

LONGITUDINAL TRACKING OF SLEEP AND RESTING HEART RATE (RHR)

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WHAT DID I DO



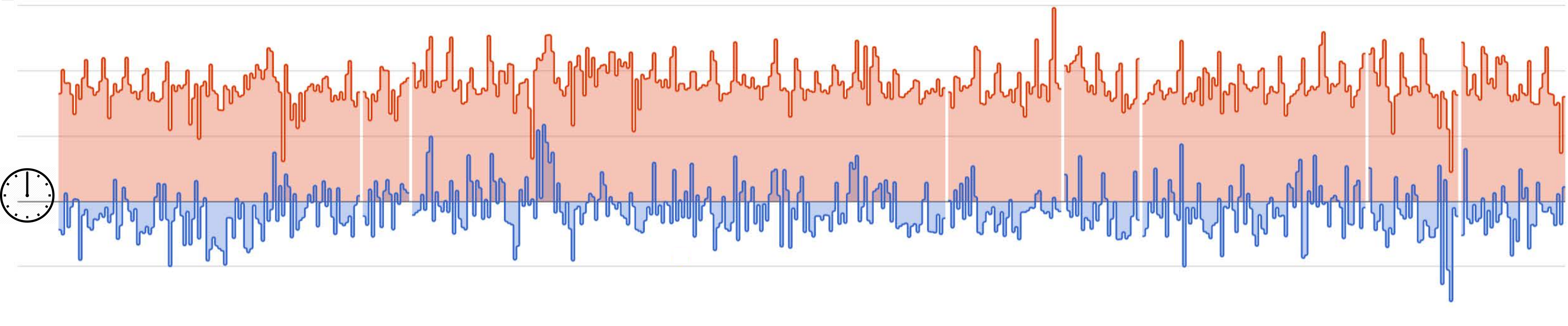
HOW DID I DO IT



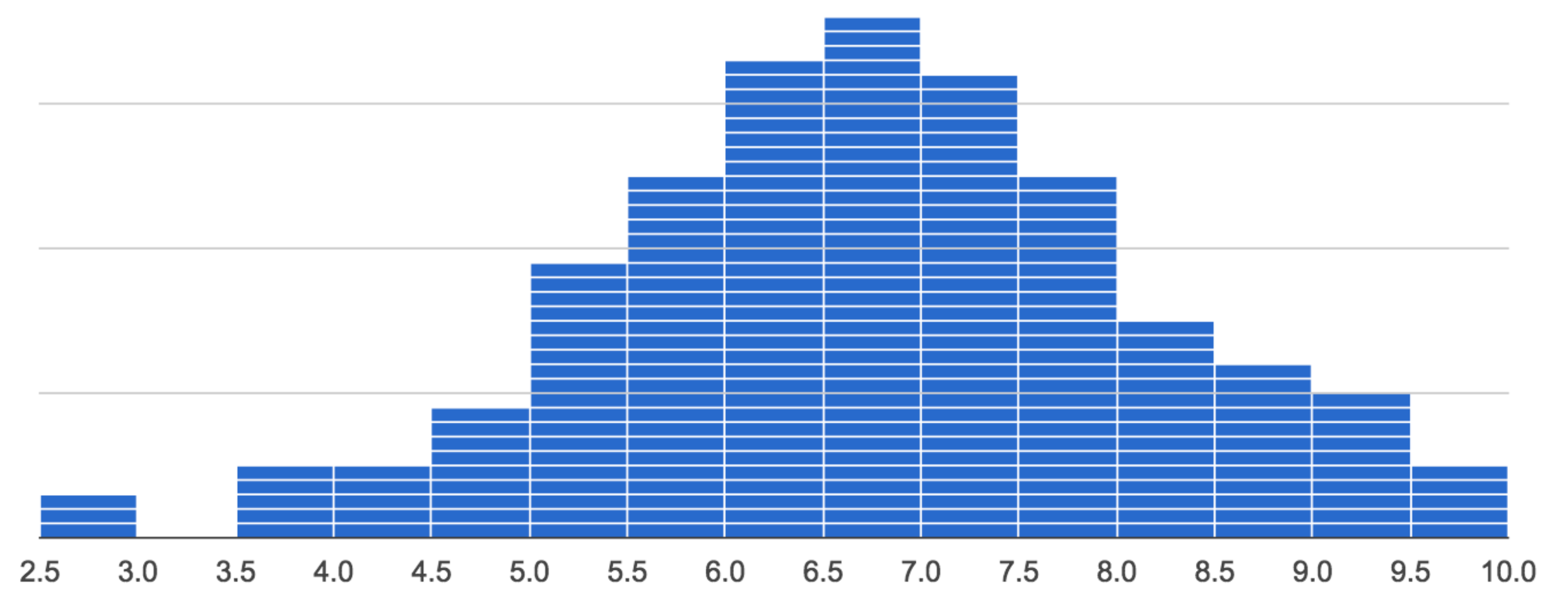


SLEEP DURATION, ONSET, WAKEUP

■ Sleep onset ■ Wakeup



1/1/2016 2/1/2016 3/1/2016 4/1/2016 5/1/2016 6/1/2016 7/1/2016 8/1/2016 9/1/2016 10/1/2016 11/1/2016 12/1/2016 1/1/2017 2/1/2017 3/1/2017 4/1/2017 5/1/2017 6/1/2017



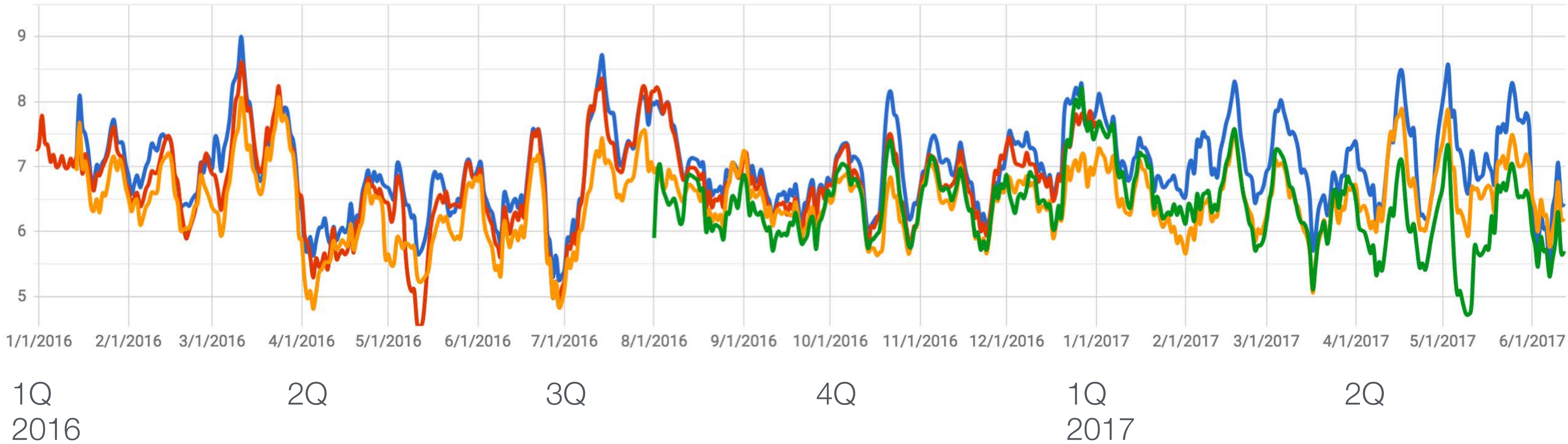
SLEEP DURATION IN HOURS

Manual

Basis

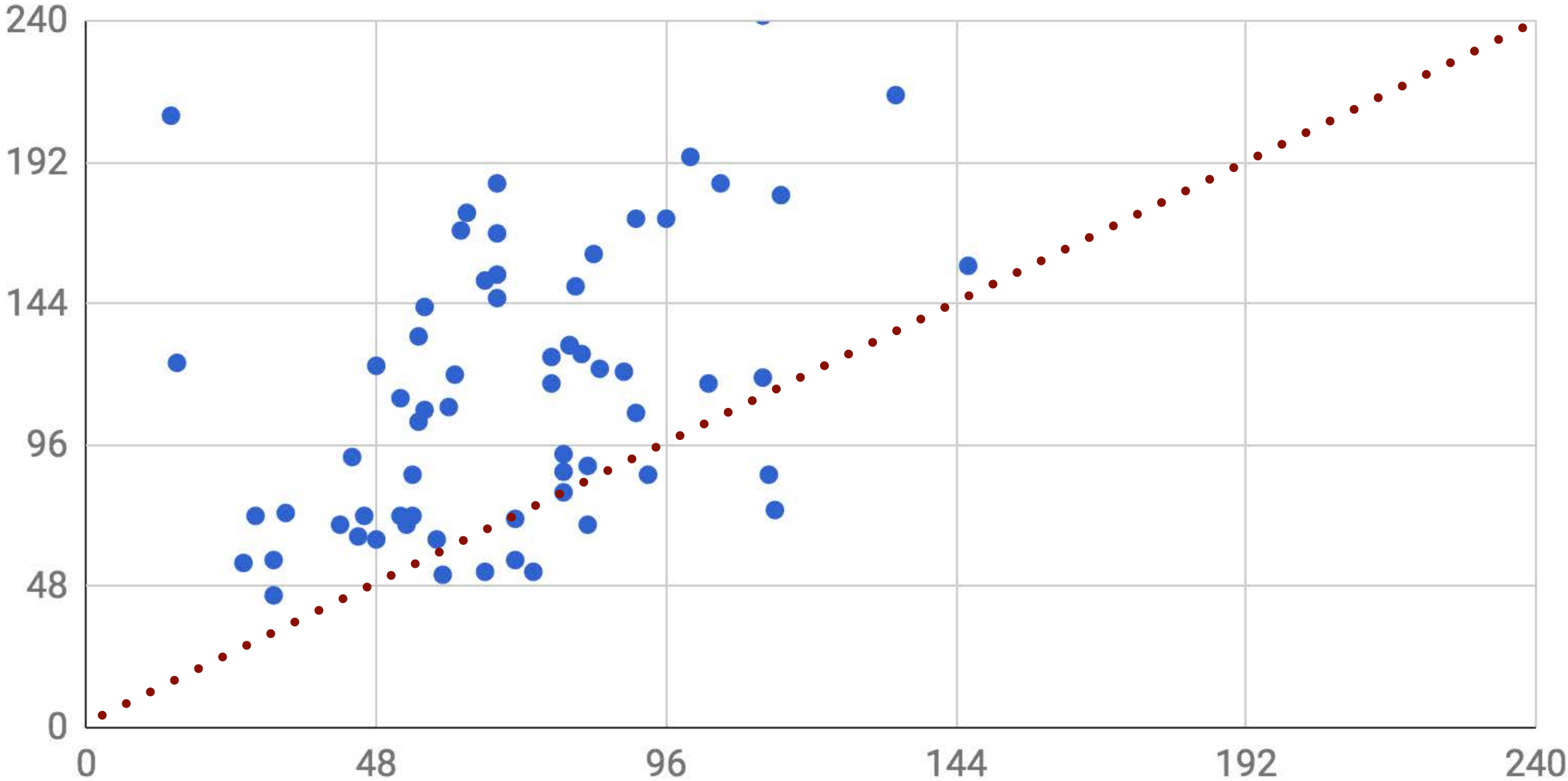
Oura

Fitbit

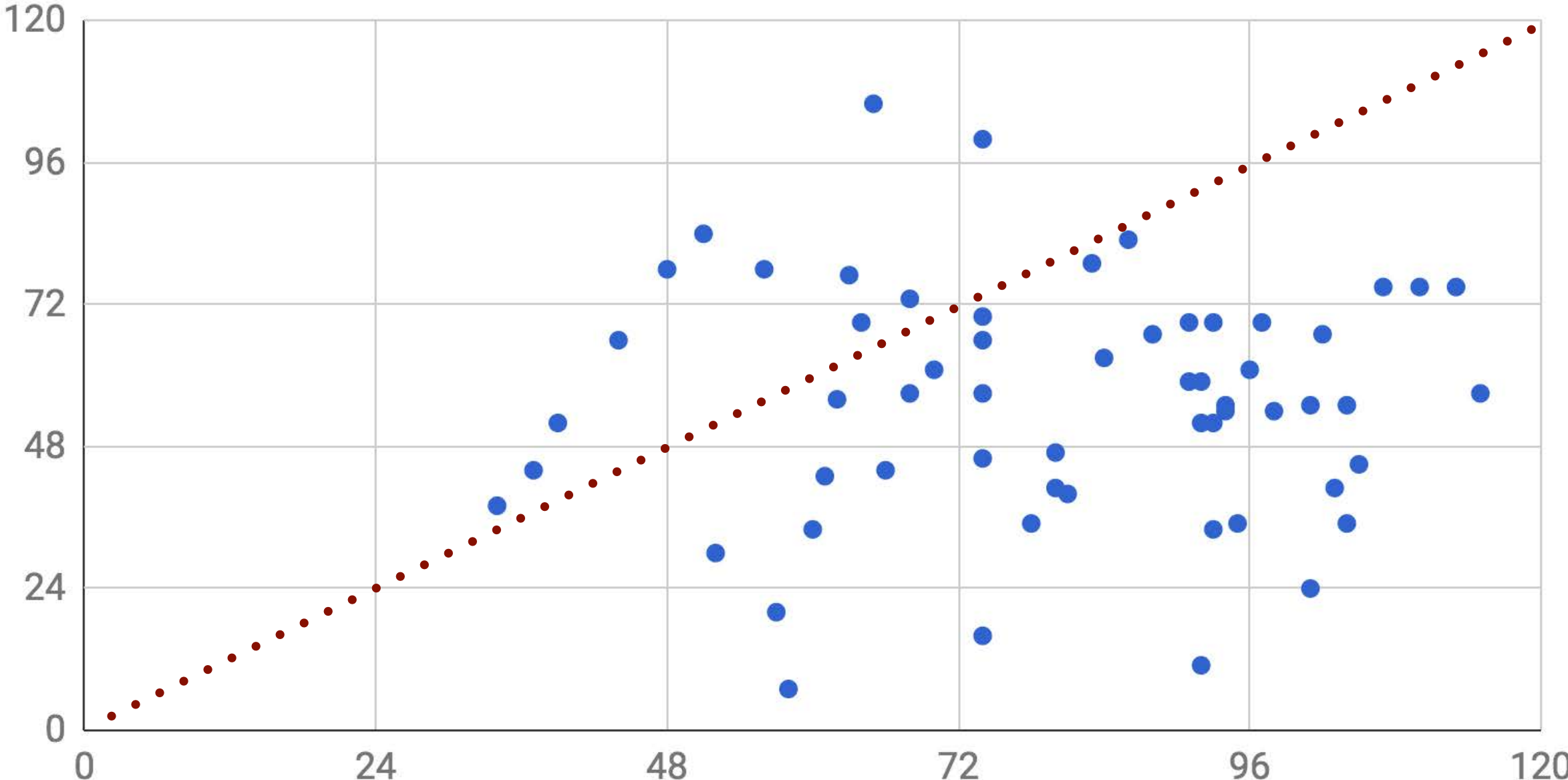


SLEEP STAGE DETECTION

REM SLEEP



DEEP SLEEP



SLEEP STAGE DETECTION

REM SLEEP

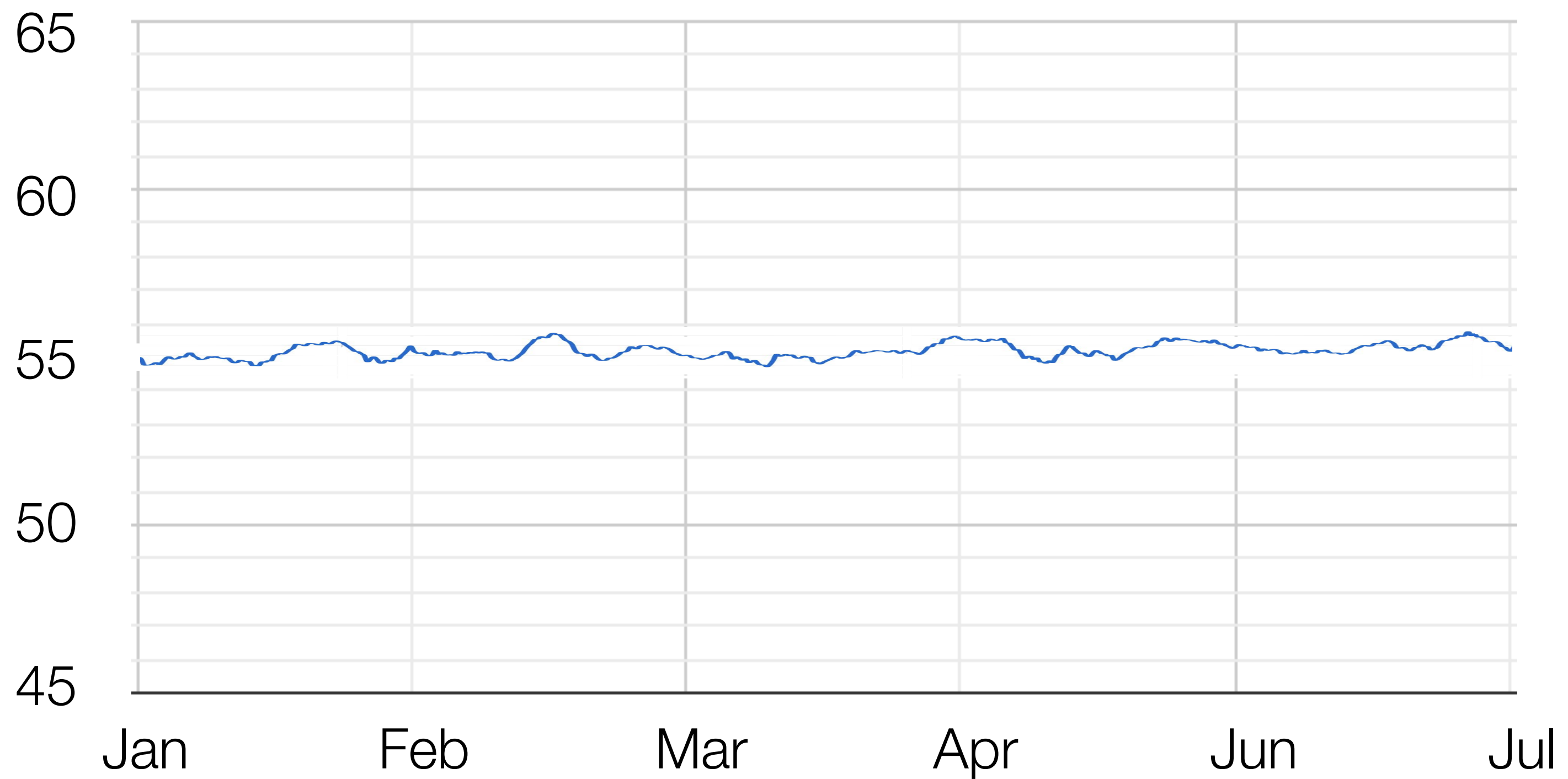
DEEP SLEEP



RESTING HEART RATE



RESTING HEART RATE (RHR)



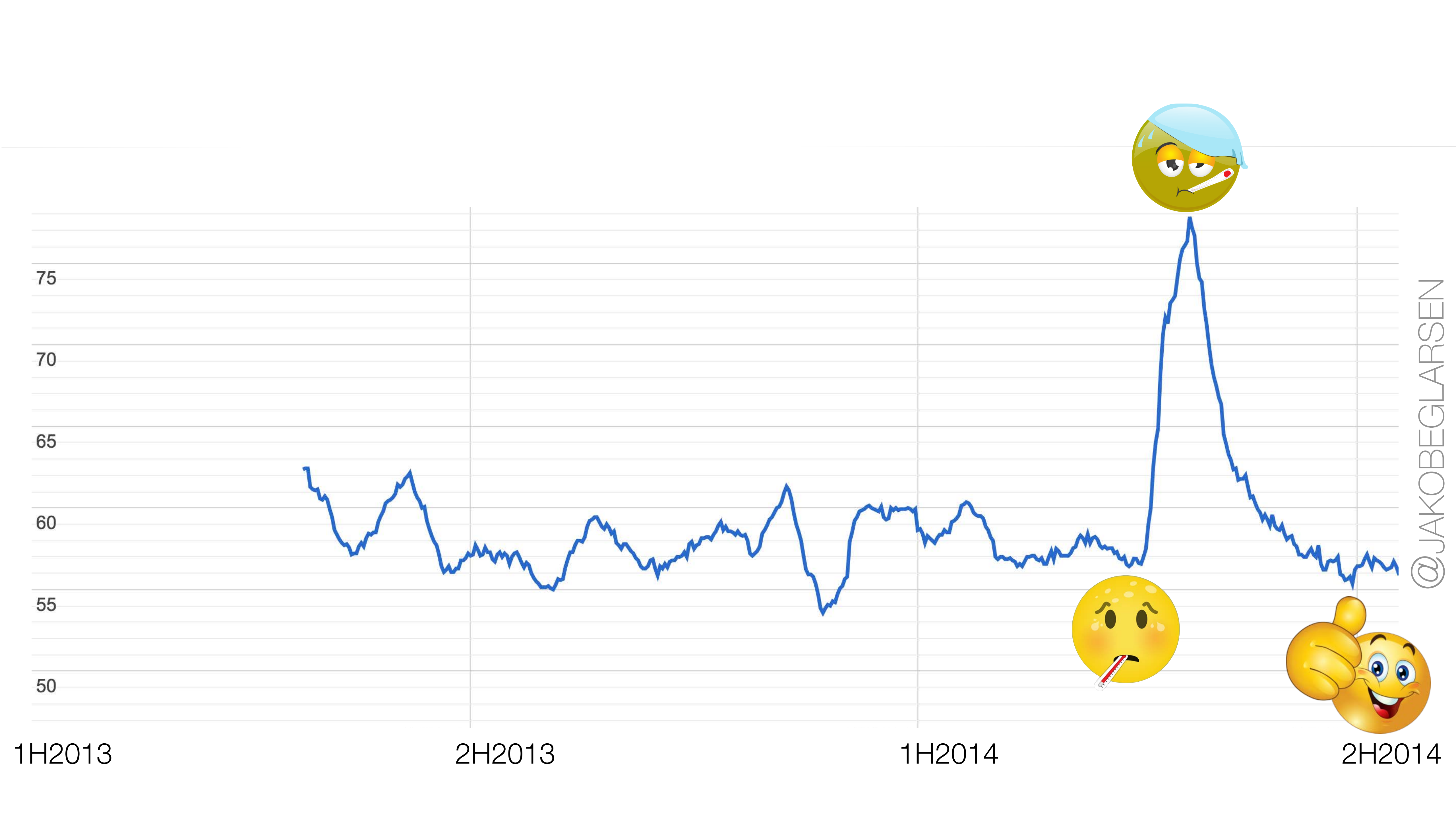
FIRST YEAR OF RESTING HEART RATE

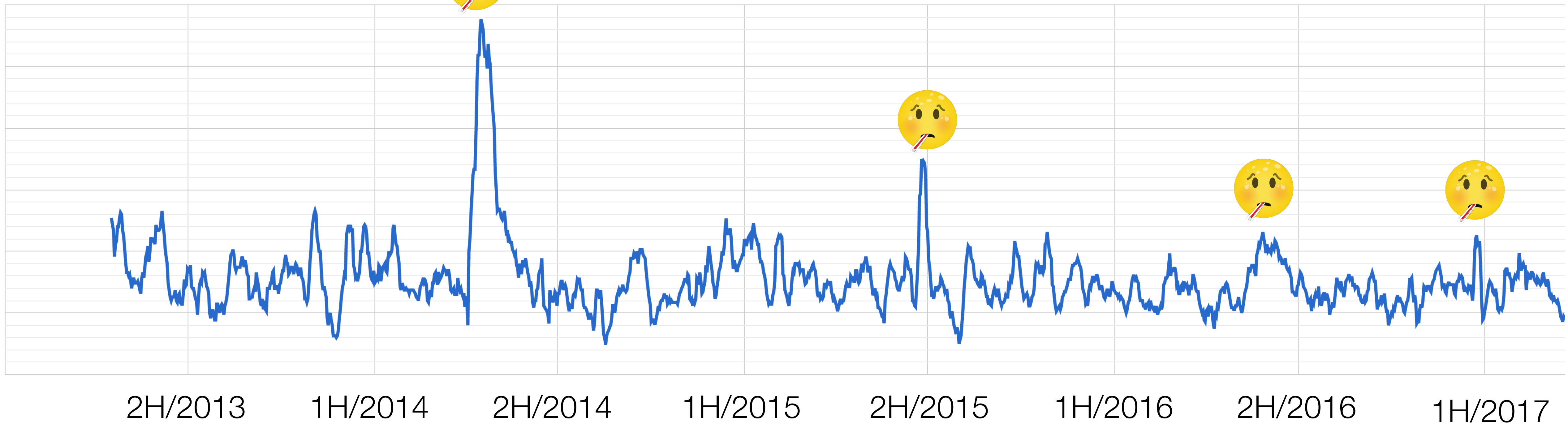


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RESEARCH ARTICLE

Digital Health: Tracking Physiomes and Activity Using Wearable Biosensors Reveals Useful Health-Related Information

Xiao Li¹✉, Jessilyn Dunn^{1,2}✉, Denis Salins¹✉, Gao Zhou¹, Wenyu Zhou¹, Sophia Miryam Schüssler-Florenza Rose^{3,4}, Dalia Perelman⁵, Elizabeth Colbert³, Ryan Runge¹, Shannon Rego³, Ria Sonecha¹, Somalee Datta¹, Tracey McLaughlin⁵, Michael P. Snyder¹✉

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Data Availability Statement: These data are available at <http://hmpdacc.org/data/wearable/stanford.tar>.

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Abstract

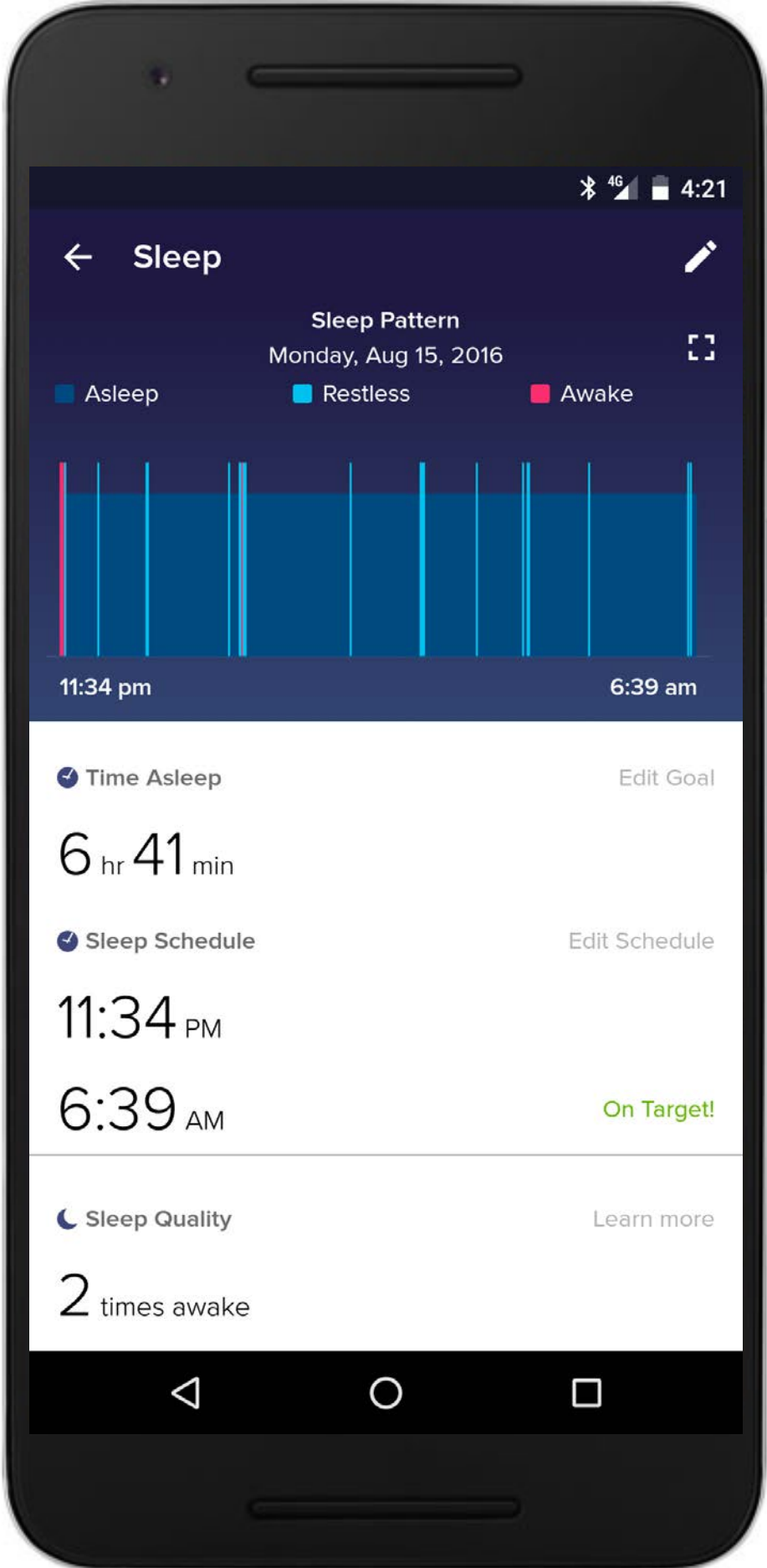
A new wave of portable biosensors allows frequent measurement of health-related physiology. We investigated the use of these devices to monitor human physiological changes during various activities and their role in managing health and diagnosing and analyzing disease. By recording over 250,000 daily measurements for up to 43 individuals, we found personalized circadian differences in physiological parameters, replicating previous physiological findings. Interestingly, we found striking changes in particular environments, such as airline flights (decreased peripheral capillary oxygen saturation [SpO₂] and increased radiation exposure). These events are associated with physiological macro-phenotypes such as fatigue, providing a strong association between reduced pressure/oxygen and fatigue on high-altitude flights. Importantly, we combined biosensor information with frequent medical measurements and made two important observations: First, wearable devices were useful in identification of early signs of Lyme disease and inflammatory responses; we used this information to develop a personalized, activity-based normalization framework to identify abnormal physiological signals from longitudinal data for facile disease detection. Second, wearables distinguish physiological differences between insulin-sensitive and -resistant individuals. Overall, these results indicate that portable biosensors provide useful information for monitoring personal activities and physiology and are likely to play an important role in managing health and enabling affordable health care access to groups traditionally limited by socioeconomic class or remote geography.

ACCURACY

PRECISION

RELIABILITY

OURA RING AND FITBIT BLAZE

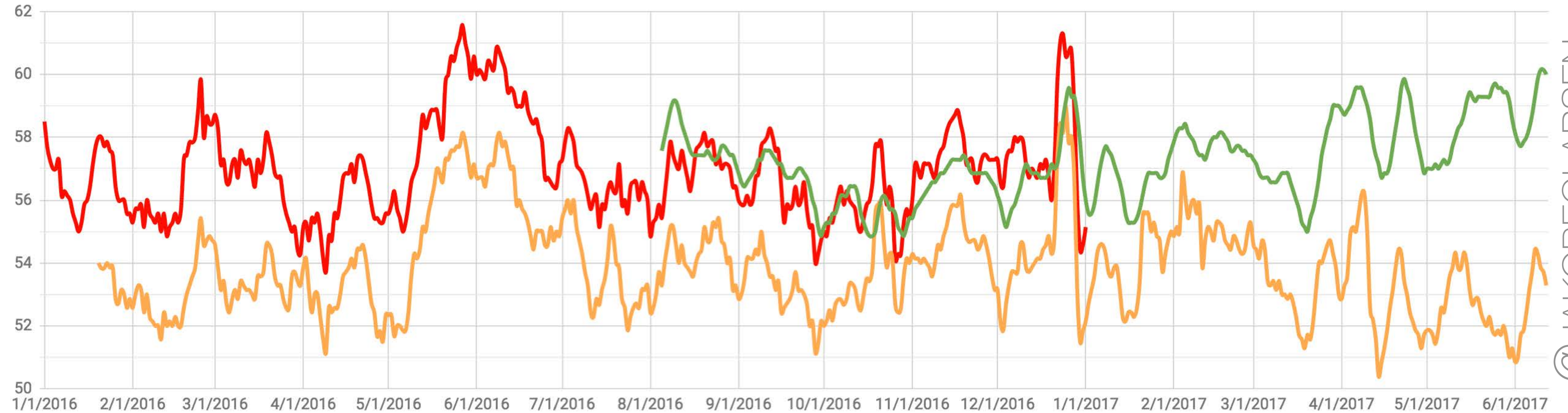


RESTING HEART RATE — COMPARISON

Basis

Oura

Fitbit Blaze



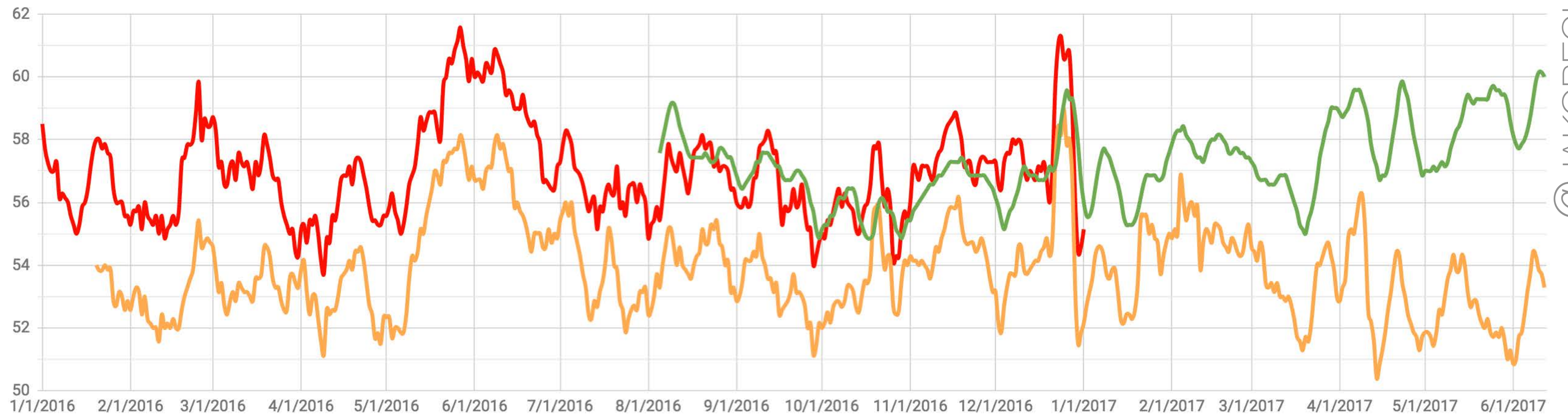
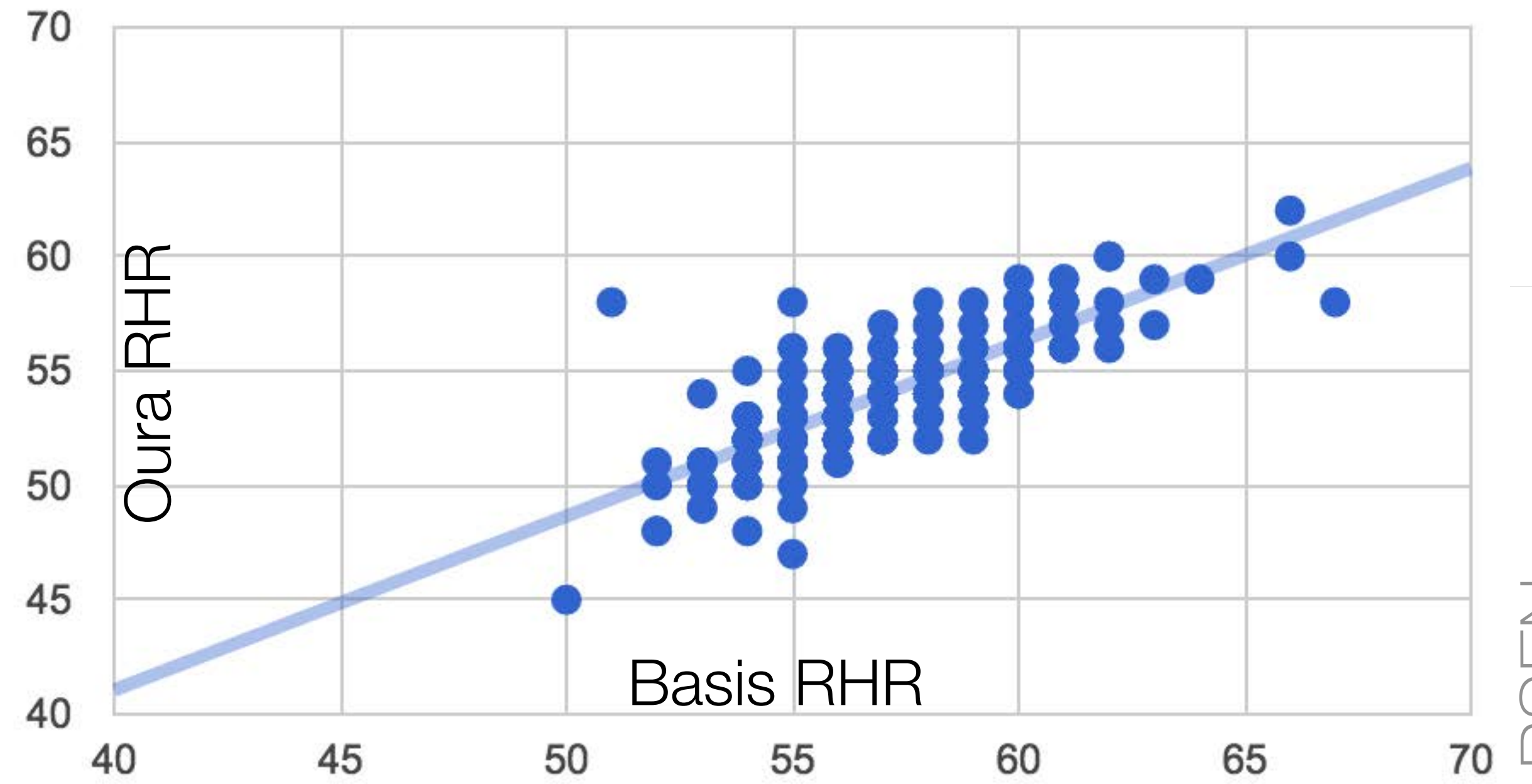
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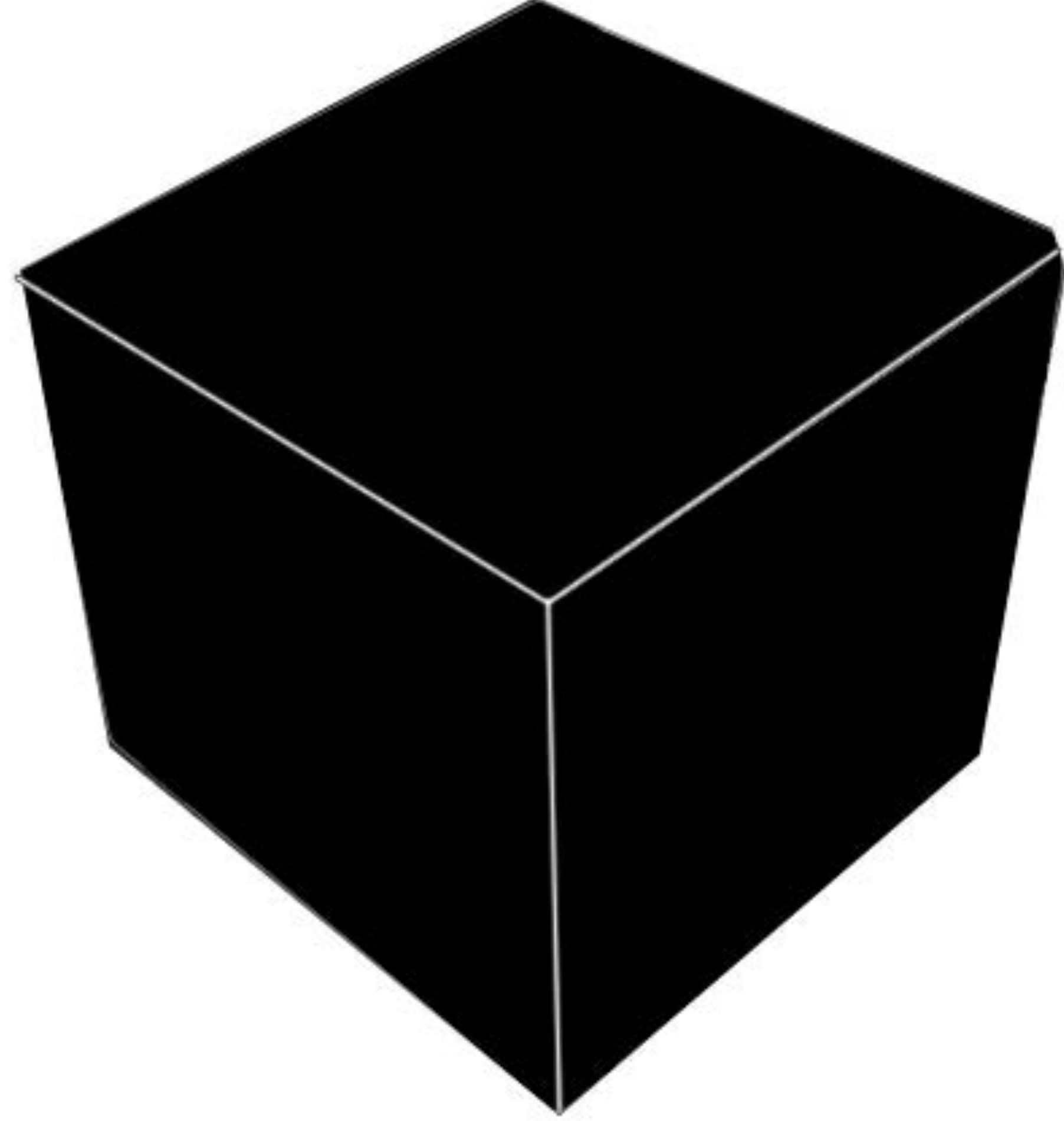
RHR — MOVING AVERAGE

Basis

Oura

Fitbit Blaze

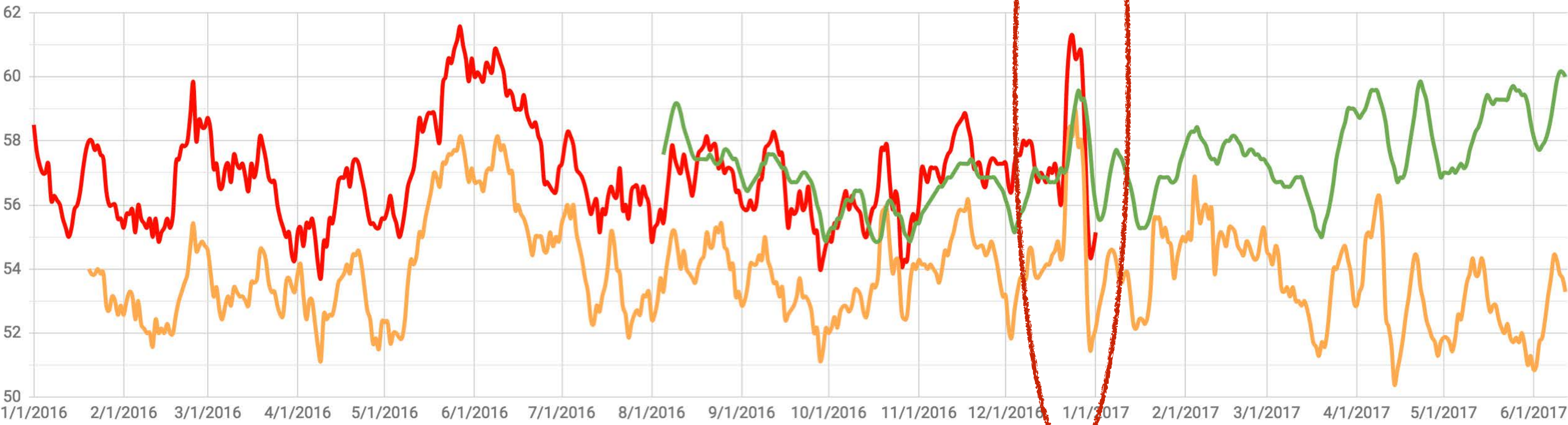




TEMPERATURE DATA

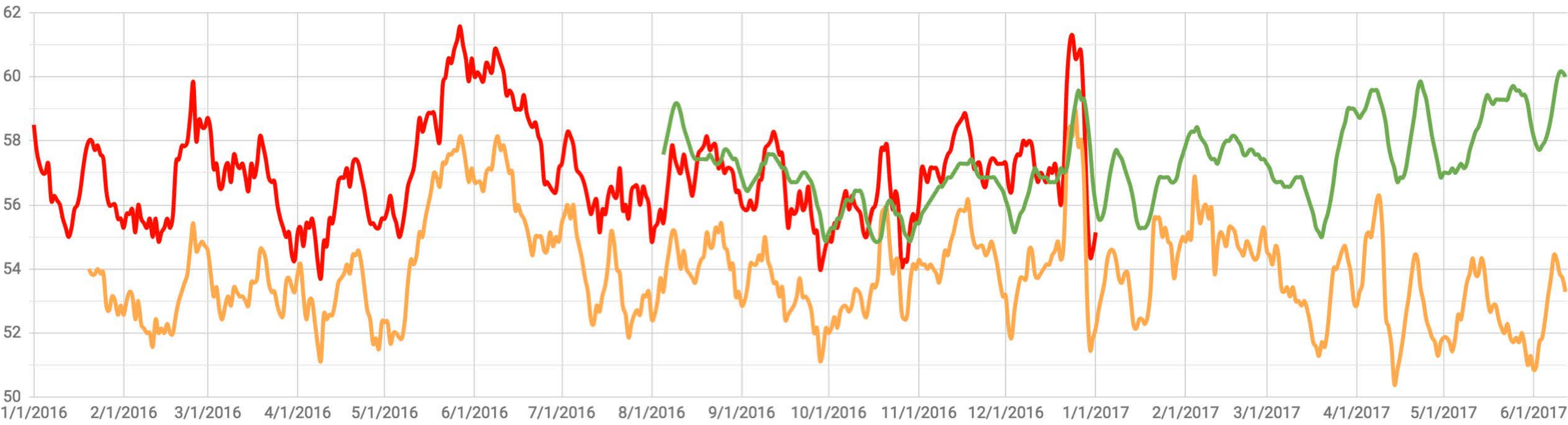


TEMPERATURE AND RHR DATA



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TEMPERATURE AND RHR DATA



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RHR



2H/2013

1H/2014

2H/2014

1H/2015

2H/2015

1H/2016

2H/2016

1H/2017



THANK YOU

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