Using Heart Rate Variability to Help Your Athletic Performance

By Paul Montgomery and Ben Wisbey

One of the great unknowns in endurance training is how to monitor fatigue so that training load can be adjusted to achieve the desired results. How often have you wondered if you should be doing that quality session today despite being a bit flat? How often have you thought 'Am I fatigued or just lacking motivation'?

In order to get optimal adaptations from your training, fatigue is something that needs to be taken into consideration when deciding whether to continue to apply training load or back it off. There are times when fatigue is expected and even required to get the required gains, but there are also times when excessive fatigue will limit the effect of your training session. Having the ability to know this adds a new dimension to training, allowing you to control your training load in order to achieve the desired outcome.

Resting heart rate (RHR) has long been used to give a guide to fatigue state. However, with so many external factors easily able to affect RHR, more effective and reliable methods have been developed. For endurance athletes, a morning orthostatic HR test can be used to monitor RHR, heart rate variability (HRV) and HR response to posture change. Over the last ten or more years many methods have been used to analyse orthostatic HR recordings, with mixed success. Only recently has a method of analysis been used effectively to track recovery and fatigue in elite athletes

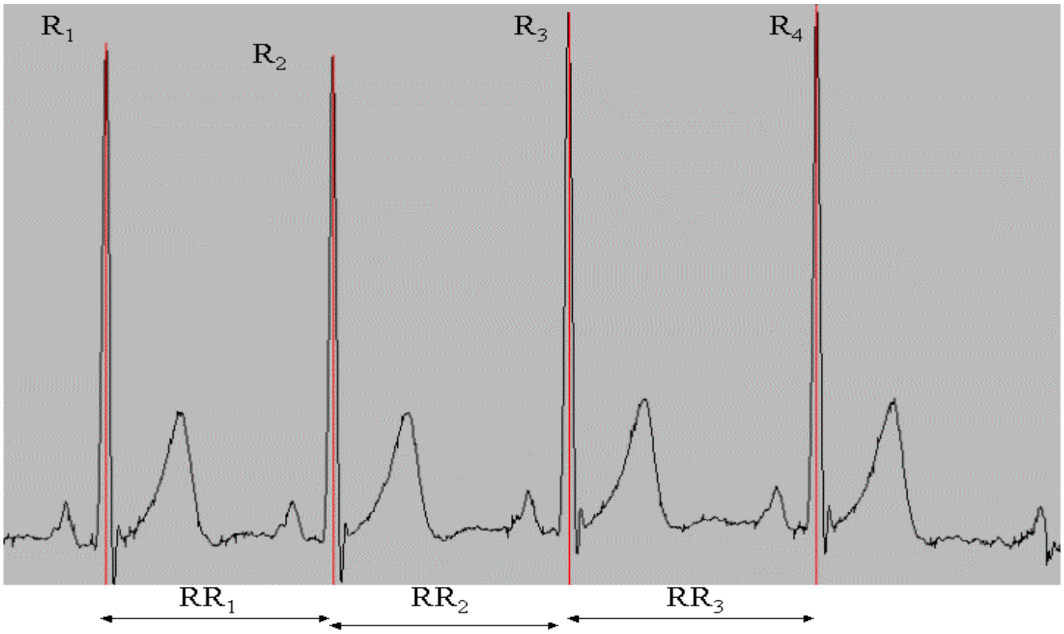
What is Heart Rate Variability (HRV)?

Have you ever wondered what controls heart rate?

We know that heart rate (HR) increases when we exercise, because the heart pumps faster to supply oxygenated blood to the active muscles. But underlying this is the autonomic nervous system (ANS), which plays a direct role in speeding up and slowing down HR. There are two branches to the ANS that influence HR; the sympathetic nervous system (SNS), responsible for speeding up heart rate, and the parasympathetic nervous system (PNS), responsible for slowing HR.

Following long term training, lower resting and exercising HR’s are observed, and most often an increase in heart rate variability (HRV) measures.

Heart rate variability is measured as the time between beats, or the RR interval. The RR interval comes from measuring the time points in milliseconds between beats indicated during normal cardiac rhythm (see below). However, during periods of excessive training the SNS can be over-active as the body responds poorly to recovery, resulting in an elevated resting HR.



Beat number *i*	Time of occurrence of the R peak, R_i	RR-interval, R_{i+1}-R_i
1	0.200	
2	1.060	0.860
3	1.942	0.882
4	2.843	0.901

Orthostasis/orthostatic test

Orthostasis means upright posture, and the change in posture causes a change in blood pressure. Standing upright quickly means the heart has to beat faster to maintain the output of blood required by the brain, otherwise we would faint.

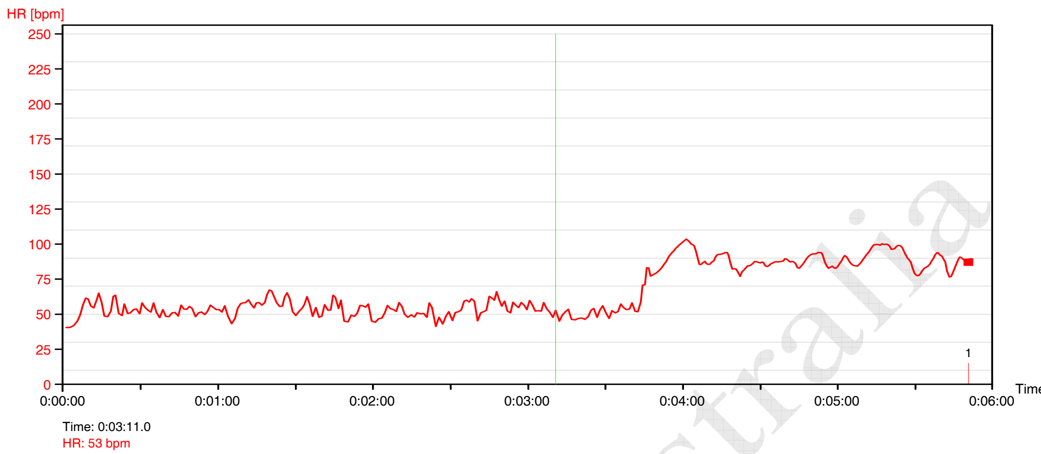
An orthostatic test is a reliable test of assessing HRV in athletes, as it combines the resting heart rate with the interaction of the SNS upon standing.

Heart rate and HRV parameters have a normal circadian variation of 24 hours. This is one reason why measurements are recommended to be repeated at about the same time every day.

To perform the orthostatic test, you will need to be as relaxed as possible, so going to the toilet first is a good idea! To control the influence of external factors, we recommend the measurements be repeated in the same place. As the previous meal, alcohol, caffeine and drugs also influence the results; a good way to control these factors is to take the measurements in the morning soon after awakening and before breakfast.

With the HR receiver set to record RR intervals, collect data for a 3 minute lying down period. When this period finishes stand upright immediately and stay as still as possible for a further 2 minutes while continuing to record the RR intervals. Stop recording.

The graph below displays the output when downloaded.



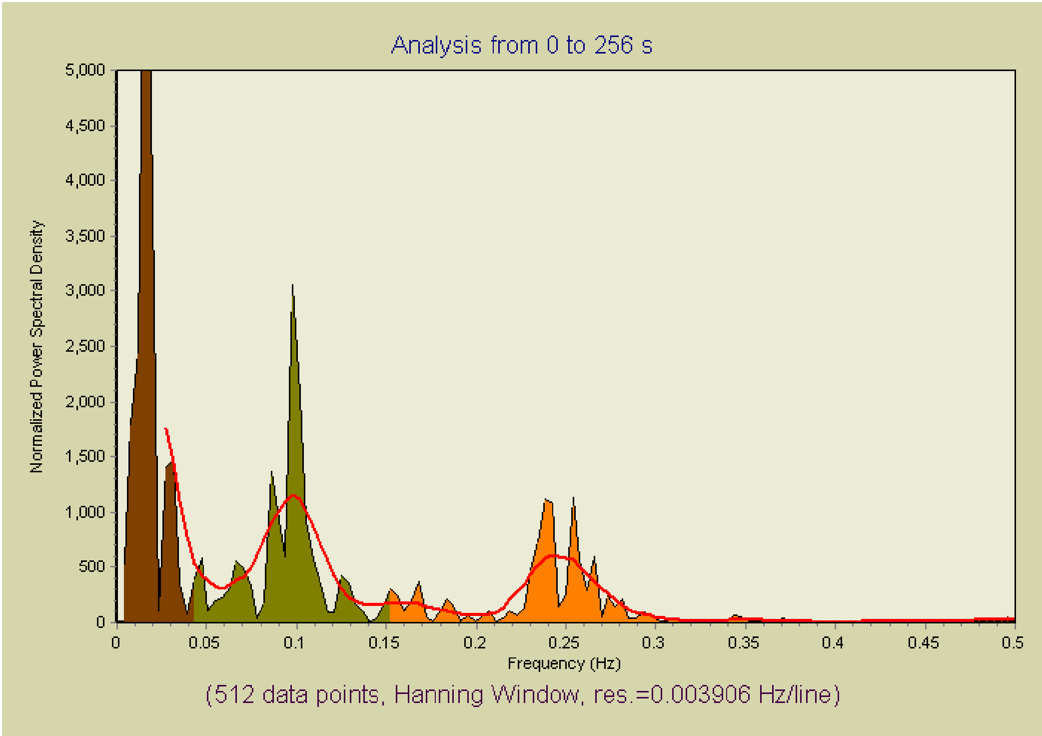
The lying period is believed to be dominated by the PNS with SNS withdrawal, but when we stand quickly, the SNS must snap into action to compensate for the change in blood pressure and redistribution of blood volume. What this means for us is that we can measure the input from the ANS during the overall period, and track the changes over a training cycle.

How information is analysed

The information from the orthostatic test can then downloaded into purpose built software for analysis. The software uses a fast Fourier transform and a power spectral density analysis to describe how the power (or variance) of a time series is distributed with frequency (cycles/second).

The software then breaks the information down into the contribution from the SNS and PNS. This is determined by breaking the frequency of the cycles into low (SNS), and high (PNS) as per the graph below.

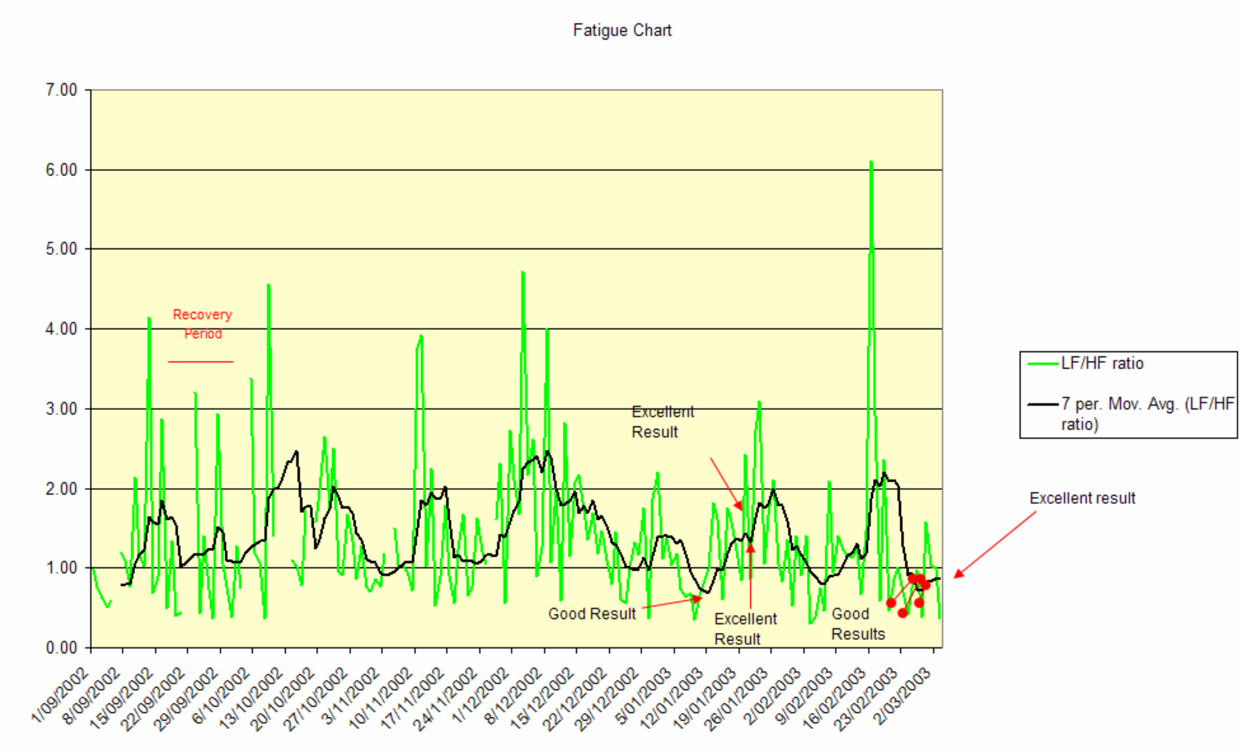
By observing the ratio of low frequency (LF) to high frequency (HF) we gain an indication of the status of the ANS in relation to fatigue and freshness.



What does this tell us?
What this means for the athlete is that they can have ready information about their training status, with respect to how their body is responding. This information can be used to adjust the current days training load to suit the level of fatigue the athlete ordinarily would not know they are experiencing.

The system is so sensitive that it can reveal periods of anxiety and restlessness, which are driven by the SNS, which can impact on the athlete's performance in training or competition. This is important because all too often athletes will train through periods of staleness (over reaching/overtraining) leading to poor performance or illness. With this system training can be adjusted to suit individual training needs.

Methods of Analysis
The information from each day is then graphed (as below) to create an overall picture of ongoing training stress. The fatigue chart not only includes day-to-day fluctuations in fatigue, but more importantly a rolling average that can be used to gain an idea of overall fatigue. This rolling average minimises the impact of one single day of training, and focus's on the cumulative effect. This is very useful in predicting racing performance as can be seen in the chart below. Obviously the athlete was in good form during the last few months of monitoring, as a general trend emerges with the 'excellent' results occurring as the fatigue ratio begins to rise after a recovery period. This indicates SNS activation, which is required for optimal performance, and highlights the importance of creating an individual profile to establish the 'optimal' recovery and activation (training) combination leading into an event. Poor results during this period have not been highlighted but generally occurred when the overall fatigue index is high as indicated by a high LF/HF ratio.



If you require more detailed information, or have any further questions relating to heart rate variability please go to www.endurancetraining.com.au/HRV.htm or email bwisbey@fitsense.com.au