Heart Rate Variability (HRV), Recovery Index (RI) and Heart Rate Variability Index (HRVI)

Accurate tools for assessing Psychological Stress, Physiological Workload and Recovery in Athletes

A briefing note written by Sports Physiologist and Coach Eddie Fletcher

General Introduction

There are a number of factors which influence training and race performance, ranging from daily living (work and family), diet and hydration, cold, heat and humidity through to the lack of adequate rest and recovery. It is important to understand how stressful a normal training day is and to know the extent of overnight recovery.

The human heart is a wonderful barometer of the overall psychological stress and physical workload experienced by the body. The heart is a muscle, it gets tired and like any other muscle requires time to recover if optimum training and race performance is to be maintained.

The heart responds automatically and immediately to any increase or decrease in stress level. This heart rate response can be used to manage and mitigate the risk **of over training, under recovery, illness or injury,** to the body.

By monitoring the influence of psychological stress and physiological workload it is possible to use an analysis of heart rate to monitor overnight **recovery** and to moderate the **duration** and **intensity** of training to match the extent of **recovery**.

The consequences of getting it wrong should not be under estimated. Unless '**listening to your heart'** is normal practice deterioration in performance can occur almost unseen.

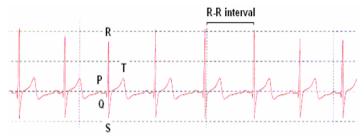## What are the benefits of measuring daily stress?

- Maximize recovery between training sessions
- Know how travelling, jetlag, high altitude and other stressors influence stress and recovery
- Learn how different daily routines enable and limit recovery
- Measure recovery between training sessions when training in high altitude
- Assess how travelling and jetlag influences recovery after a competition
- Check for social and psychological stressors that influence recovery
- Check athlete's daily routines for arrangements that could be done better to minimize stress during the day
- Interpret results together with athlete to detect stressors that influence recovery and to plan things that could be done differently in the future
- Repeat the daily stress recordings and observe how changes in daily routines influence stress and recovery

What are the benefits of measuring recovery?

- Detect early signs of overtraining or illness
- Optimize training load by finding the balance between training load and recovery
- Evidence based support for critical coaching decisions
- Record individual reference values e.g. during off-season when the body is recovered
- Check the recovery status during hard training periods
- Check recovery status when subjective feelings and fitness level indicates poor recovery
- Make sure that the body is recovered sufficiently before a new hard training period
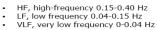
How does it work?

Tracking daily stress and overnight recovery needs only one physiological signal – **beat-by-beat heart rate data (the R-R interval)**. This measurement may be carried out during normal daily routines, whilst training and whilst sleeping. Although the data collection procedure is simple, the analysis methodology produces accurate recovery information.
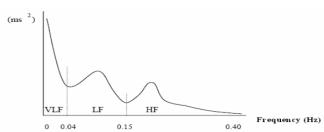

Under resting conditions, healthy athletes show a periodic variation in the **R-R interval**. This rhythmic fluctuation is caused by breathing. Heart rate increases whilst breathing in and decreases when breathing out.

By accurately measuring the time interval between heartbeats (known as **Heart Rate Variability HRV**) it is possible to use the detected variation in time to measure the psychological and physiological stress and fatigue on the body. Generally speaking the more relaxed and free from fatigue the body is, the more variable the time between heartbeats. **Increased Heart Rate Variability is linked to good health; decreased Heart Rate Variability is linked to stress or fatigue**.

Heart Rate Variability also distributes as a function of *Frequency*.

- HF, high-frequency 0.15-0.40 Hz
- LF, low frequency 0.04-0.15 Hz
- VLF, very low frequency 0-0.04 Hz

Because of the characteristics of the *increase* (high frequency *HF*) and *decrease* (very low and low frequency *LF*) of the heart beat, changes in this frequency distribution can be used to monitor *overall daily stress and overnight recovery*.

Recovery is strongly associated with high frequency reactions and stress with low frequency reactions.   These values are highly individual and the most sensitive markers for monitoring stress and recovery status. By looking at the difference from athlete specific baseline values the status of stress and recovery can be monitored and a *Recovery Index* or *Heart Rate Variability Index* created.

The intensity of stress/recovery is calculated from the *HF*, *LF*, *Respiration rate* and *HR*.

How easy is it to collect the data?

Very easy, simply wear a Suunto t6 or Suunto Memory Belt during training sessions and overnight. The log is downloaded into Suunto Training manager software and Firstbeat SPORTS or Firstbeat PRO for detailed analysis.
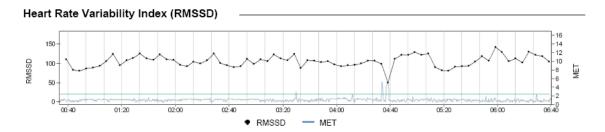
What is a Recovery Index?

The *Recovery Index* is the relationship between the total duration of the *Stress* (low frequency) and *Recovery* (high frequency) reactions during an overnight measurement. The index is generally calculated from the first 4 hours of sleeping time as this time period is the most sensitive time for detecting recovery status. Average values provide information for both stress and recovery reactions during the selected time period indicating the relative strength of the reactions.

The intensity of the *Stress/Recovery* is calculated from the high and low *Heart Rate Frequency* mix, *Respiration Rate* and *Heart Rate*. The *Recovery Index* is represented by two numbers i.e. 60/100. The left number represents *Stress* reactions with the right number representing *Recovery* reactions.

Athletes need to measure their own individual baseline values at rest and compare subsequent values against the baseline figures.

What is a Heart Rate Variability Index?

Another useful tool for detecting recovery is the *Heart Rate Variability Index*

This is a single number and reflects the slowing down of the heart. The index can be used to detect recovery from an overnight recording. A high index figure represents increased recovery and a low value poor recovery.

During the day the value should be at least 15 but normally over 25. During the night the value should be at least 50 % higher (20-30) although athletes can have a value of several hundred (athlete above is 100 +). These limits are just guidelines; medication, heritage and training status also influence HRV level. Research indicates that these limits may be associated with burn-out.
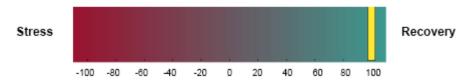
As with the *Recovery Index* an individual baseline *Heart Rate Variability Index* value would need to be established for comparison purposes.

Example

The ratio for this athlete is 42/100 and represents full recovery. For this athlete normal 100% recovery is 40-110

	Average	Range	Duration	Proportion
Stress	42	23 - 128	0 min	0 %
Recovery	109	69 - 134	3h 22min	95 %

Intensity and proportion of stress and recovery during the selected time period.
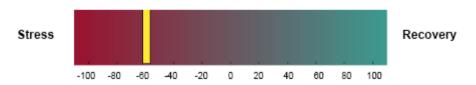

Stress and recovery index from the **selected time period** is 100.

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During a period of high stress for a different athlete a ratio of 117/74 represents under recovery. For this athlete normal 100% recovery range is 60-100

	Average	Range	Duration	Proportion
Stress	119	47 - 342	3h 8min	78 %
Recovery	74	46 - 93	48 min	20 %

Intensity and proportion of stress and recovery during the selected time period.

Stress and recovery index from the **selected time period** is -59.
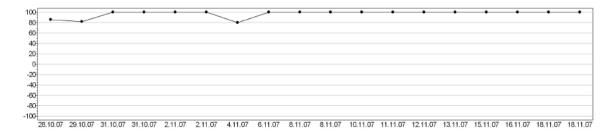
Tracking the Recovery Index

There are some endurance athletes whose heart rate level is so low during the night that despite the changes in **HF** and **LF** levels the night recording appears to show mainly recovery reactions.

The overall index may indicate 100% recovery when the underlying values show under recovery. It is important to get a reference level by measuring athlete specific baseline values in a rested state and comparing future results to the baseline figures.
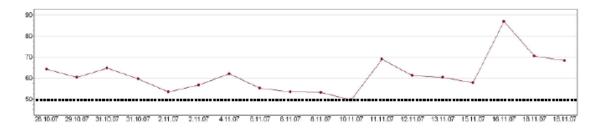
In the example below note 100% recovery during the period 6/11/2007 to 18/11/2007.

Baseline resting values for this athlete 50 (stress)/115 (recovery)
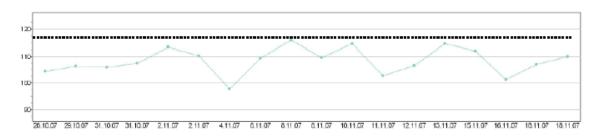

By looking at the individual figures for stress and recovery the true extent of stress or recovery can be determined and compared against baseline level.

The intensity of the stress reactions

The intensity of the recovery reactions

Normally when recovery increases, stress level decreases and vice versa. It will be noted that although the overall index shows 100% recovery for the 16/11/2007 the **Recovery Index** is approximately 85/100 which when compared against baseline 50/115.
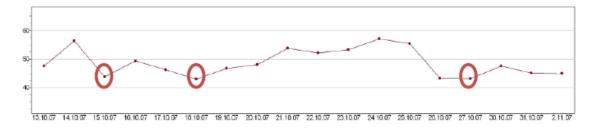
The Questions
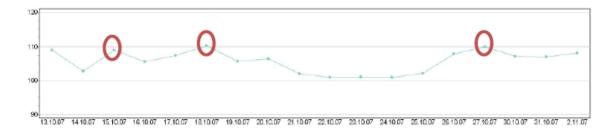
Am I fully recovered?

More precise answers are obtainable with a long measurement history.

In this example the days when the athlete is recovered are marked on both the **Stress** and **Recovery** follow-up charts.
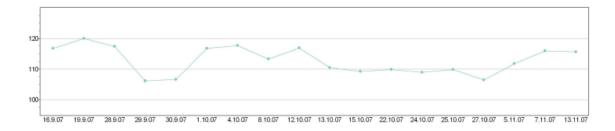
Stress reactions:

Recovery reactions

Am I tired but training can continue? Am I tired and must rest?

These are the too hardest questions to answer and this is where the experience of the athlete and coach in using the **Recovery Index** is important. When the goal is to train hard and upset the body's homeostasis the stress level should increase and recovery decrease.

In the charts above the hard training period was 18/10/07 – 25/10/07 (8 days). Based on the rate of recovery (recovery occurred within two days - see **Recovery index** 27.10.07) the overreaching period was successful.

The chart below is another athlete training at high altitude 12/10-07 – 27/10/07. The last measurement was 25/10/07. The recovery level was below baseline value all the time and the athlete reported subjective feelings of "big fatigue". This 15 days hard training period without any easy days may have been too long. Time to reach baseline values after the training period took 10 days (recovery occurred 07/11/07).

When will I know I can train again?

After ending the last hard training period, the recovery level should be measured daily to see when the baseline values are reached again. In the example above, the new training period could be started on 07/11/07 or later.

Conclusion

Measuring recovery is a vital component of any training programme if an athlete is to maintain optimum training and race performance. **'Listening to your heart'** must become normal practice to avoid deterioration in performance, illness or injury.

More information

Coaches and Athletes are referred to the following articles by Eddie Fletcher for more detailed information

Peak Performance Issues:

- 237 Heart rate variability – what is it and how can it be used to enhance athletic performance
- 246 Using HRV to optimize rest and recovery
- 253 Duration-intensity-recovery: a new training concept

Also see www.fletchersportscience.com for further reference articles

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