Most athletes know that getting enough rest after exercise is essential to high-level performance
- Still many over train and feel guilty when they take a day off

Continuous training can actually weaken the strongest athletes
- Rest is physically necessary so that the muscles can repair, rebuild and strengthen

Standardized training programs produce well documented results however they do not take individual responses into account
- Age, gender, race, baseline fitness level and genetic factors are known determinants of individual differences in responses to endurance training*

The status of the Nervous System is an important indicator of training response
- Nervous System measures indicate individual responses

Heart Rate Variability (HRV) is a view into the nervous system
- HRV is reflection of vagal tone which is affected by overtraining
- HRV can be used to guide an optimal training program
- HRV is non-invasive and can be measured with an off the self chest strap
What is Heart Rate Variability (HRV)?

HRV is the variation in time between each heart beat.

This illustration shows an unhealthy Heart Rate Variability with constant 1 sec intervals between beats.

This illustration shows a healthy heart rate variability with variation between beats.

This variation in time between beats is caused by a “tug of war” between the sympathetic nervous system speeding the heart up and the parasympathetic slowing it down.

HRV has been researched for more than 30 years.
The Vagus Nerve is the 10th of 12 paired cranial nerves and controls parasympathetic innervation of the heart and acts to lower the heart rate.

Vagal innervation is the mediator of HRV and therefore HRV is an indication of Vagal Tone.

The higher the HRV, the stronger the Vagal Tone.

Higher HRV is an indication of an individual's ability to “put the brakes on stress” by mediating the sympathetic control over the nervous system and heart rate.
The Autonomic Nervous System (ANS) has two branches:
- Sympathetic
- Parasympathetic

LF is the measure of the Sympathetic Branch
HF is the measure of the Parasympathetic Branch
HRV calculations are performed on the “RR interval time series”. What exactly is that?

- ECG “R” point can be thought of as the beat time
- The R-R interval is the time between beats

The resulting “RR interval time series” looks something like this:

0.978516
0.982422
1.06641
1.06738
0.974609
1.05273
1.08887
0.974609
0.961914
1.04688
1.02734
HRV Can Be Measured in Multiple Ways

- **Statistical Analysis**
  - Standard Deviation (SDNN)
    - RR intervals have also been called NN intervals which is why SDNN instead of SDRR
  - Root Mean Square of Successive Differences, (rMSSD)
  - pNN50, TINN, Triangular index

- **Frequency analysis**
  - Very Low Frequency (VLF)
  - Low Frequency (LF, associated with sympathetic activation)
  - High Frequency (HF, associated with parasympathetic activation)

- **Non-Linear:**
  - SD1/SD2, ApEn, SampEN
**HRV Parameters of Interest: rMSSD**

- rMSSD is a reflection of Vagal Tone
  - rMSSD is non-stationary and varies +/- 10 ms at rest
  - Average rMSSD ranges from ~20ms to ~80ms depending on age and state of health
  - Generally calculated on 5 minute window
    - SweetBeatlife uses 3 minute window per customer requests
  - Used in clinical research for HRV and performance training
- Most consumer HRV applications provide a number 0-100 based on rMSSD
  - Each application uses a slightly different scaling algorithm so it is important to choose one and stick with it
- A high HRV (rMSSD) is an indication of health and training recovery
HRV Parameters of Interest: LF, HF

- LF is associated with sympathetic nervous system
- HF associated with parasympathetic nervous system
- There are industry standards for LF and HF frequency ranges
  - LF = 0.04hz - 0.15Hz
  - HF = 0.15hz – 0.4hz
- LF and HF units are Power
  - Power represents “amplitude” of electrical impulses flowing through nervous system
- LF and HF Ratio is another standard of measure
  - LF/HF < 2 is indication healthy stress levels
HRV is an indication of your resilience – the ability of the nervous system to **respond** and **recover** from physical or psychological stressors.

**IMPORTANT**: HRV values depend on length of measurement

- 5 Minutes = Short term HRV
- 24 Hour = Long term HRV

**IMPORTANT**: HRV is age and gender dependent

HRV has a circadian rhythm

HRV may change day to day with your biorhythm or due to emotional or physical stress

Chronic low HRV is an indication of systemic health (psychological or physical) issues
SweetBeatLife features used by coaches and trainers

- HRV for Training Feature
  - Coach provides specific Instructions of how and when to take reading

- Stress Monitoring
  - Daily stressors also affect performance
  - Usually includes stress awareness and reduction techniques
    - Breath work
    - Meditation/Yoga

- Heart Rate Recovery
  - Another measure of ANS flexibility

- Food Sensitivity
  - Nutrition and inflammation interact negatively with cortisol and adrenaline
HRV for Training: When and How to Measure

- **HRV has a circadian rhythm**
  - [Graph showing circadian rhythm]

- **HRV is dependent on body position**
  - [Images showing different positions: lying down, sitting, standing]
  - Measurement for same length of time each day (3 minutes typical)

- **HRV value is dependent on length of measurement**
  - First thing in the morning while lying in bed is recommended
  - Try to keep a blank mind. Thoughts about a busy day can affect the reading

- **HRV taken at same time each day**
  - In same position
    - Lying down
    - Sitting
    - Standing
  - Measurement for same length of time each day (3 minutes typical)
HRV for Training Example

Ben G.

Low Exertion Day Recommended

Good Recovery Proceed or Increase

Good HRV Proceed with training

Low Exertion Day Recommended

Rest Day Recommended
Guided Training Flow Chart Example

Source: Endurance training guided individually by daily heart rate variability measurements. Kiviniemi et al. 2007
There are multiple ways for coaches/trainers to access data

- SweetBeatLife now works seamlessly with Restwise recovery program
  - HRV and Resting Heart Rate automatically entered into Restwise when SweetBeat session is uploaded
  - HRV may be displayed in relation to recovery score and any of the other RestWise metrics
- Login to MySweetBeat to access SweetBeatLife session summaries
  - Create client accounts/share login credentials
- Add to notes section in Training Peaks
- Email Screenshots
  - Clients take a screenshot of their SweetBeatLife summary screens
  - Client emails screenshot of graphs or sessions summaries to coach
- Download client sessions and view in SweetBeatLife
  - Within app, login as client and download sessions
There are 4 major HRV metrics to consider

- **rMSSD/HRV**
  - “HRV” is derived from rMSSD -> 0-100 values easier to understand than raw rMSSD
- **Stress level** -> derived from LF/HF and represents the balance of the nervous system
- **LF Power** -> represents the sympathetic or “fight or flight” response
- **HF Power** -> represents the parasympathetic or “rest and repair” response

**IMPORTANT** – In order to meet the accepted definition for “Short Term HRV”, SweetBeatLife algorithms operate on a 5 minute window. While rMSSD/HRV settle down in 3 minutes, LF and HF do not!

- **When evaluating LF and HF, a minimum of 5 minutes is required**
HRV can vary greatly from person to person depending on health and fitness

HRV can vary greatly for an individual from day to day and even hour to hour

While there are “average HRV values” determined through clinical research, HRV is dynamic and individuals will tend to have their own range

Some athletes have HRV values that are magnitudes higher than average persons

Some healthy and fit athletes may have values at the high end of average

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Average HRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>10-29</td>
<td>72.29827</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>67.68875</td>
</tr>
<tr>
<td>Male</td>
<td>30-49</td>
<td>62.51162</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>60.47521</td>
</tr>
<tr>
<td>Male</td>
<td>50-69</td>
<td>52.91486</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>55.733</td>
</tr>
<tr>
<td>Male</td>
<td>70-99</td>
<td>52.91486</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>52.91486</td>
</tr>
</tbody>
</table>

Source:

Values based on 24 hour measurements

HRV represents rMSSD scaled to a value between 0 – 100 and is SweetBeat specific
Healthy vs Un-Healthy Variations

- Through time you will start to see the individual range for each client
  - The following graphs indicate healthy and expected variations of HRV
  - This range may trend down by 10% during heavy training
  - Average stress is “yellow” with sensitivity setting = 5 (LF/HF avg <1.5)

- Red Flag Warnings
  - Established normal range drops more than 30% and becomes the new norm
  - HRV < 50 (rMSSD < 20) consistently
  - LF, HF < 100 – consistently *
  - LF/HF > 10 consistently * = chronic stress, lack of sleep or other
  - NOTE: Sessions are run while supine or sitting, NOT during exercise

* Minimum session length = 5 minutes
*HRV measured using SweetBeat
*HRV measured using SweetBeat
LF vs. HF Elite Athlete

Day of first race high cortisol measure day before

Tuesday after race high cortisol measured

LF vs. HF Elite Athlete
LF vs. HF Fitness Enthusiast
For those who want to Geek Out further…..

- Plot LF, HF, rMSSD for any given session in Excel
- You will need the data from SweetBeatLife
  - From session summary select Share -> Email
  - 2 Files will be emailed, 1 will contain the rMSSD, LF, HF, HealthPatch metrics

For even more geekiness…….

- Download Kubios for free [http://kubios.uef.fi/](http://kubios.uef.fi/)
- You will need the RR intervals from SweetBeatLife
  - From session summary select Share -> Email
  - 2 Files will be emailed, 1 will contain RR intervals
  - Follow these instructions for preparing RR intervals for import to Kubios
- Inflammation is a common reaction to a hardcore work out and is part of the recovery process.
- Inflammation is an innate response to stress, illness, poor gut function or eating toxic foods.
  - Stress increases cortisol which contributes to inflammation.
- What causes stress for one person will not cause stress for another.
  - Same thing goes for food.
  - Individuals need to track what works and doesn’t for them.
- Interdependence of our body functions make it complicated.

Source: http://robbwolf.com/2012/04/09/real-deal-adrenal-fatigue/
When this response becomes the norm for your body, whether it is from workouts, stress or food, it becomes a low-level feature in your physiology:

- Mild, chronic, inflammation produces few symptoms and subtle changes on blood tests, though has a very different effect on your metabolism.
- Chronic low-grade inflammation makes your brain and body resistant to the normal regulatory effects of hormones, including insulin and cortisol.
- It interferes with recovery and thus optimal performance.

It is recommended that stress and diet be monitored in addition to HRV for optimal performance.

Source: http://www.integrativepsychiatry.net/adrenal_fatigue.html
Future Coaching Packages

- SweetBeat and SweetBeatLife now work seamlessly with Restwise recovery program
  - HRV and Resting Heart Rate automatically entered into Restwise when SweetBeat session is uploaded
  - HRV may be displayed in relation to recovery score and any of the other RestWise metrics

- We are working with TrainingPeaks to automatically upload HRV
  - Write them asking for SweetBeat support
  - Cast your vote for HRV to TrainingPeaks

- Write support@sweetwaterhrv.com to request your training site