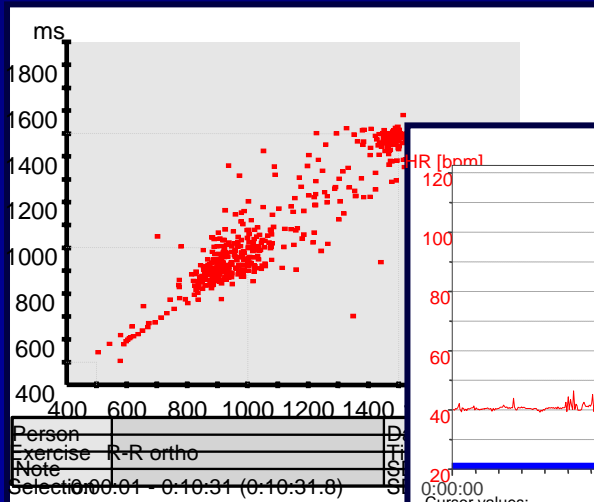
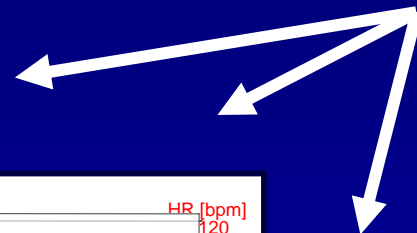
Blood markers - stress hormones, certain amino acids

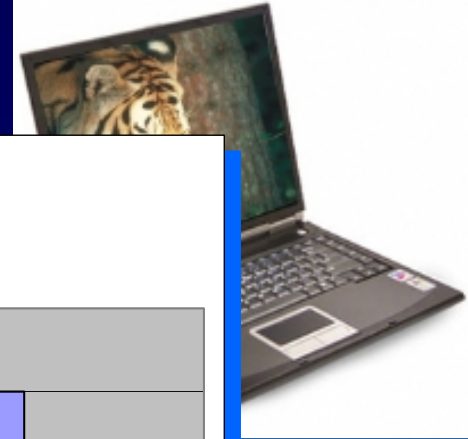
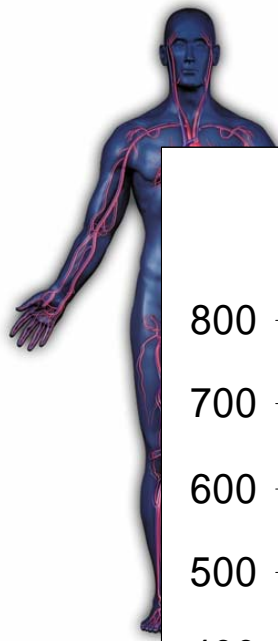
Not feasible on a day to day basis

Without reliable measures coaches are in the dark

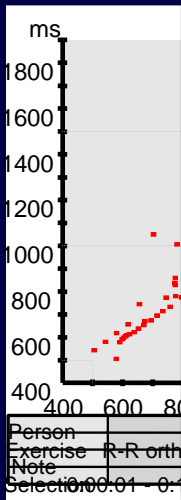
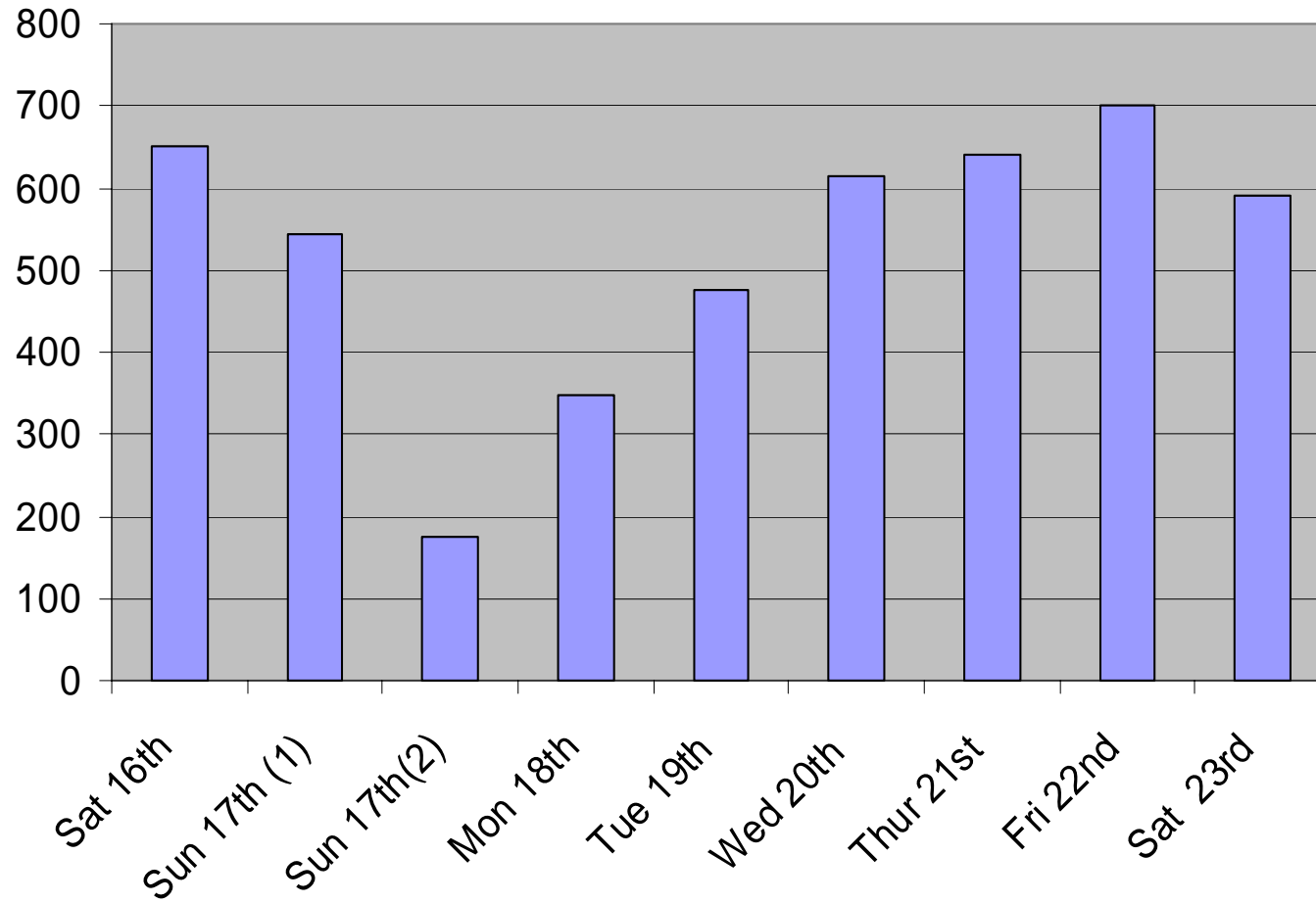


Deep insights into fatigue and recovery





Supine Recovery Index SD1 times SD2



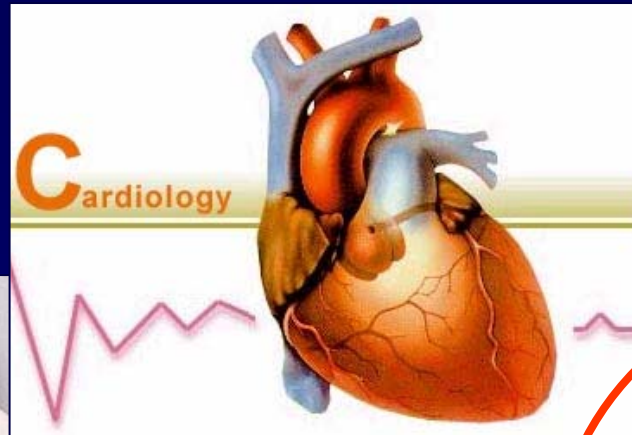
Sport Cycling Duration 10:31.8
Note Selection - 0:10

Sat 16th
Sun 17th (1)
Sun 17th (2)
Mon 18th
Tue 19th
Wed 20th
Thur 21st
Fri 22nd
Sat 23rd

into
d

So Why Heart Rate Variability

The strong association between high HRV and good health has been known for a long time



The link between survival from a heart attack and HRV is very strong

Patients with high HRV have a much stronger chance of recovery than those with low HRV

**Relatively recently strong links established
between HRV and
training & competition induced fatigue in sport**

The Finnish Connection

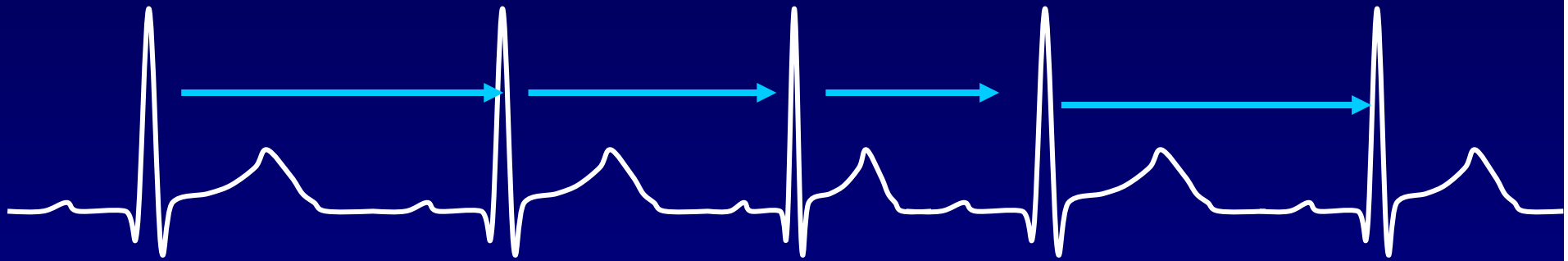


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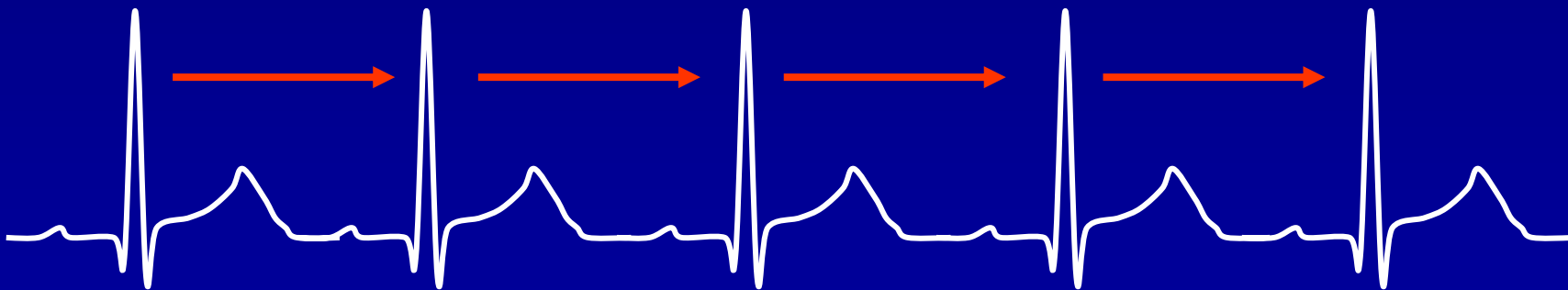
KIHU - Finish Institute for Olympic Sports

University of Kuopio - Bio Signals Research Group

ECG Trace with High Variability

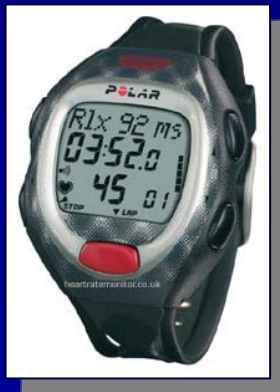
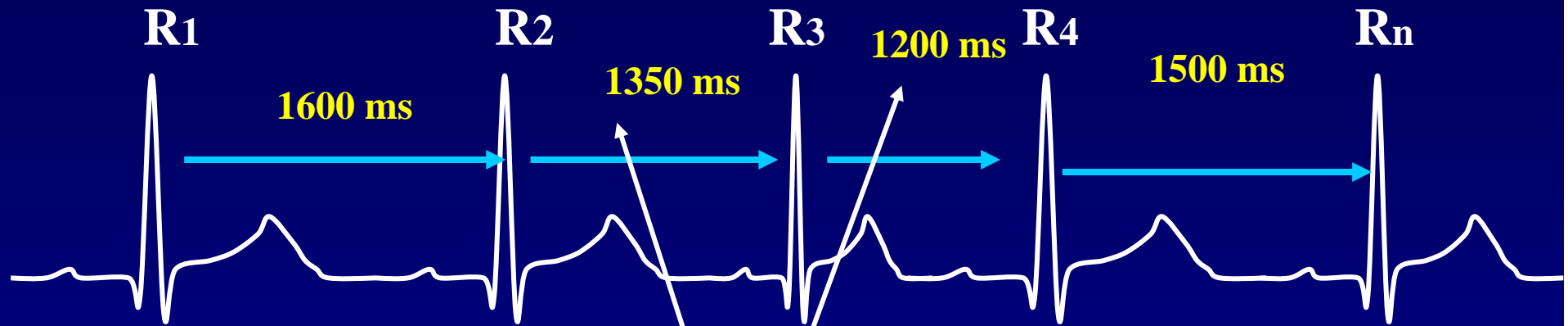


ECG Trace with Low Variability



Low variability is **BAD** indicates fatigue, sickness etc
High variability is **GOOD** shows good health, recovery

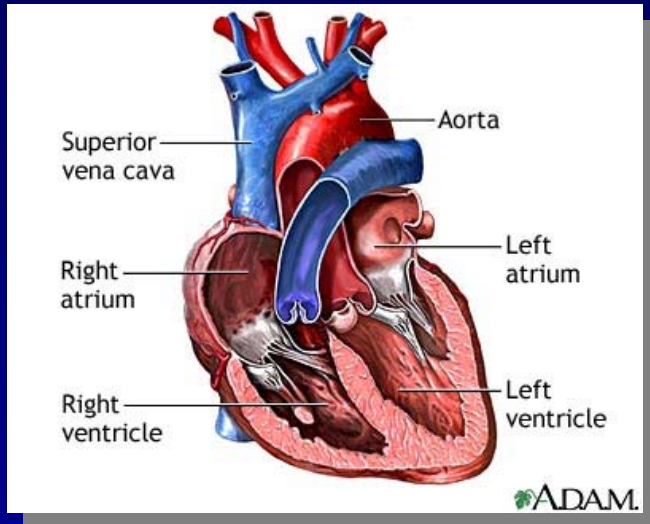
Measuring Heart Rate Variability



Measure R-R with a Polar monitor

The link between HRV and the Central Nervous Systems

HRV is governed by the Central Nervous System - CNS

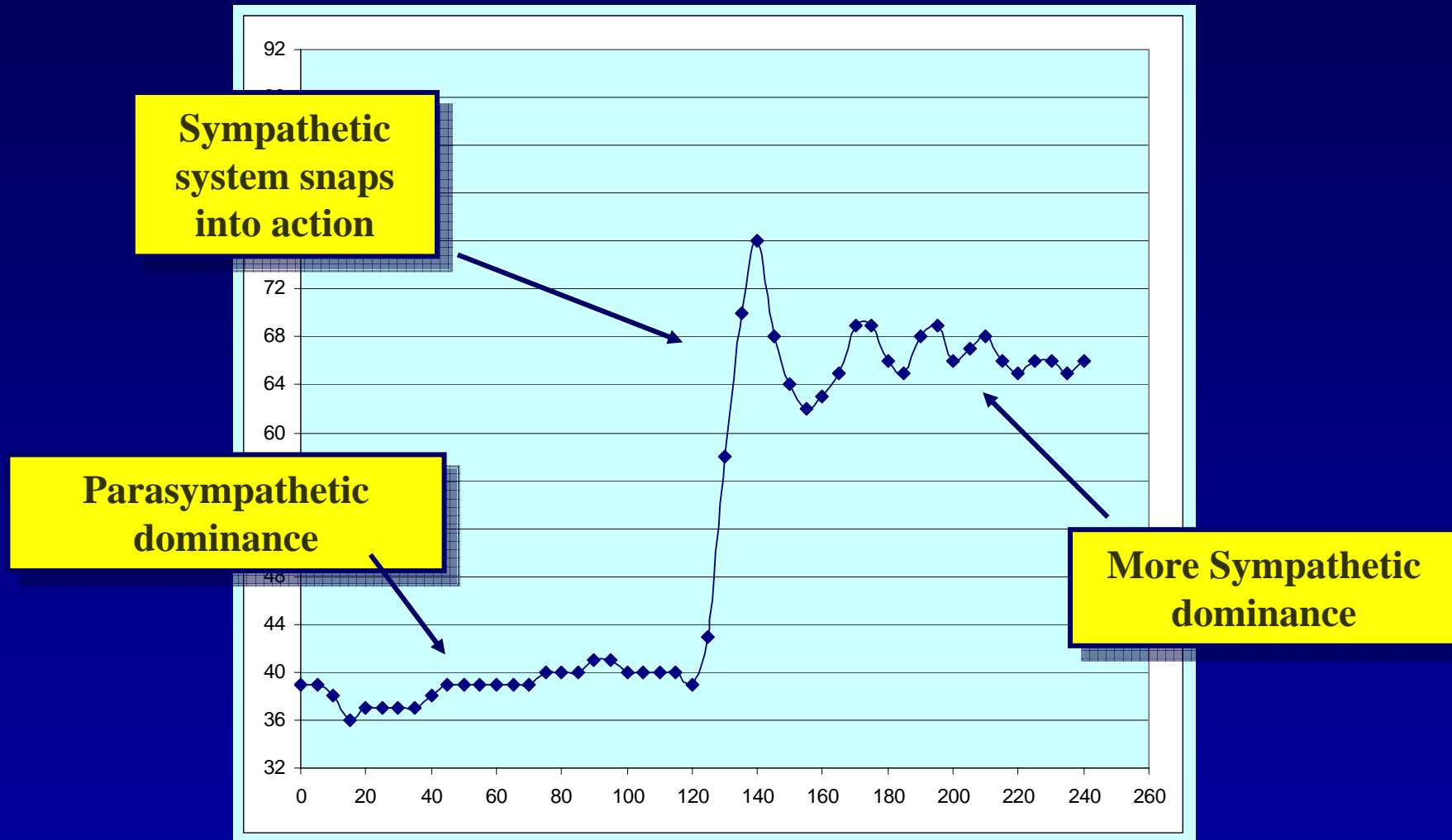


‘Parasympathetic’ branch slows HR and increases HRV

‘Sympathetic’ branch speeds up HR tends to reduce HRV

Parasympathetic and sympathetic branches of the CNS are constantly balancing each other

Typical Orthostatic heart rate profile



Average heart rate every 5 seconds against time in seconds

The link between Fatigue CNS & HRV

- **Fatigue disturbs the CNS indicated by HRV**
- **Increased fatigue - increases CNS disturbance and reduces HRV**
- **During recovery CNS returns to normal and HRV increases**
- **Measuring HRV indicates CNS disturbance & provides insights into fatigue & recovery**

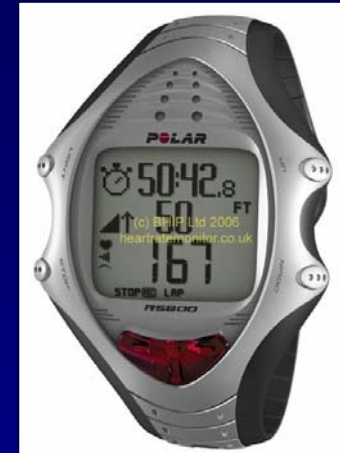
**So how can we use R-R data
to measure HRV**

**And in turn gain insight into
fatigue and recovery**

Polar CS600



Polar RS800



You need one of these monitors

Plus computer software

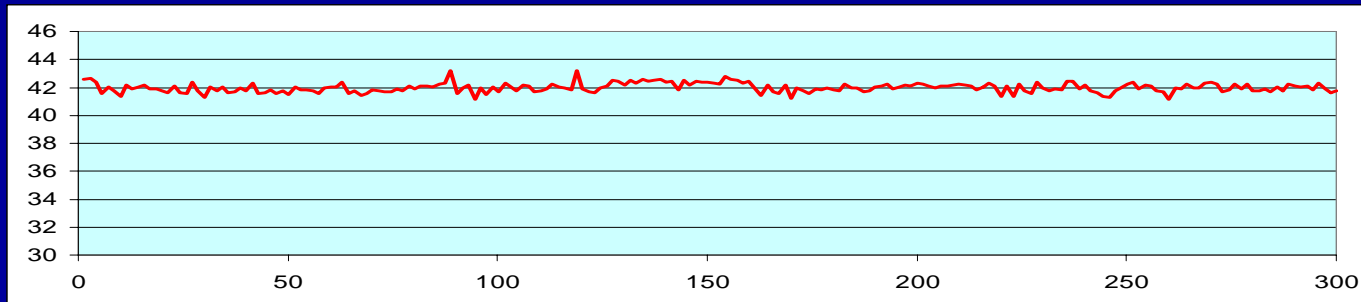
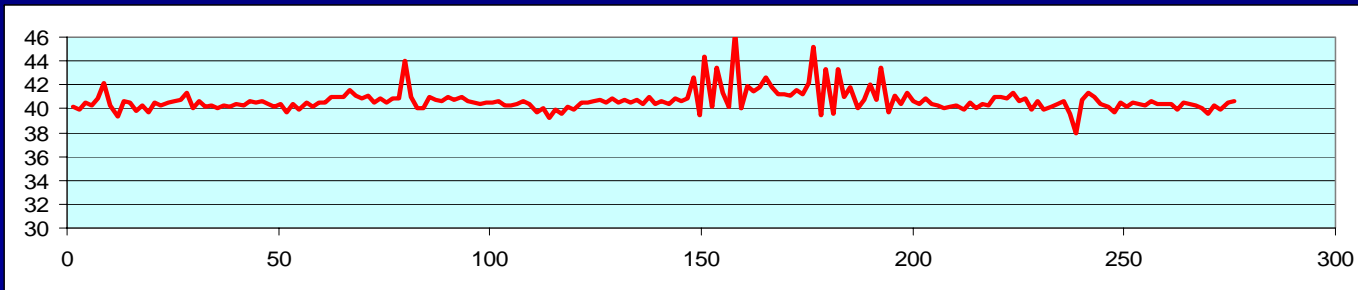
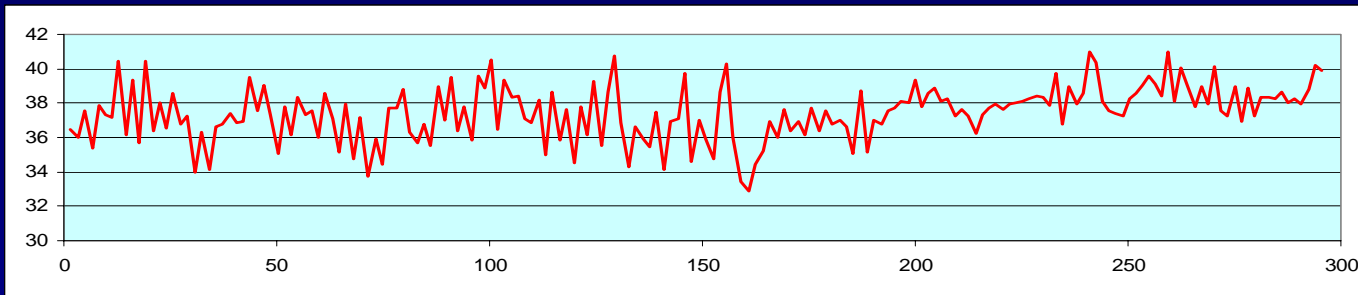
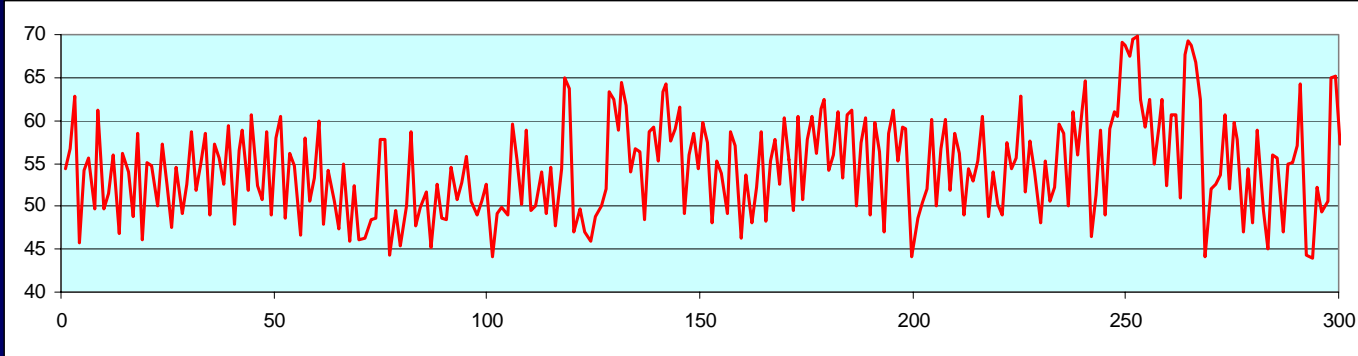
To get R-R traces

Polar S810i



Suunto T6 or T4

R-R traces from a Polar S810i



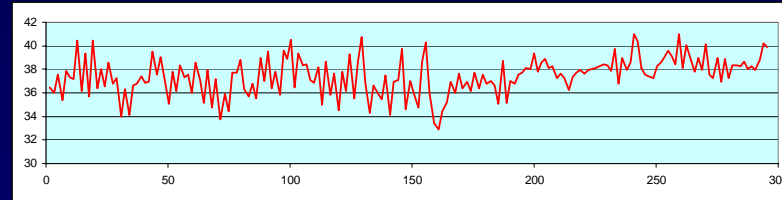
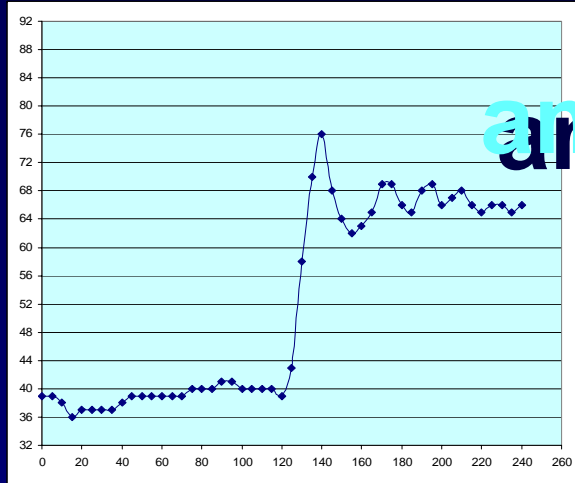
Different
degrees
of HRV

**There are different ways we can use
this data**

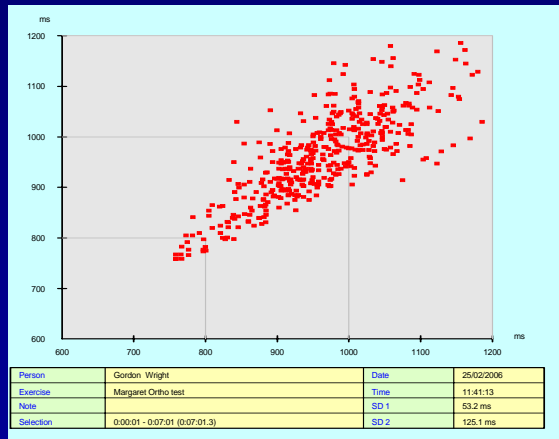
to turn it into useful information

Three levels of

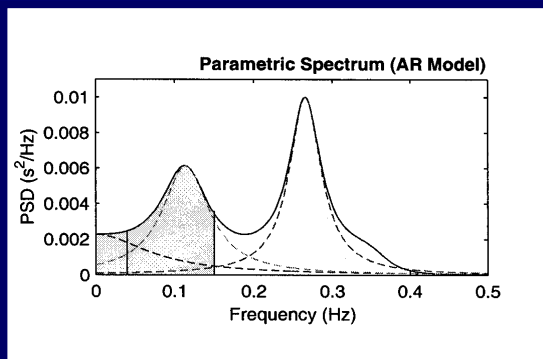
analysis



← Orthostatic HR profiles



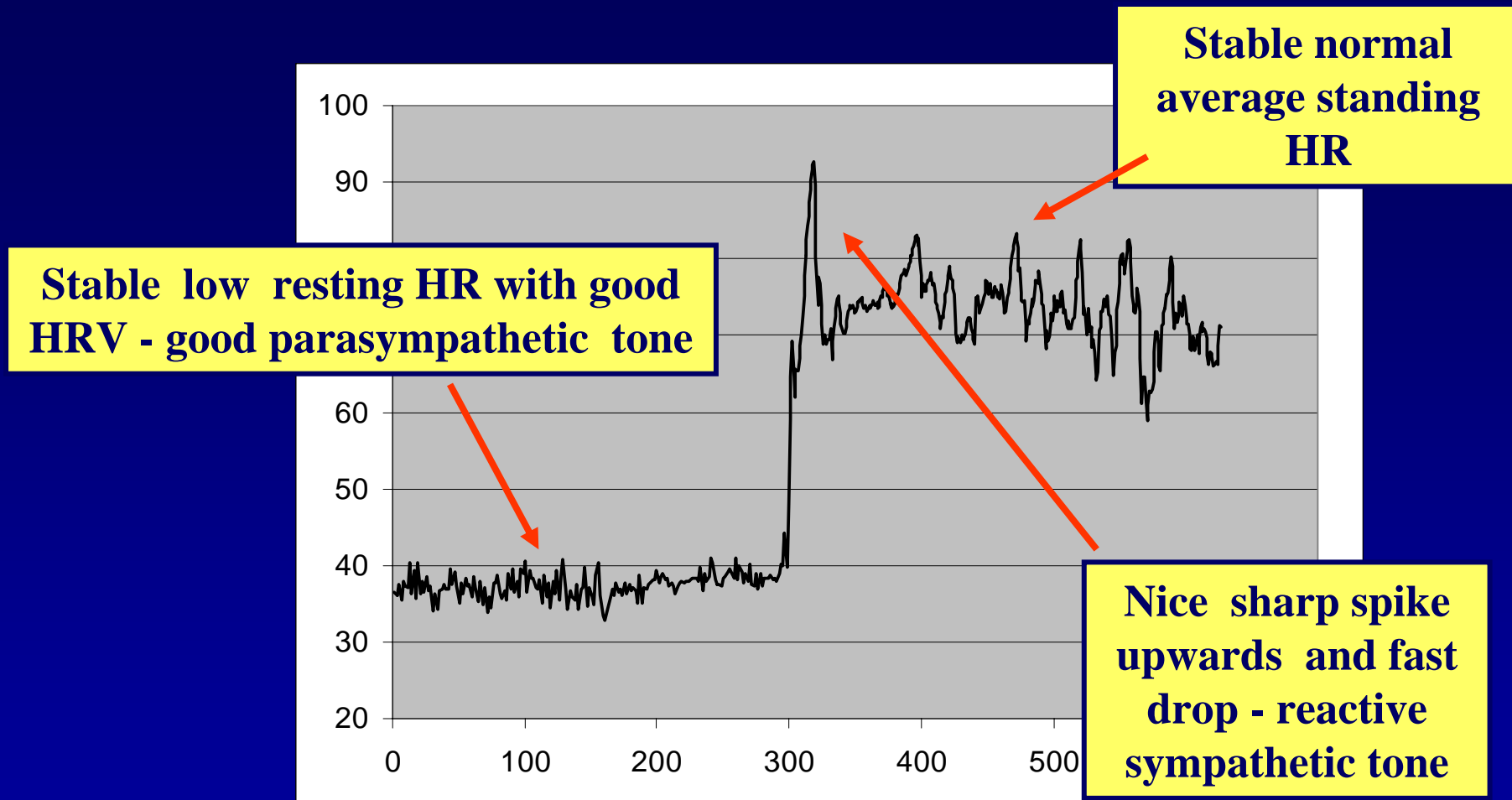
← Poincare Plots



← Spectral analysis

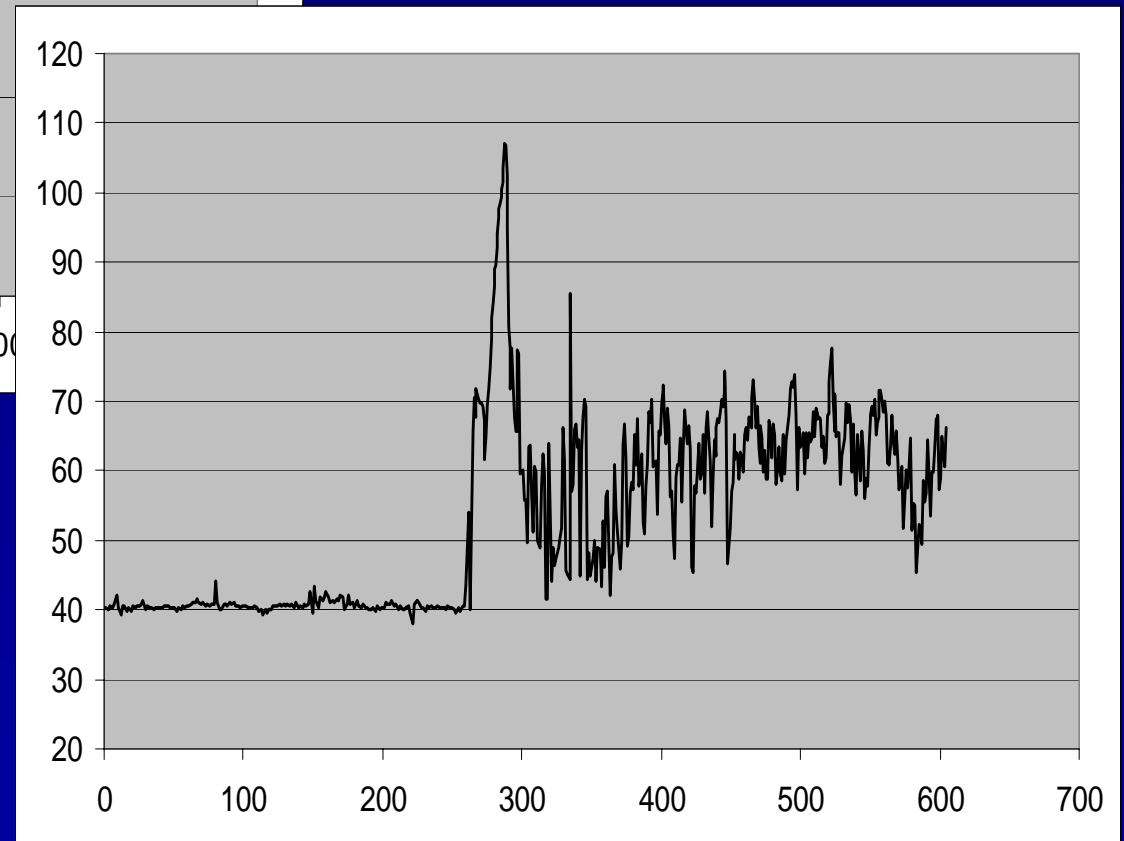
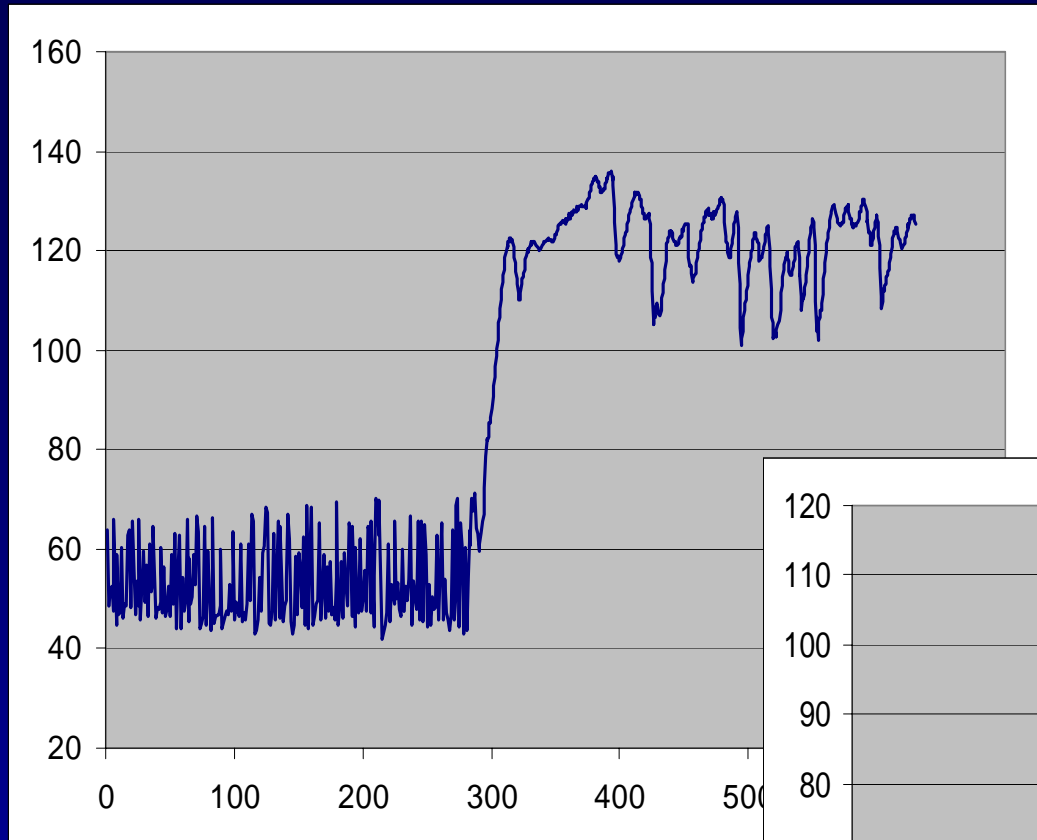
Orthostatic profiles

Profile of a recovered rider



In instant 'beat to beat' format or HRV format

**Same rider
fatigued and
overloaded**



**Same rider over
trained**

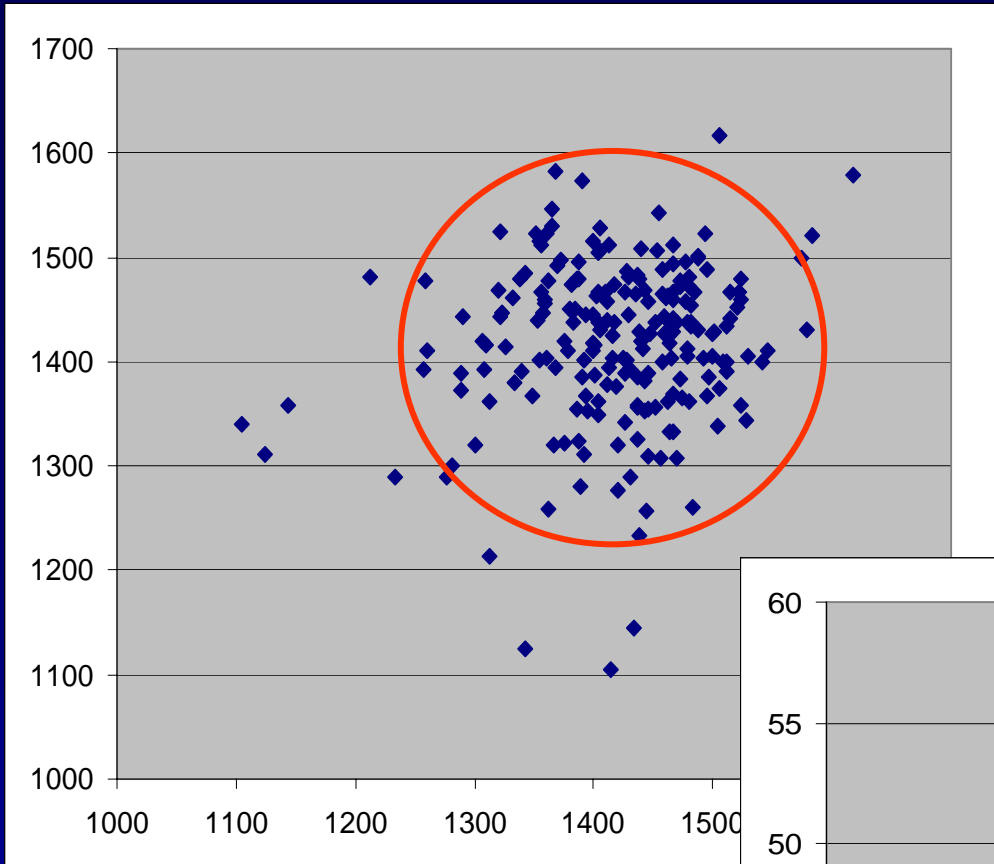
- Orthostatic heart rate profiles are of value in *tracking fatigue* and recovery
- It's the *shape* and *appearance* of the profile that is a useful guide plus *day to day* changes
- However there is much *individuality* in such profiles - so you need to know your rider
- But we can do more using *Poincare* plots

A set of RR values from a Polar Heart monitor

**Time
between each
beat in milli
seconds**

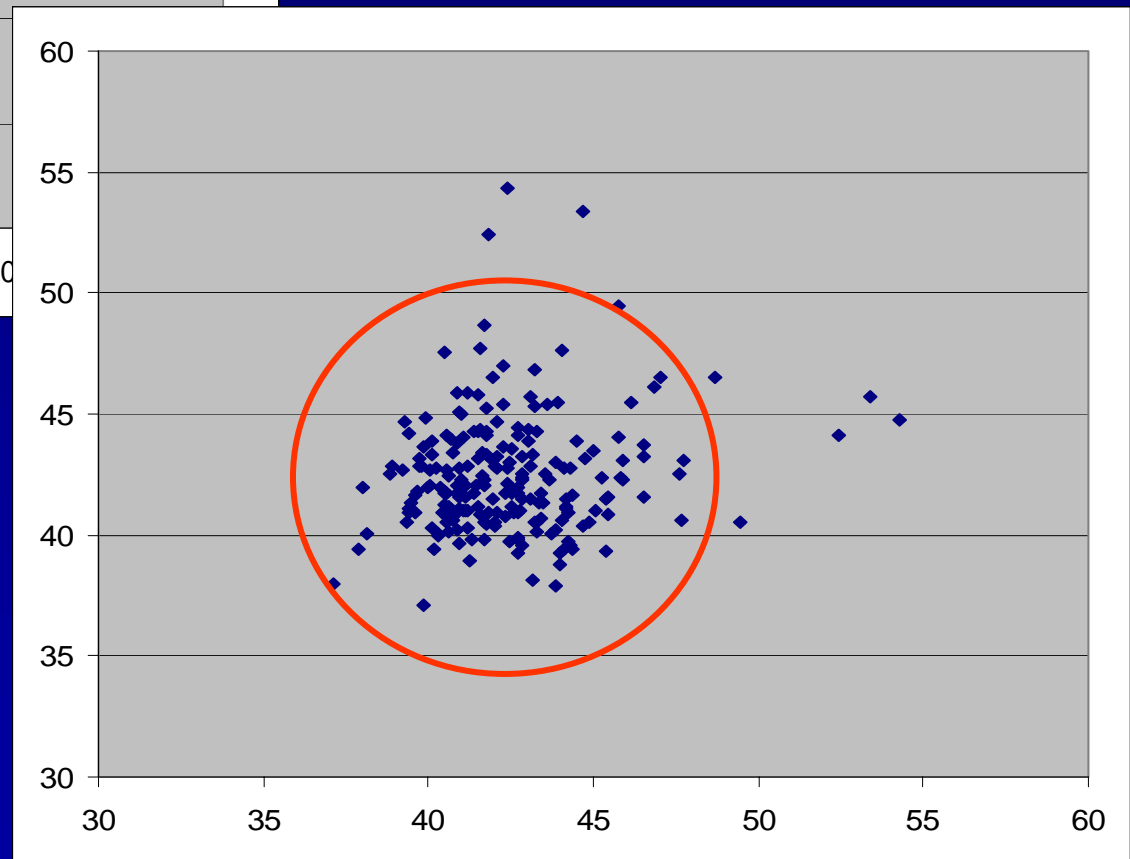
1237	940	49	64
1151	1237	52	49
1139	1151	53	52
1264	1139	47	53
910	1264	66	47
1345	910	45	66
1018	1345	59	45
1280	1018	47	59
1274	1280	47	47
995	1274	60	47
1298	995	46	60
1229	1298	49	46
1233	1229	49	49
957	1233	63	49
940	957	64	63
1243	940	48	64
915	1243	66	48
1076	915	56	66
1281	1076	47	56
1123	1281	53	47

**Same data as
equivalent heart
rate in beats per
minute**

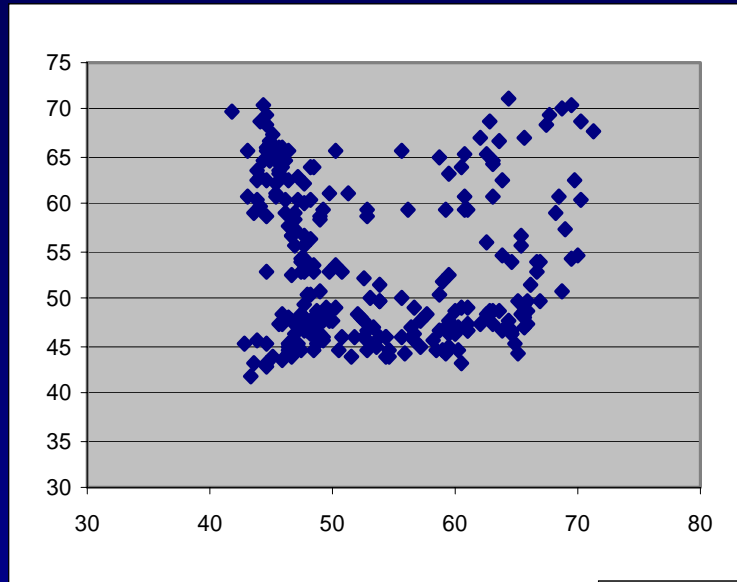


**Poincare Plot R-R
format - scale in
milli seconds**

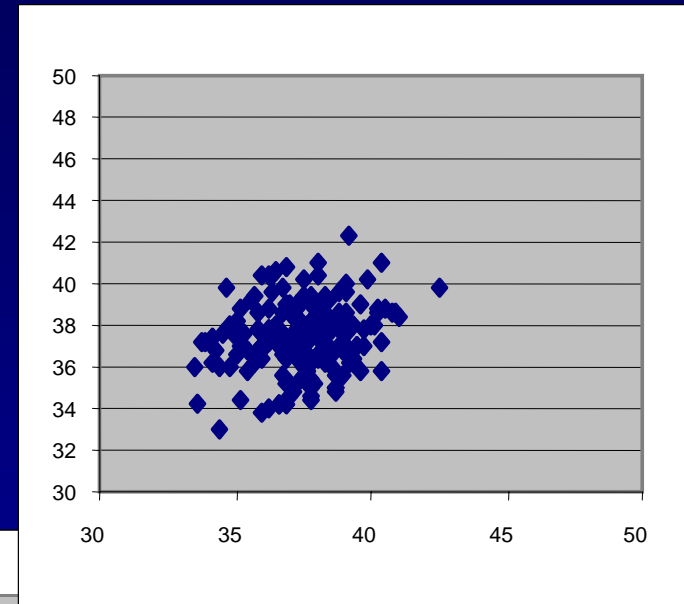
**Poincare Plot
Heart Rate
format**



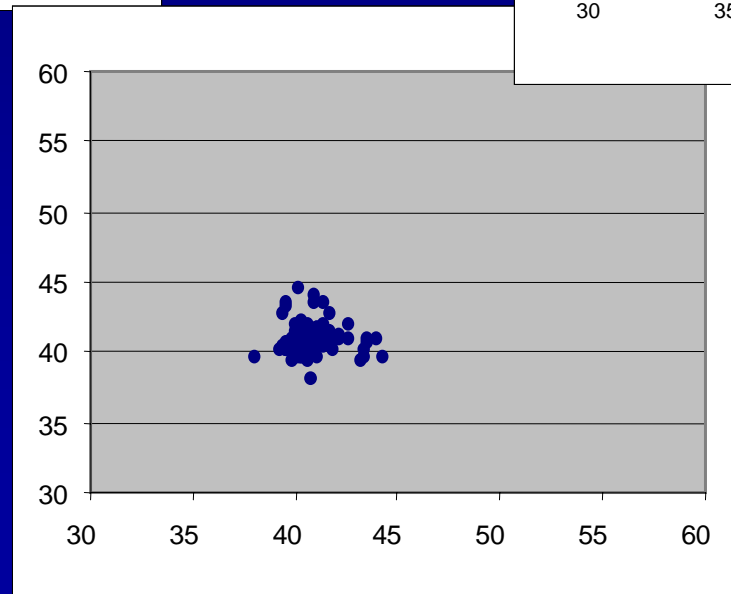
**Overloaded rider
CNS agitated**



**Rested & recovered
CNS & HRV balanced**



**Overtrained rider HRV
collapsed**

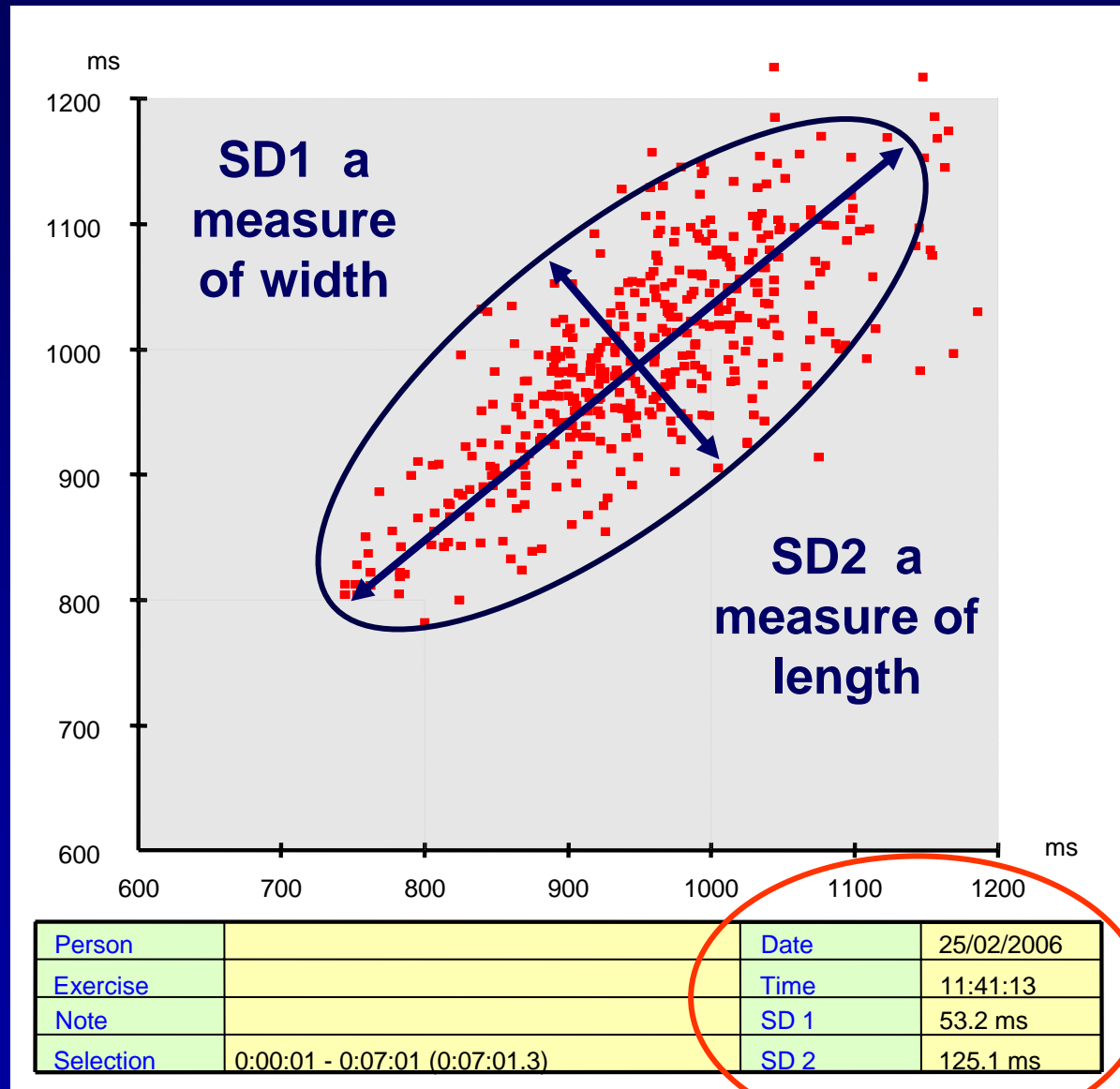


Poincare Plots can be quantified

Polar produced Poincare Plot of a well rested rider

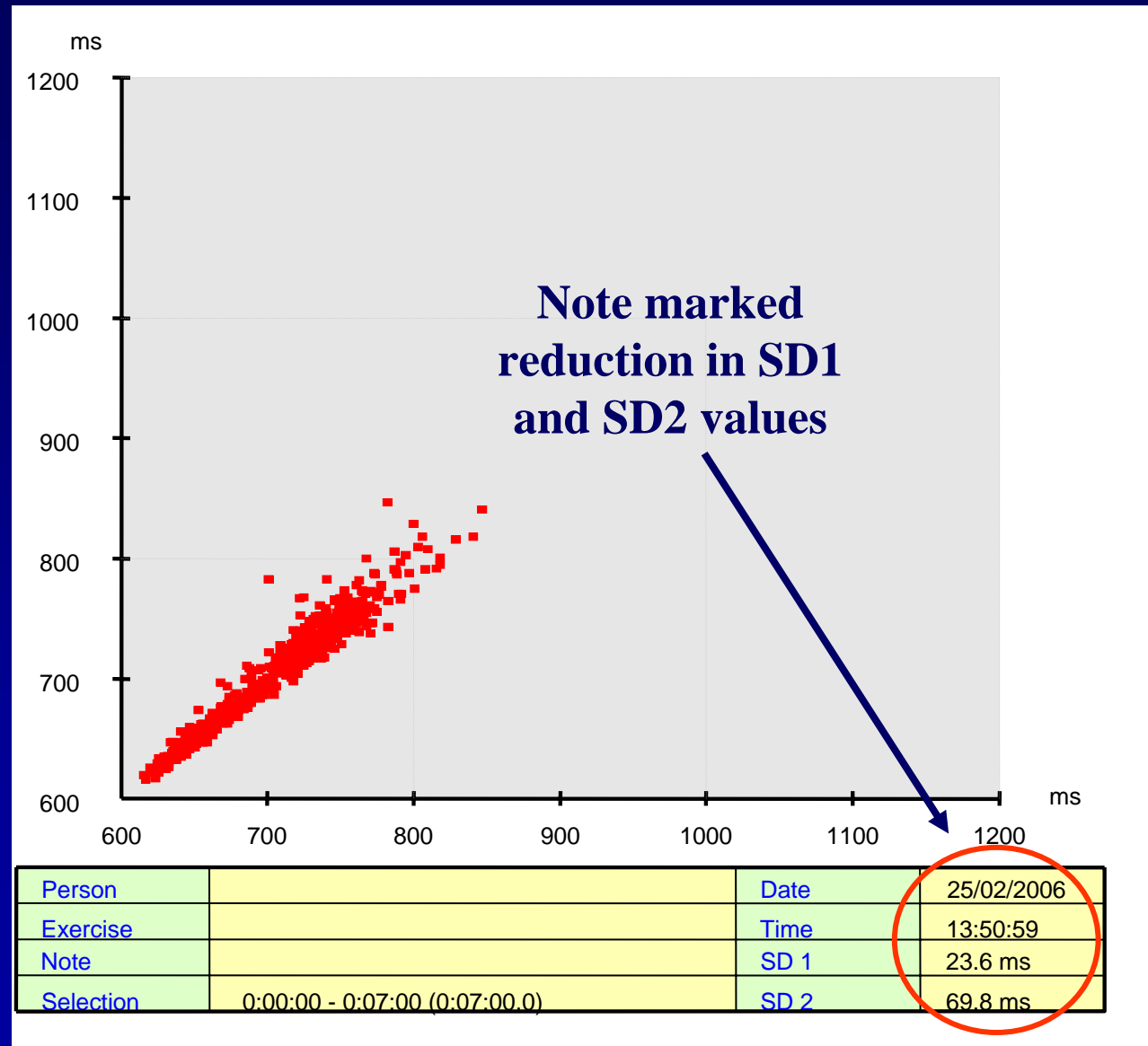
SD1 is especially sensitive to Fatigue

SD1 also correlates very closely with parasympathetic tone



Poincare plot of same rider after hard training

SD1 and SD2 can be used as recovery index values

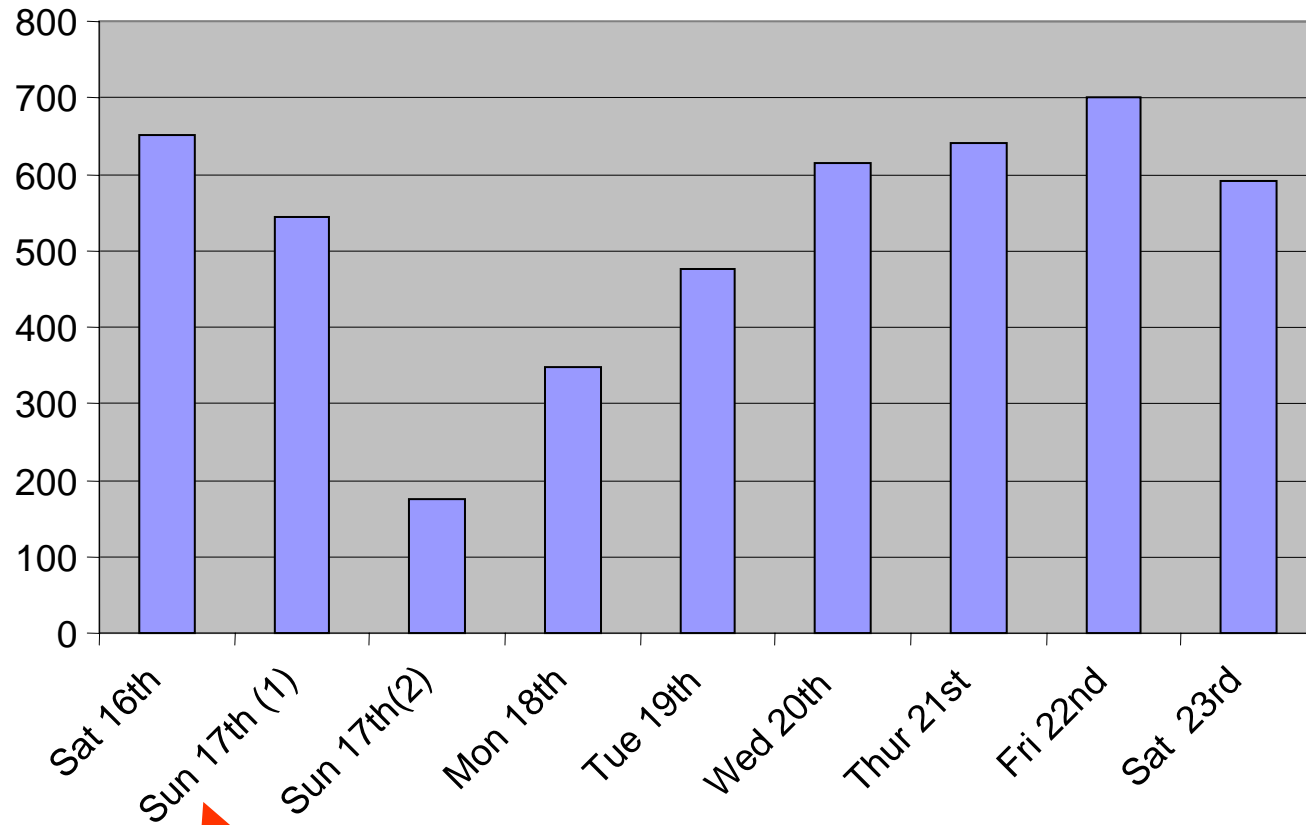


Case Study

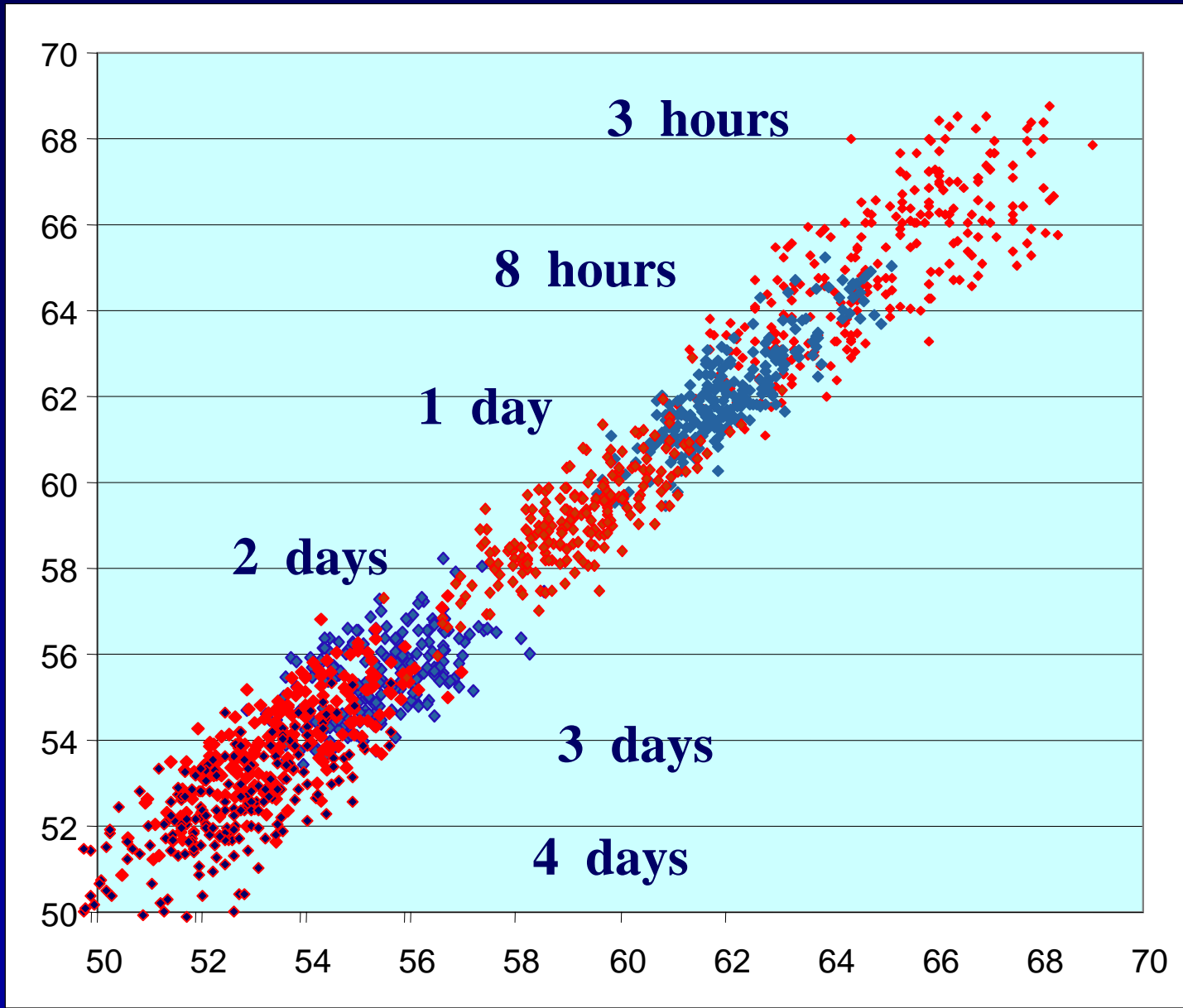
Veteran rider

Day by day recovery after a hard time trial

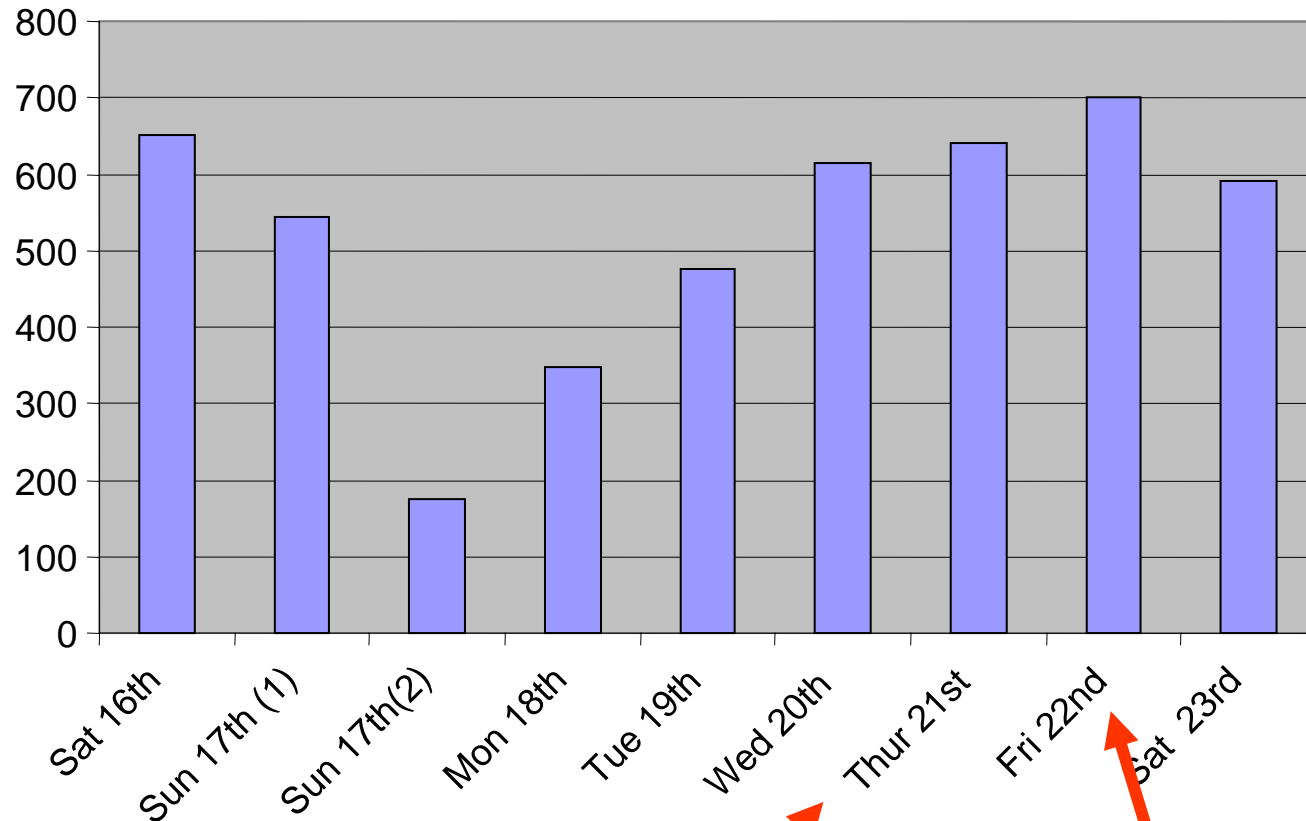
Supine Recovery Index SD1 times SD2



Hard Race Here



Supine Recovery Index SD1 times SD2



Full recovery took some 4 days !

Maybe 5 days to overcompensate ?

End 1st session