# Consumer Near Infrared Spectroscopy as a Training and Recovery Tool

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# Outline

- What is NIRS?
- Devices
- Data interpretation
- Practical Application
- Future Impacts

# *Disclaimers*

- **Suffix “light”**
- **Moxy “expert retailer”**
- **Missing Link to practical application for endurance sports**
- **Basic power graph knowledge needed for presentation**

# NIRS

- **Near-infrared spectroscopy (NIRS) is a spectroscopic method that uses the near-infrared region of the electromagnetic spectrum *(from about 650 nm to 2500 nm).***
  - ***1950's Early Industrial Applications with UV and Mid-IR spectrographs***
  - ***1980's First stand alone devices***
  - ***1990's Improved technology allowed for scientific/medical application***
  - ***Current Research***

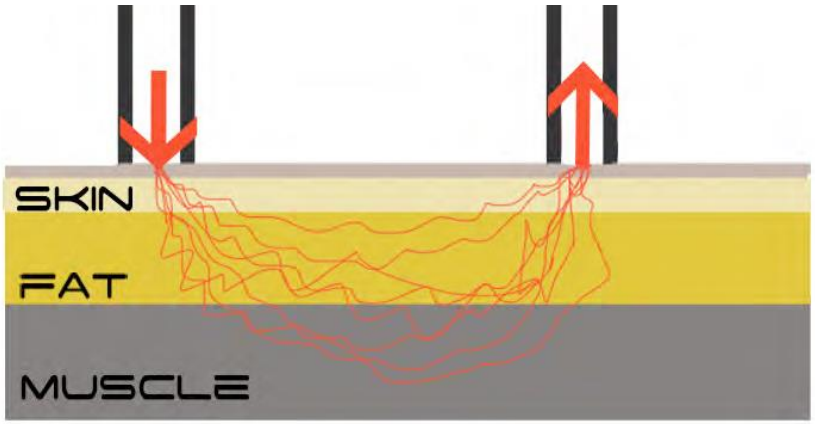
# Medical to Consumer

-NOT useful in the field


- Getting there…

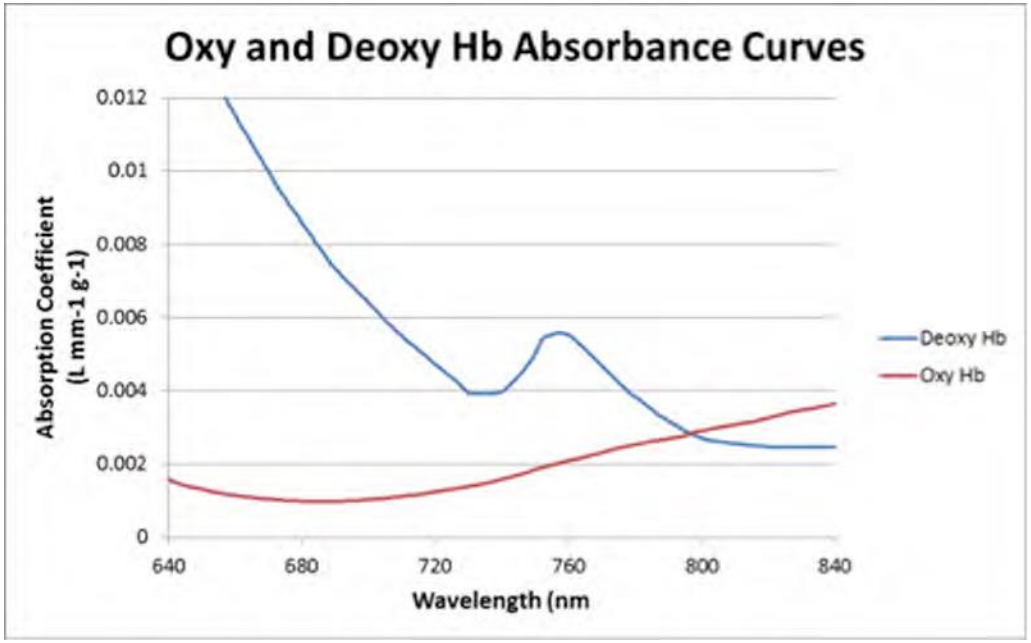
-Field unit for the consumer


# MOXY NIRS Method




- LEDs fire in rapid sequence into the tissue at one location and then is detected at two locations *(670 to 810 nm)*
- Light scatters in all directions, and the vast majority of it is lost
- Light intensity is recorded simultaneously at each of the two detectors.
- Calibration of the Moxy device is based on a mathematical model of how light propagates through tissue

# Wearable NIRS Method (cont)




**Using Beer-Lambert Law, Deoxy Hb and Oxy Hb measurements calculate outputs:**

- **Muscle Oxygen Saturation (SmO2)**
- **Total Hemoglobin (THb)**

# Lab Unit Variation

- Programmable variables
  - Wavelength, Frequency out/in, outputs, ETC
- Calibration
- *Potential* Accuracy
- Expense
- Sunlight complications

# Current Wearable Devices

## MOXY Monitor

- 1 year in Production
- Limited device issues
- Onboard Storage
- ANT+
- .CSV Export (.FIT tbd)
- Algorithms for Muscle Oxygen and Total Hemoglobin

***Double Moxy Race Data***

# BSX Insight

- BSX Insight
  - Ships December
  - Benchmark device using GXT protocol
  - Data Analysis on Train BSX website
  - No raw data export
  - Algorithm for Lactate Threshold

# MOXY Biometric Data Basics

## THb

- Provides information on Intramuscular Blood Flow
- Can be affected by Temperature
- Mechanical changes
  - Occlusion (Vascular, Arterial)
- Systemic changes
  - Cardiac Output
  - Shunting extremities to supply vital organs

## SmO2

- Percentage of THb that is bound with O2
- Provides information on O2 utilization by muscles
- Lower SmO2 = Greater Utilization
- Can be impacted by
  - Load (power output)
  - Mitochondrial density
  - Fatigue
  - Fueling

# SpO2 vs SmO2

*Apples vs Oranges*

**SpO2**

- Pulse oximetry results
- Direct pass through light measurement
- Drastic changes in respiratory system to elicit SpO2 changes
- Systemic ONLY

**SmO2**

- Intramuscular results
- Dynamic data
- More applicable to endurance sports

*Quick Questions thus far??*

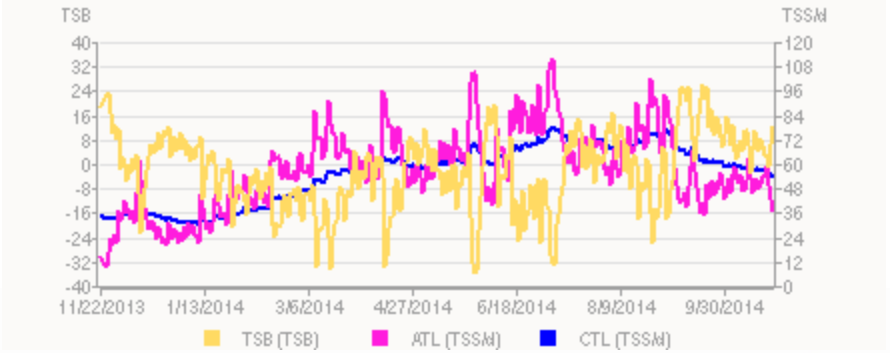
# Initial Practical Application Notes

## -Moving from the Lab to the Field

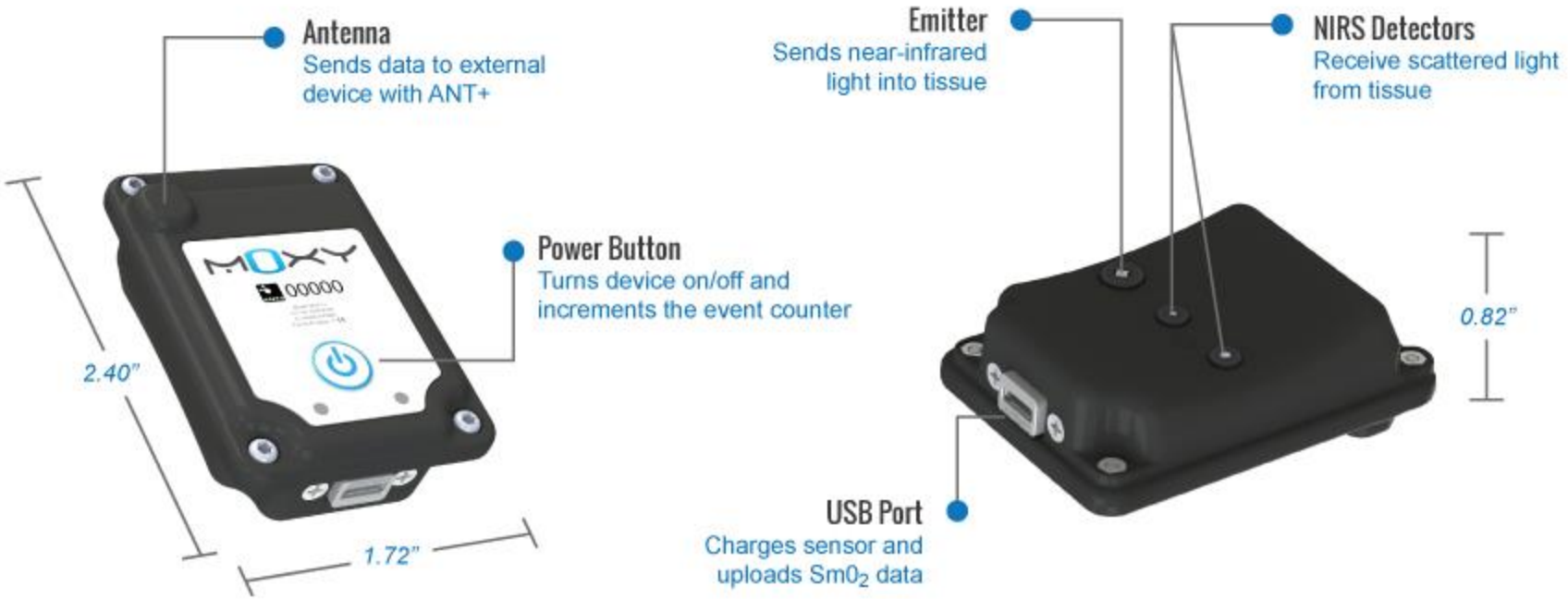
- Similar to complications of moving power measurement from lab to field
- Trial/Error
- Early in development

## - Current Hurdles

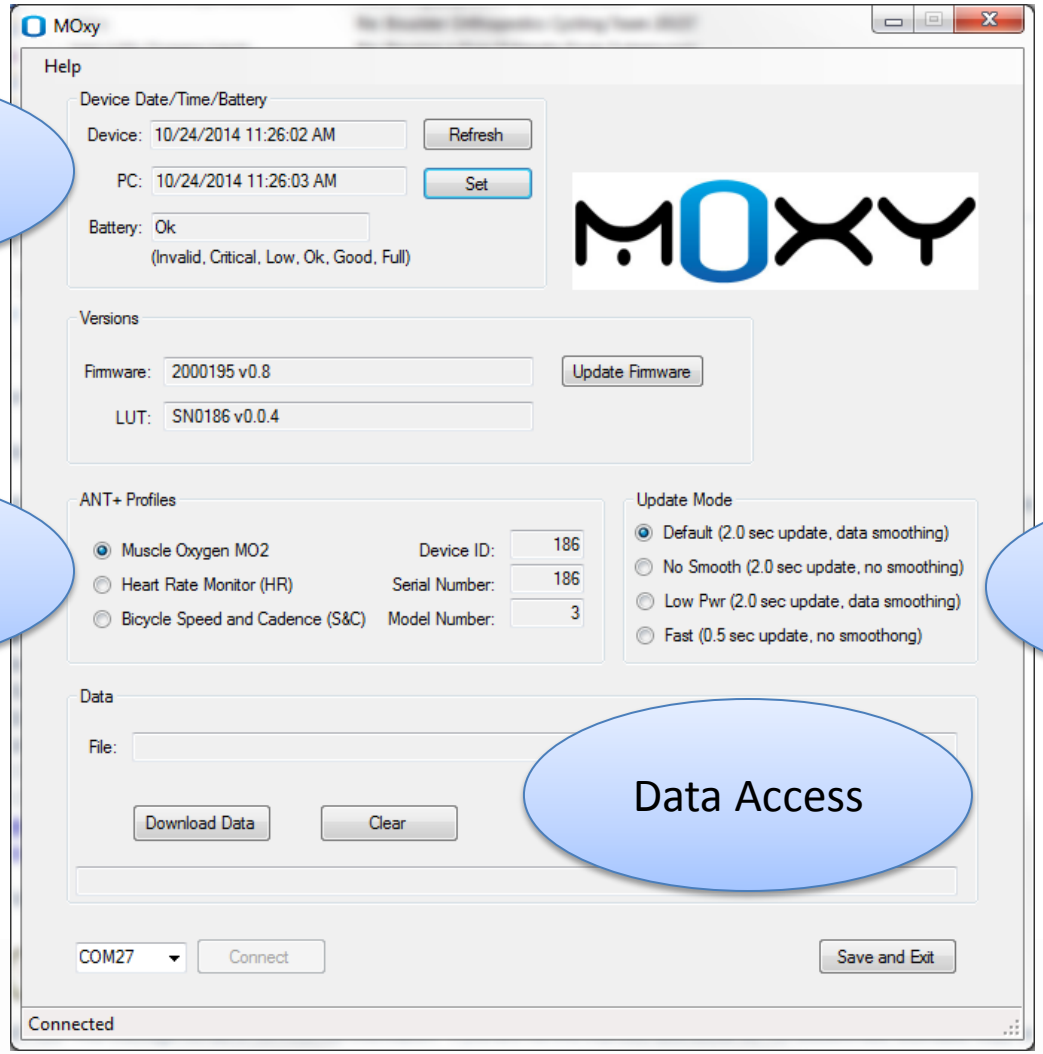
- Established Methods
- Combined data collection
- Analysis Tools
  - Training Peaks
  - Golden Cheetah
- Large Data Sets




# Moxy Unit


Antenna
Sends data to external device with ANT+
Power Button
Turns device on/off and increments the event counter
2.40"
1.72"
Emitter
Sends near-infrared light into tissue
NIRS Detectors
Receive scattered light from tissue
0.82"
USB Port
Charges sensor and uploads $SmO_2$ data

# User Interface




Time/Battery

ANT+ Signal

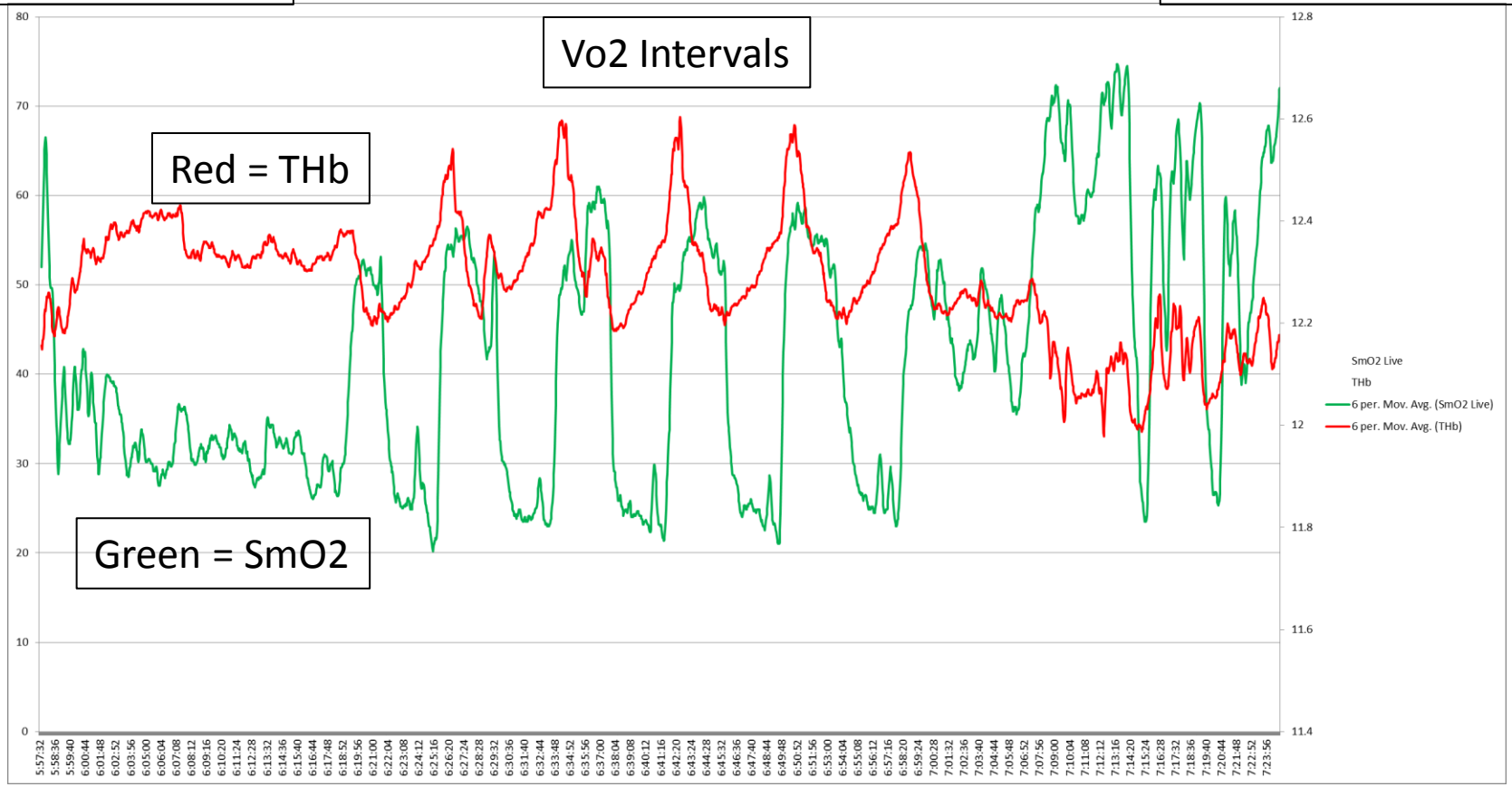
Record Mode

Data Access

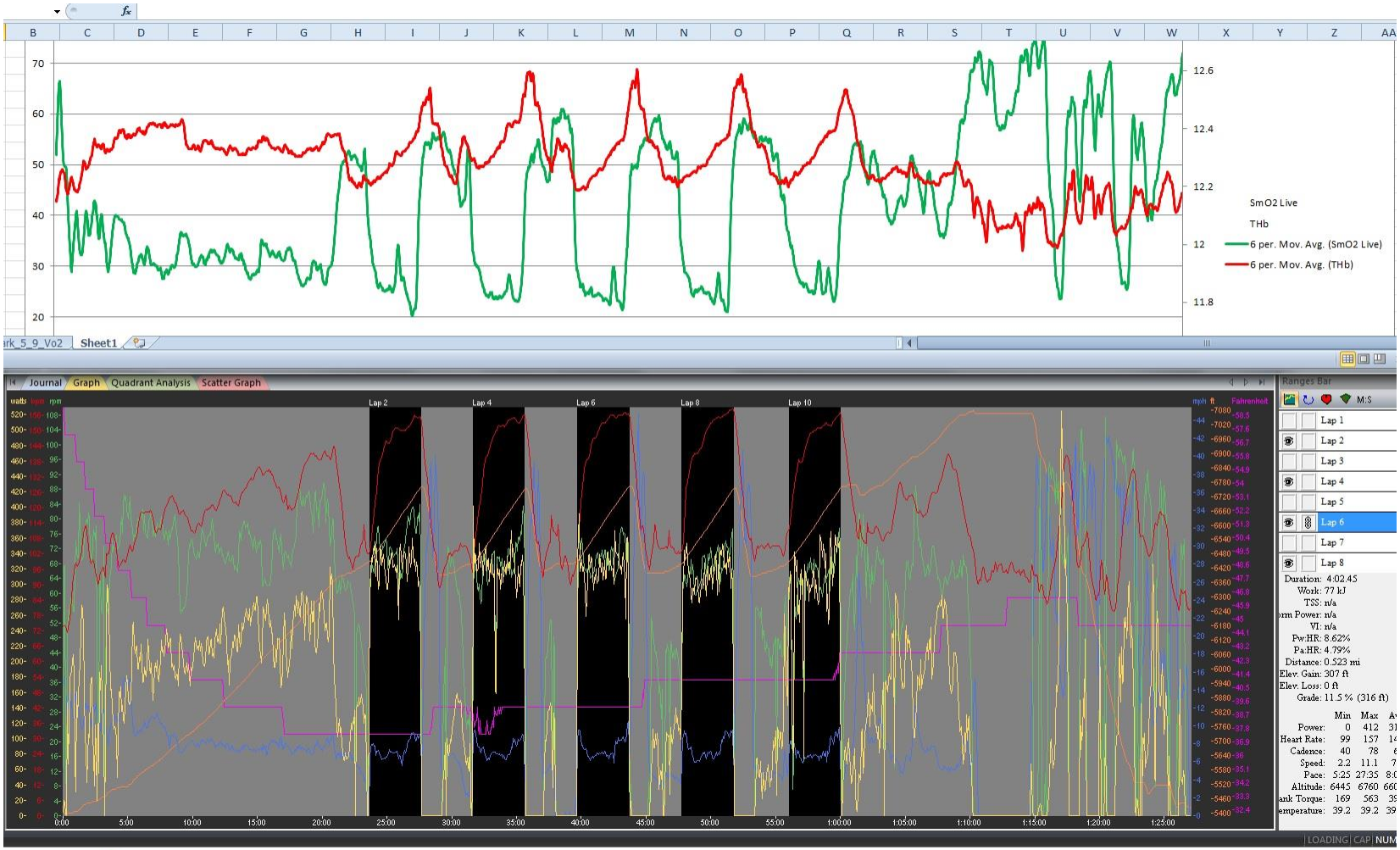
# Current Graph Basics

SmO2 Typical 0-100%

THb Typical 11-14 gr/dl




# “Combined” Graphing




# Process

- Unit operation trial/error
- Moxy “Expert” Seminar,  ANT+
- Broaden Data Collection
- Determine basic trends, continue collection
- Current Basic Summary

# Subjects


**World Tour Rider**

**31**

**12 years racing, 8 as a Professional**

**FT appx 400 W  158 BPM**

**Guy with the laser pointer**

**37**

**23 years racing, MS in getting dropped by dopers**

**FT appx 280 W  154 BPM**

**Colorado Cat 4**

**40**

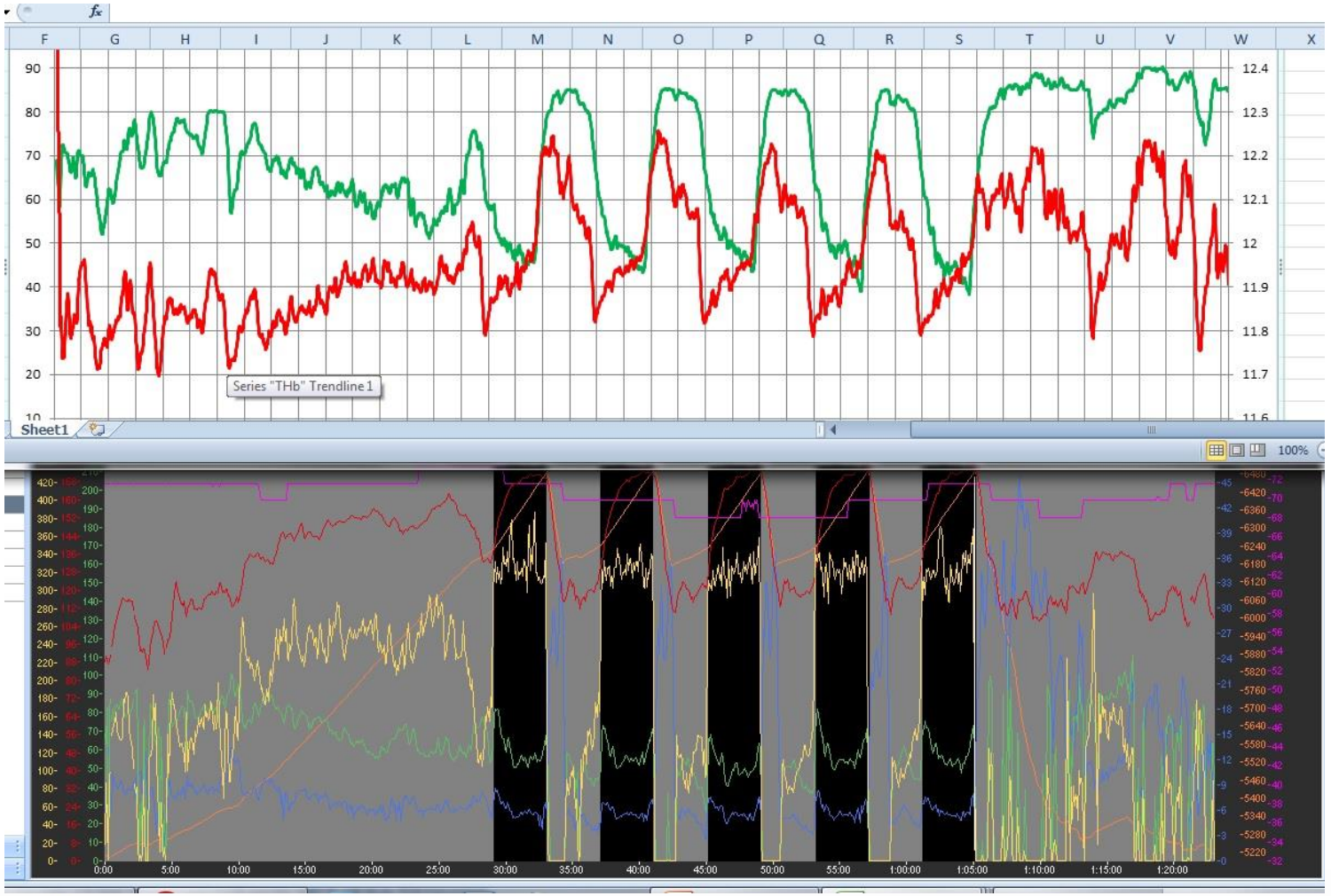
**4 Years racing, Owns a Moxy**

**FT appx  285 W  173 BPM**

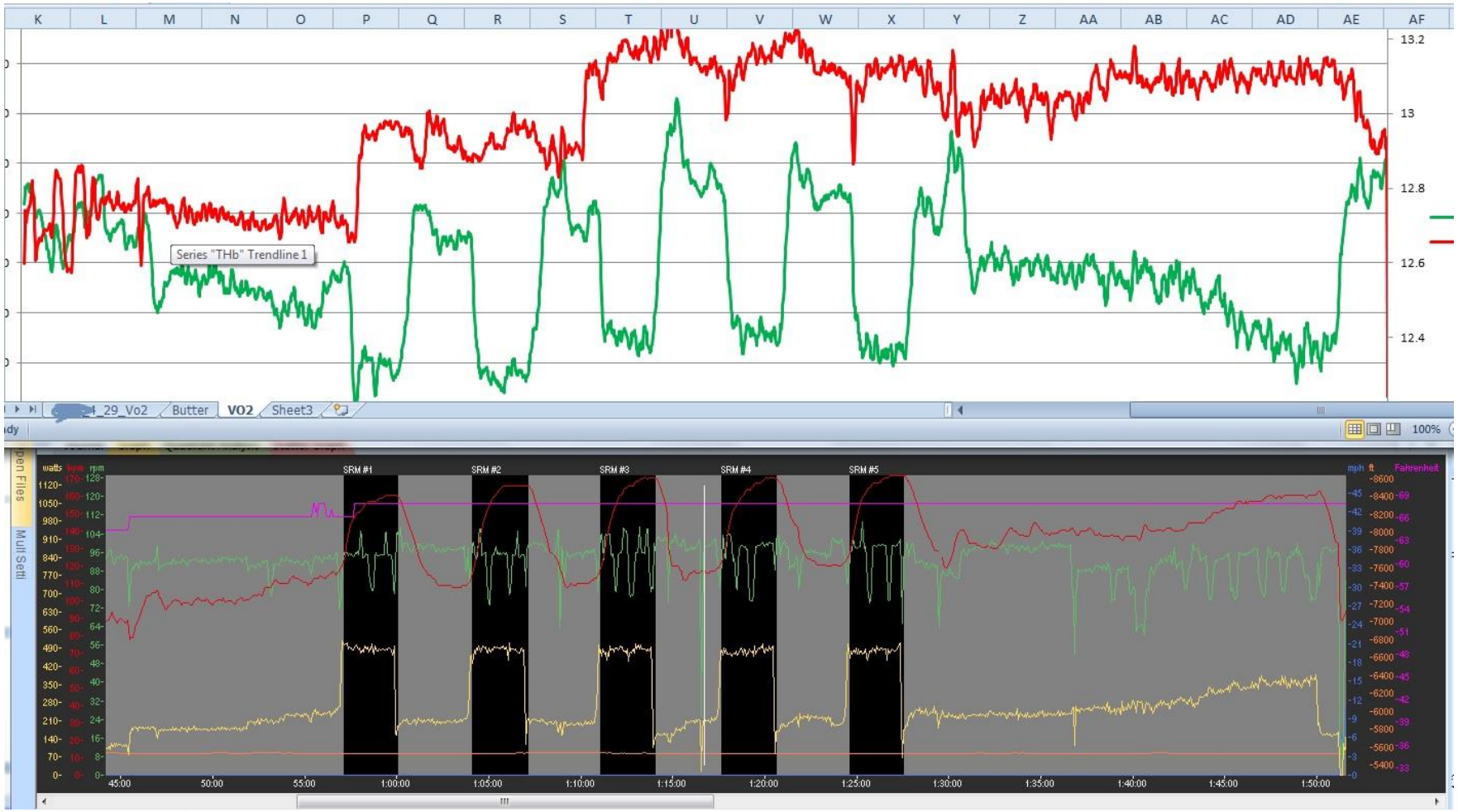
# Individuality

- Hemodynamics- Cardiac Output / Blood Flow / Circulating Volume
- Endocrine System – Multi level impact
- Extraction Variables – Mitochondrial density / Fatigue / Fuelling / Effeciency
- Temperature / Temperature Compensation
- Placement – Simple concept difficult execution
- Adipose / Tissue Variables (limited)- Thickness, Density, Hydration
- List goes on! …will grow with more field use and research

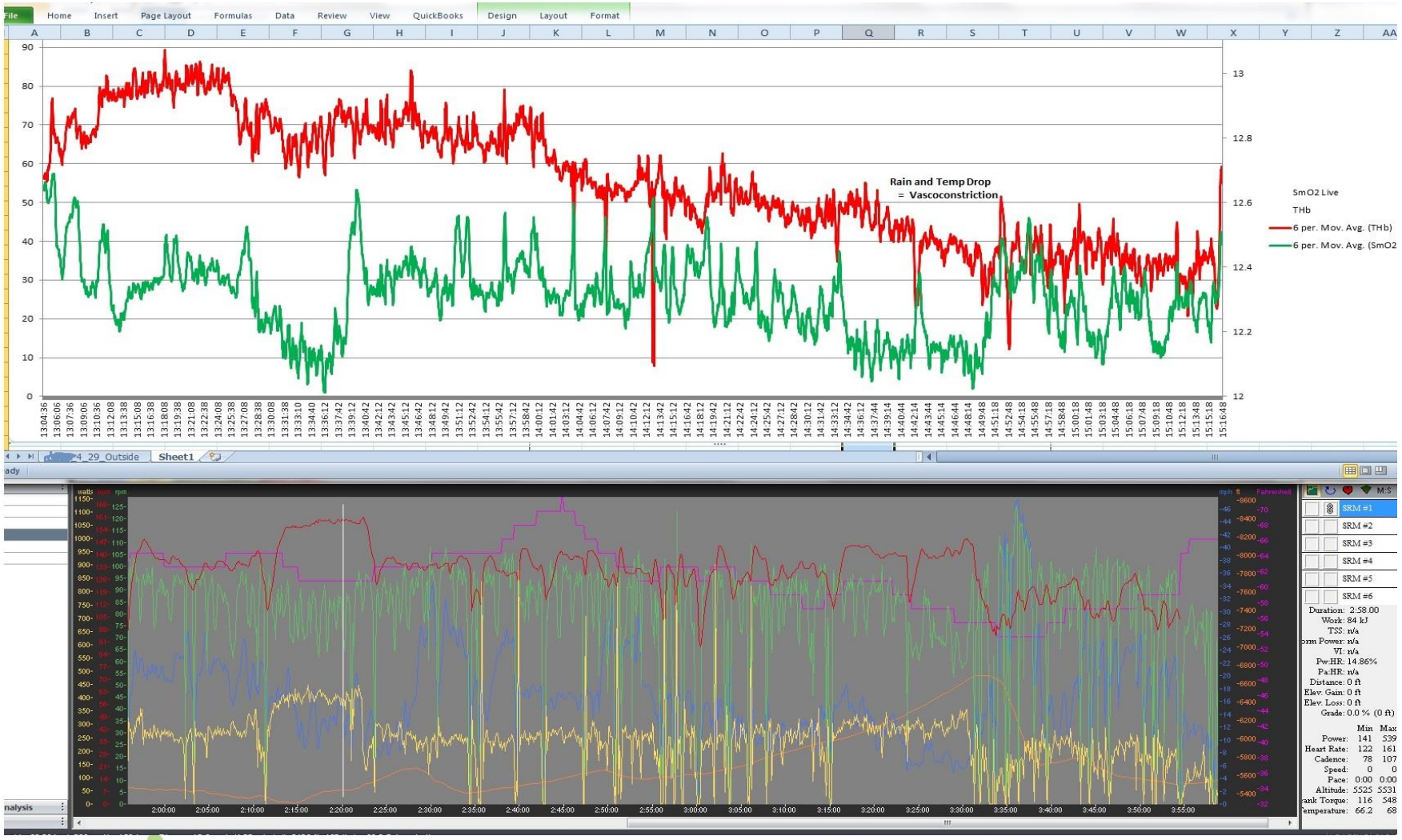
# VO2 Example 2



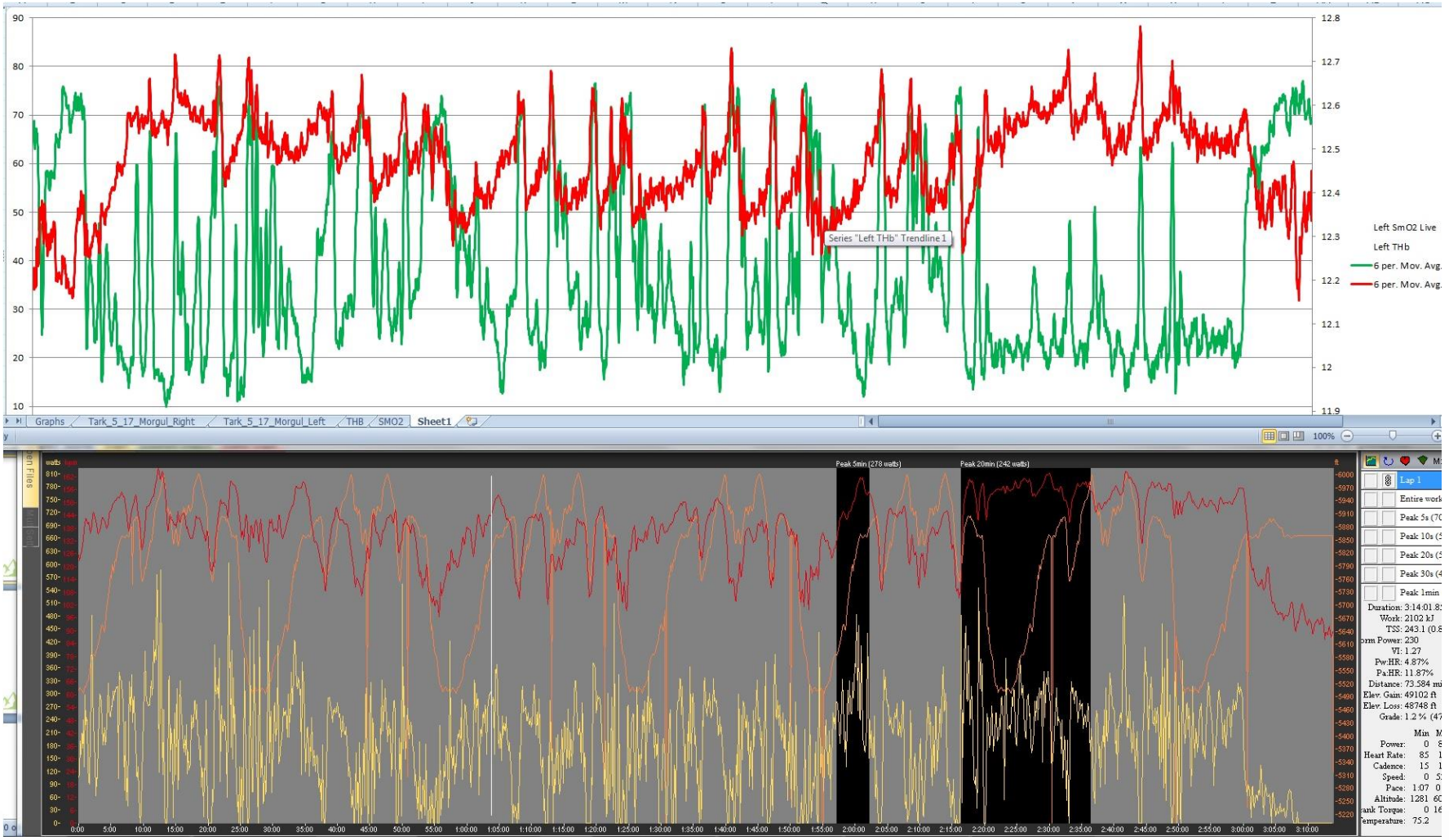
# VO2 Example 3



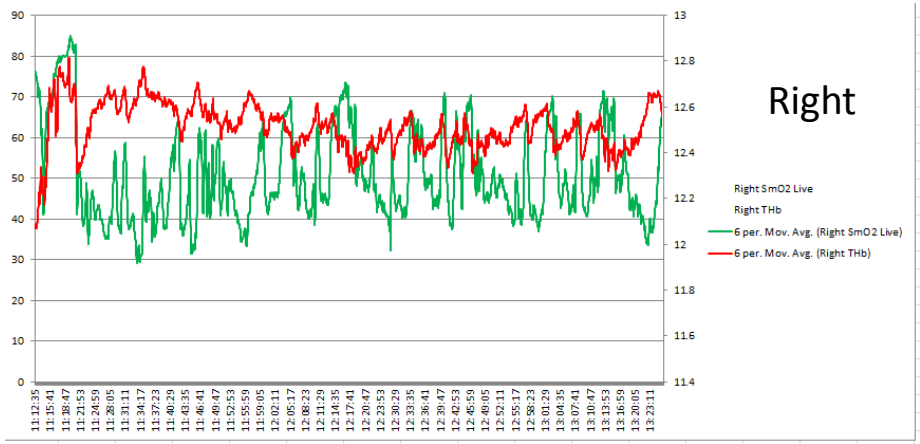

# Temperature Influence

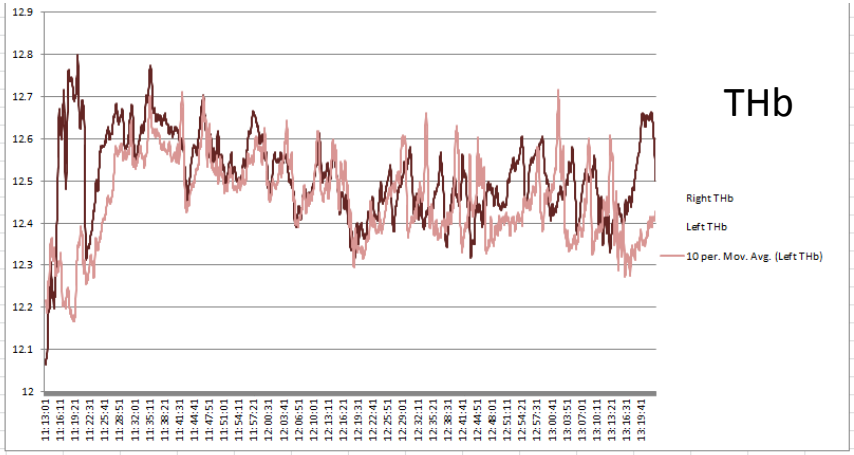


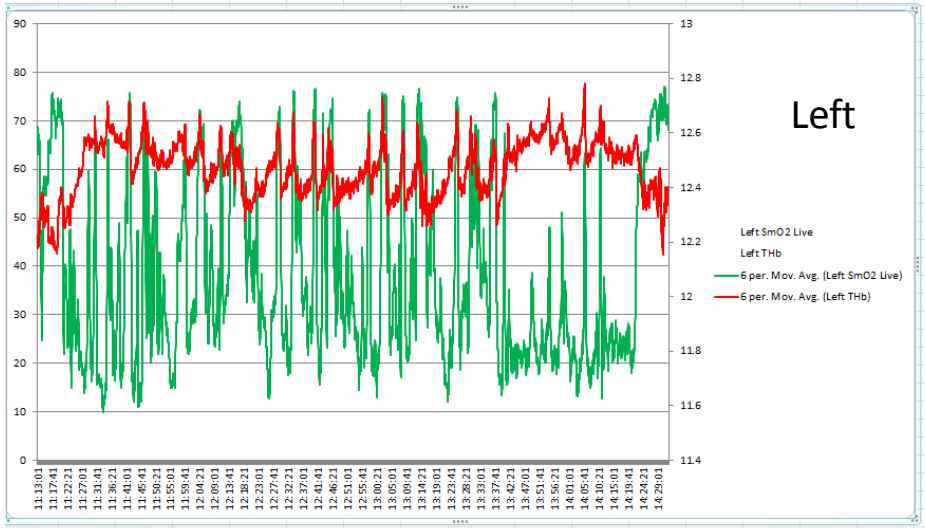
# Race Data

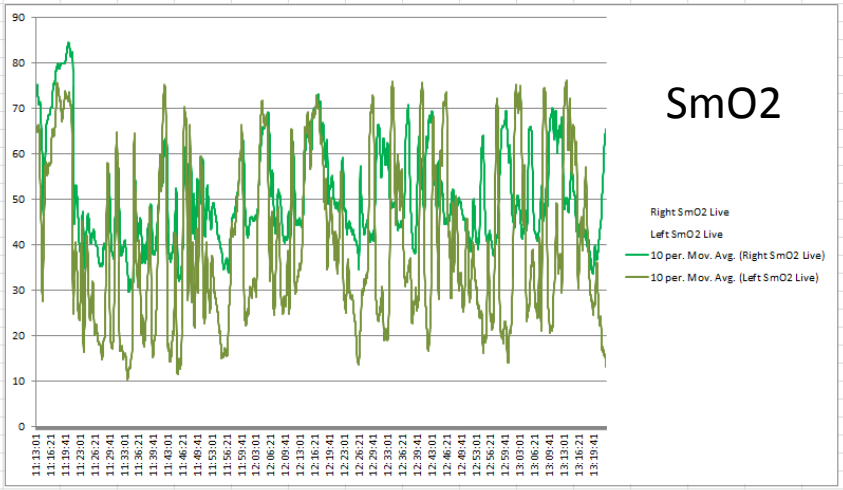

Series "Left THb" Trendline 1
Left SmO2 Live
Left THb
6 per. Mov. Avg.
6 per. Mov. Avg.
Graphs
Tark_5_17_Morgul_Right
Tark_5_17_Morgul_Left
THB
SMO2
Sheet1
Peak 5min (278 watts)
Peak 20min (242 watts)

# Placement / Execution




# Hypoxic/Hypercapnic

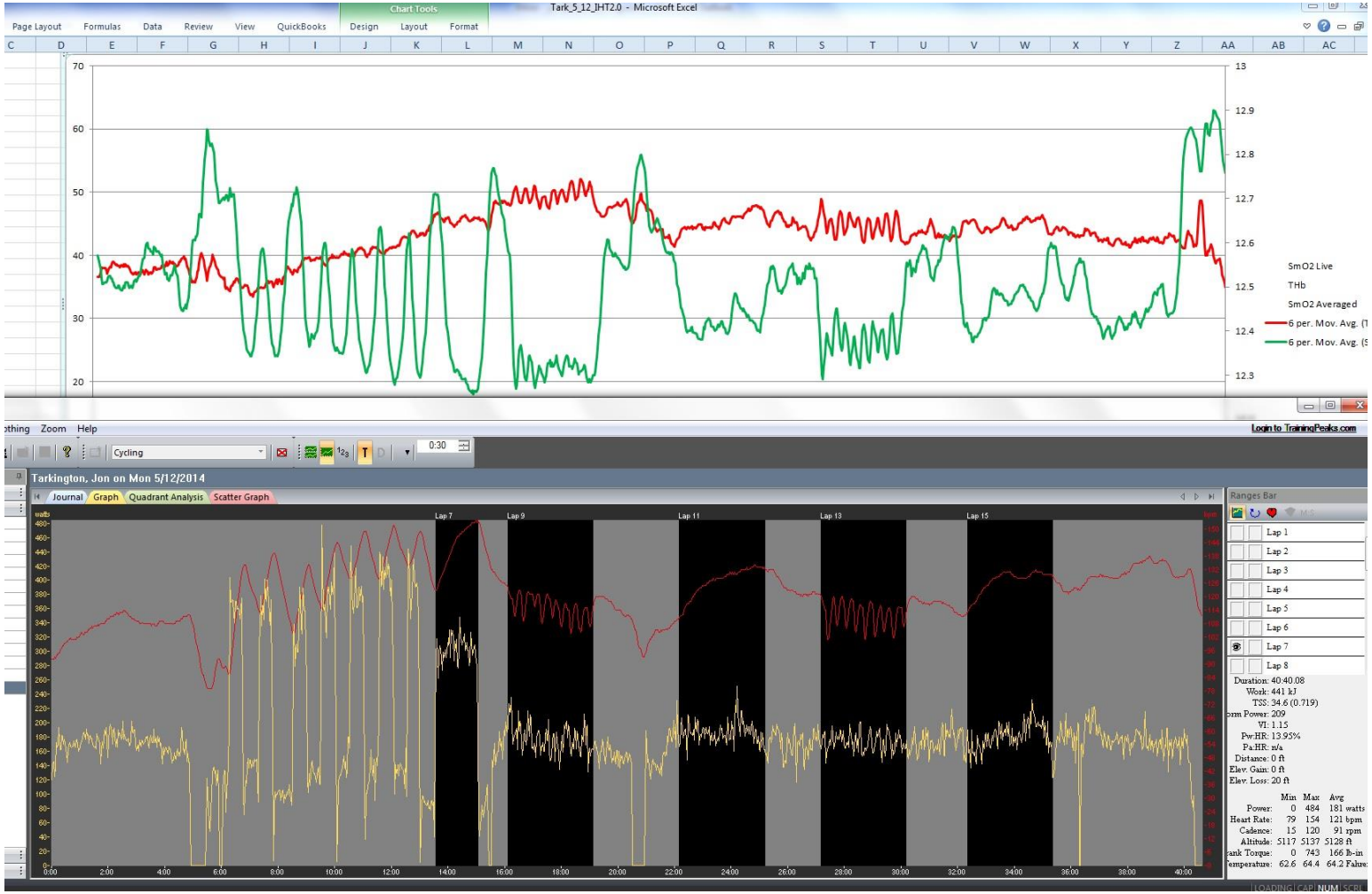
- Hypoxia- the body or a region of the body is deprived of adequate oxygen supply
- Hypercapnia- a condition of abnormally elevated carbon dioxide ($CO_2$) levels in the blood
- Breath Hold Intervals – Systemic Reactions
- Intake Restriction Devices – Intervals, Post Load Intervals – Mechanical Reactions
- SpiroTiger – Respiratory Trainer – Can be used for multiple goals (unloaded)
- Altitude – Ultimate efficiency training!

# Hypoxic/Hypercapnic

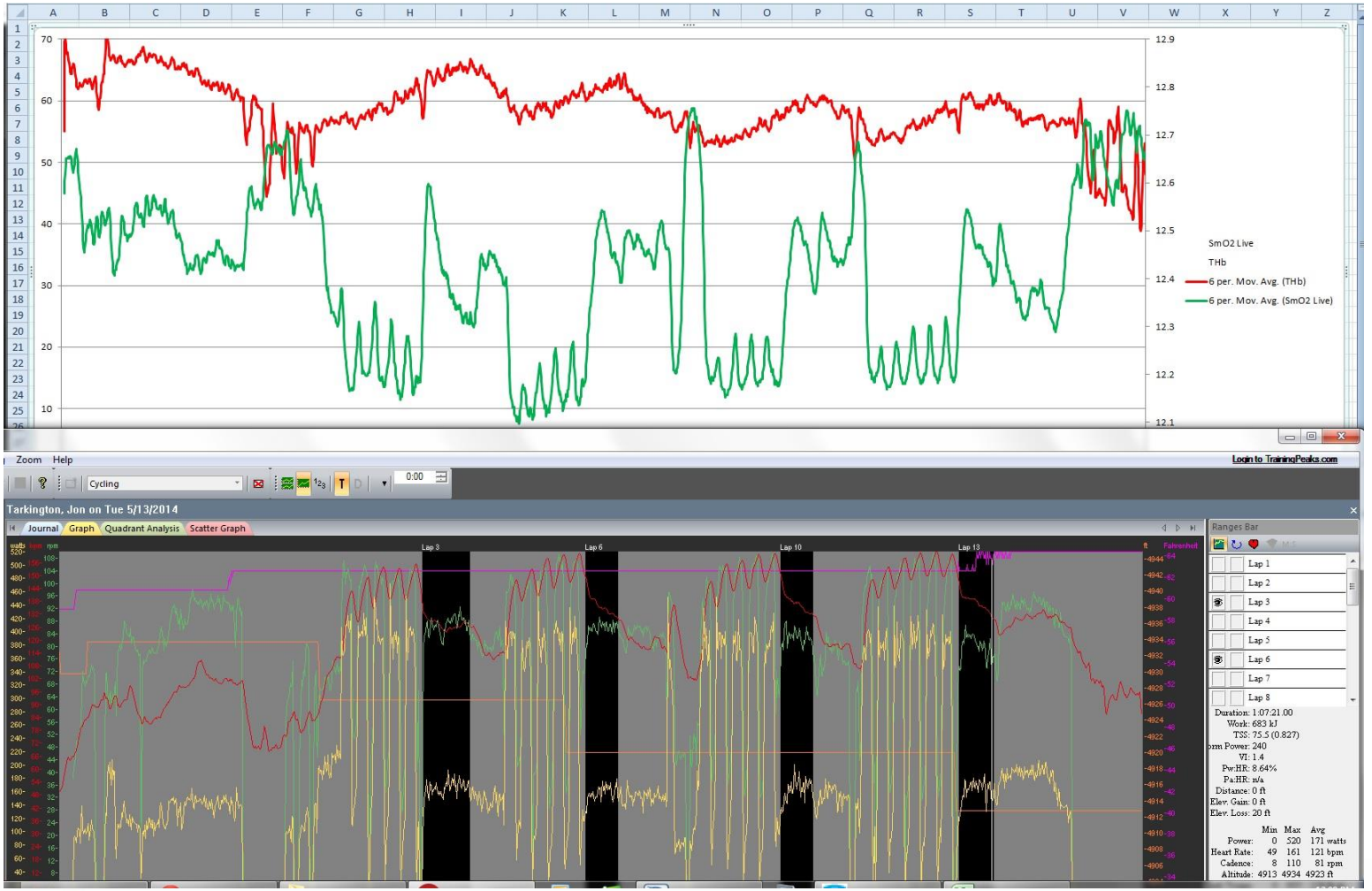
## Field Use


## Indoor Use

# Hypoxia


Tark_5_12_IHT2.0 - Microsoft Excel
SmO2 Live
THb
SmO2 Averaged
Tarkington, Jon on Mon 5/12/2014
Journal
Graph
Quadrant Analysis
Scatter Graph
Ranges Bar
Lap 1
Lap 2
Lap 3
Lap 4
Lap 5
Lap 6
Lap 7
Lap 8

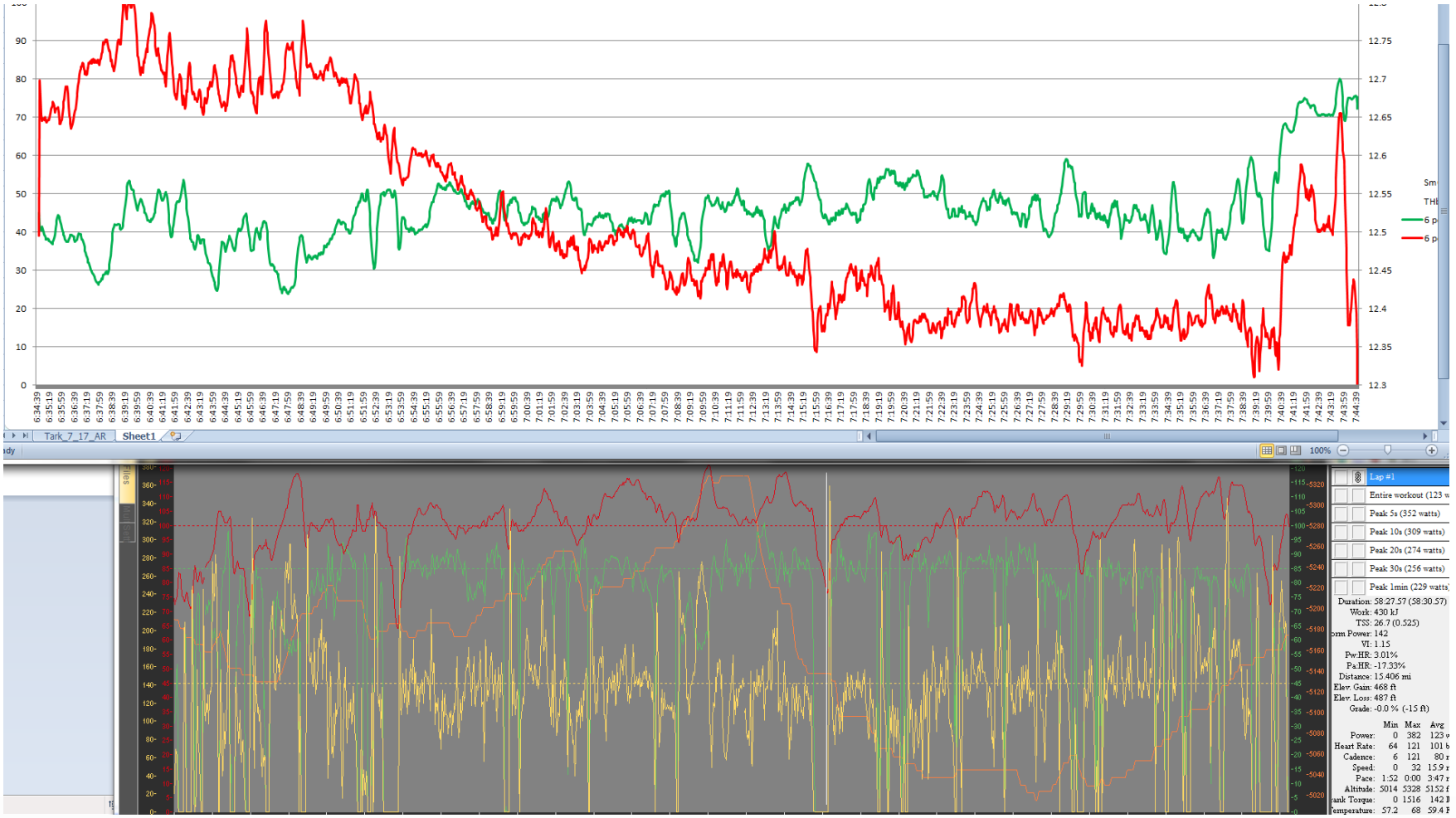
# Loaded Hypoxia



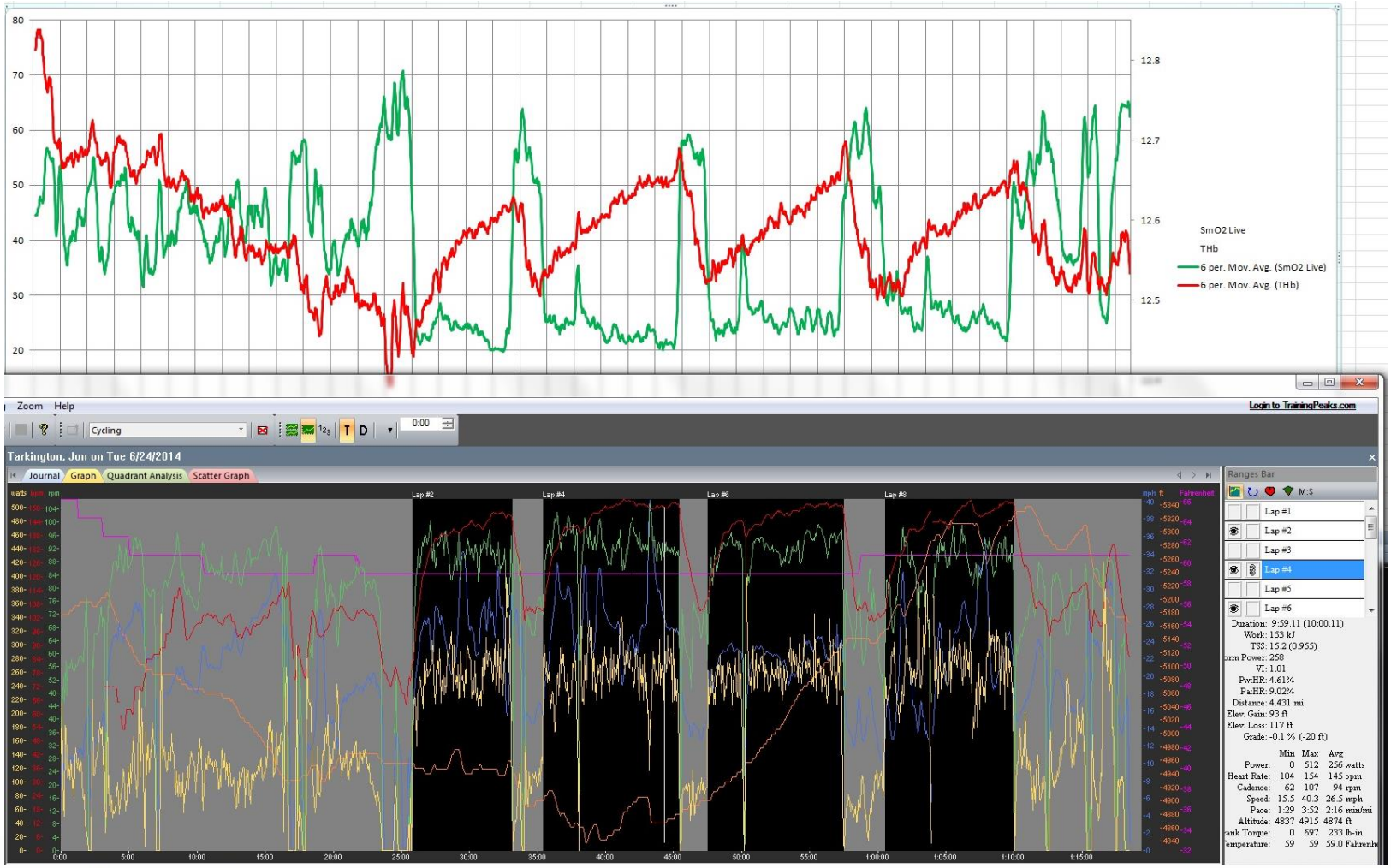

# Recovery / RPE

- Provides undeniable data for athletes on importance and impact of recovery
- Increased Blood flow
- Increased extraction efficiency
- Opportunity to evaluate training load
- Very strong correlation to Representative Perceived Exertion (RPE)

# Recovery


Tark_7_17_AR
Sheet1
100%
Lap #1
Entire workout (123
Peak 5s (352 watts)
Peak 10s (309 watts)
Peak 20s (274 watts)
Peak 30s (256 watts)
Peak 1min (229 watts)
Duration: 58:27.57 (58:30.57)
Work: 430 kJ
TSS: 26.7 (0.525)
Power: 142
VI: 1.15
Pw:HR: 3.01%
Pa:HR: -17.33%
Distance: 15.406 mi
Elev. Gain: 468 ft
Elev. Loss: 487 ft
Grade: -0.0 % (-15 ft)
Min Max Avg
Power: 0 382 123
Heart Rate: 64 121 101
Cadence: 6 121 80
Speed: 0 32 15.9
Pace: 1:52 0:00 3:47
Altitude: 5014 5328 5152
Temperature: 57.2 68 59.4

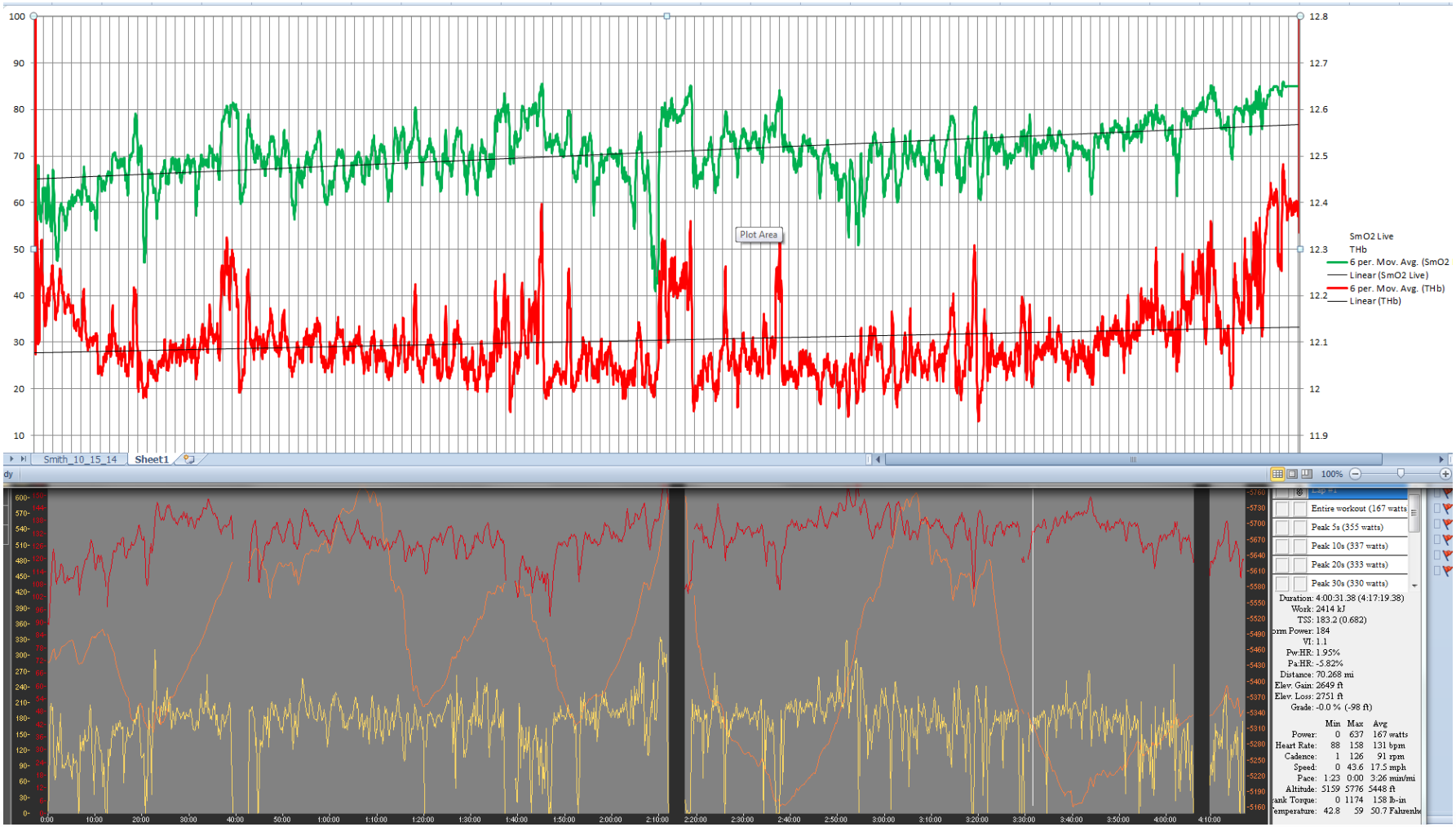
# RPE


SmO2 Live
THb
6 per. Mov. Avg. (SmO2 Live)
6 per. Mov. Avg. (THb)
Zoom
Help
Login to TrainingPeaks.com
Cycling
Tarkington, Jon on Tue 6/24/2014
Journal
Graph
Quadrant Analysis
Scatter Graph
Lap #2
Lap #4
Lap #6
Lap #8
Ranges Bar
Lap #1
Lap #2
Lap #3
Lap #4
Lap #5
Lap #6
Duration: 9:59.11 (10:00.11)
Work: 153 kJ
TSS: 15.2 (0.955)
VI: 1.01
Pw:HR: 4.61%
Pa:HR: 9.02%
Distance: 4.431 mi
Elev. Gain: 93 ft
Elev. Loss: 117 ft
Grade: -0.1 % (-20 ft)
Min Max Avg
Power: 0 512 256 watts
Heart Rate: 104 154 145 bpm
Cadence: 62 107 94 rpm
Speed: 15.5 40.3 26.5 mph
Pace: 1:29 3:52 2:16 min/mi
Altitude: 4837 4915 4874 ft
Torque: 0 697 233 lb-in
Temperature: 59 59 59.0 Fahrenh

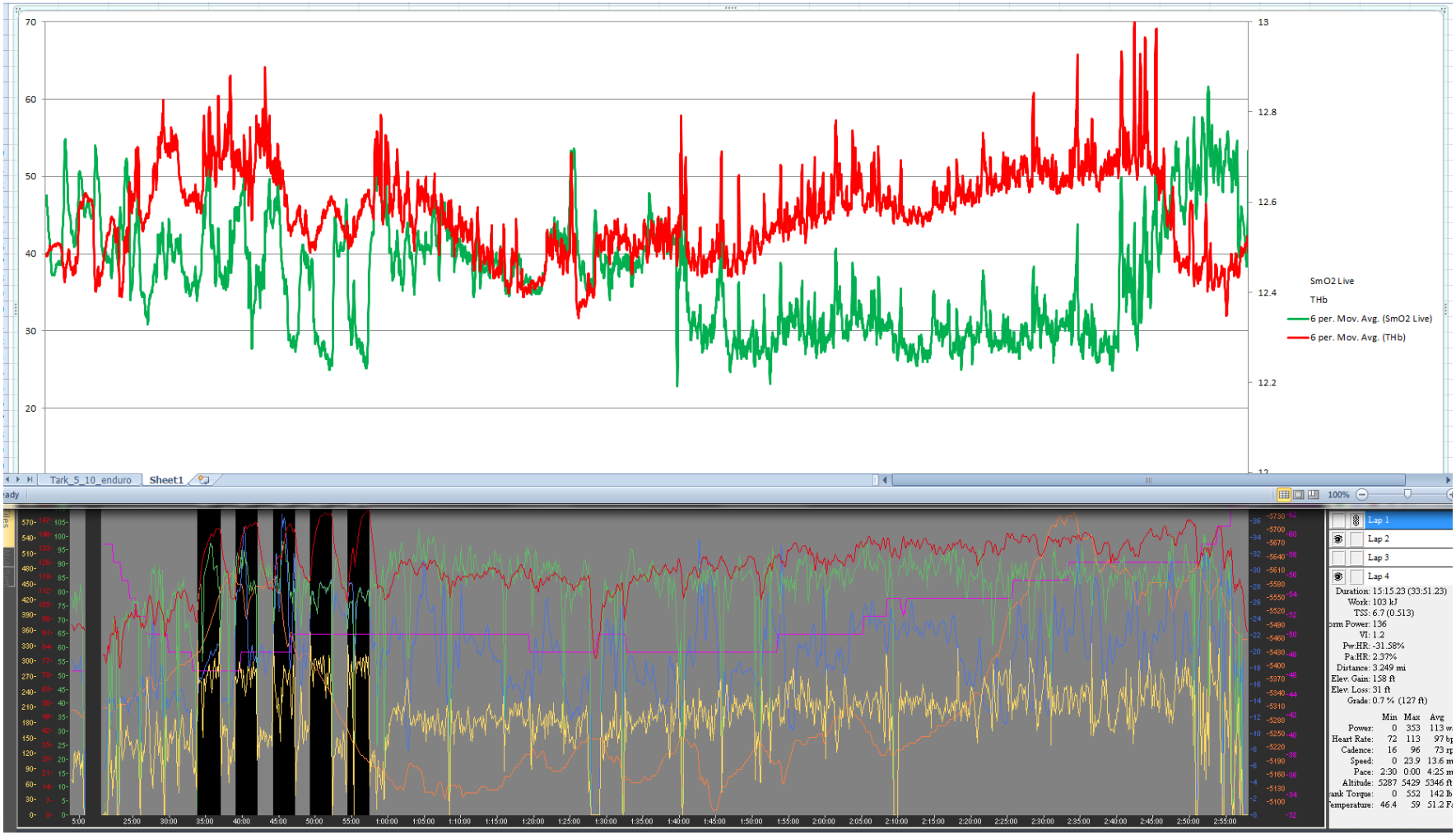
# Endurance Evaluation

- Provides undeniable data for athletes on importance and impact of proper endurance training
- Similar to recovery benefits
- Mitochondrial density?
- Impact of fueling / fatigue

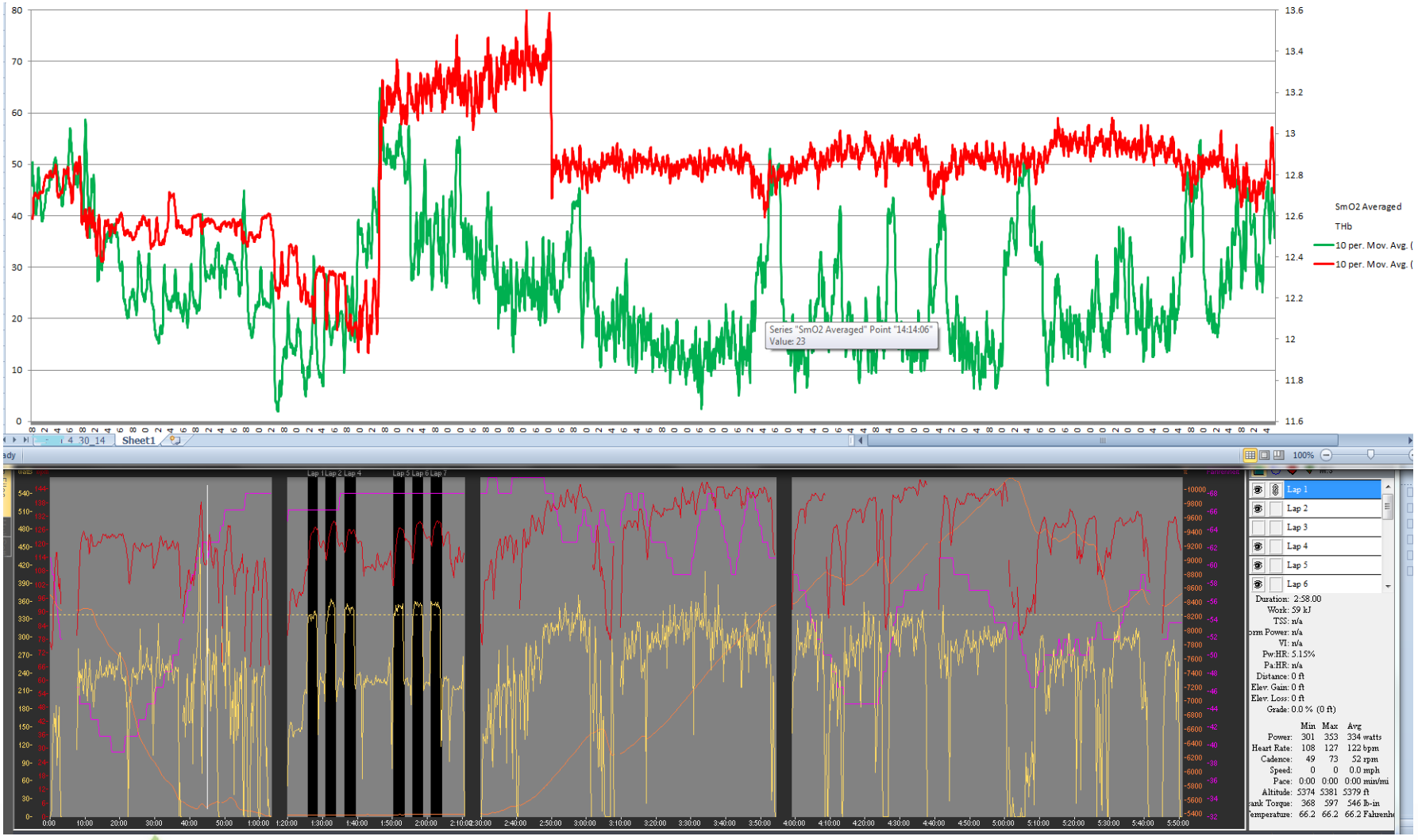
# Endurance- Basic




# Endurance- Intermediate



# Endurance- Advanced



# Congratulations!

- **Moxy data clearly has potential in the endurance sports world as an additional bio-metric**
- **Expect a busy 12 months in additional analytics and ANT+ development**
- **Many more questions than answers for practical application and specific uses**
- **What's next?**

# Future

- Wearable market exploding
- “Stress” Monitor in 2015
- 5-10 years Gas Exchange? Muscle Glycogen?
- WASP Based group training (TTT/Pursuit/Track)
- Development of practical application metrics for new data channels
- Early adoption and/or understanding = head start
- Better connecting of confusing data channels means better coaching